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ORIGINAL RESEARCH

Shoulder pain in adolescent athletes: prevalence, associated factors and its influence on upper limb function

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Abstract
Background: Sports that require the constant use of an upper limb demand the maximum kinetic chain efficiency in this segment. Immaturity of the musculoskeletal system, followed by failure in motor skills can expose adolescents to major reports of pain complaints, particularly for the shoulder.
Objective: To evaluate the prevalence of shoulder pain in adolescent athletes and identify possible factors associated with the complaint.
Method: A total of 310 athletes, of both sexes and aged between 10 and 19 years old participated on this study. The subjects filled out a questionnaire with personal, sports and upper limb function (Quick-DASH) questions. We evaluated the height, body mass, shoulder rotation range and stability of the upper limb using the CKCUES-test. The association between pain and the variables was analyzed using multilevel modeling logistic regression. We used the Mann–Whitney test for comparing between pain and function.
Results: The prevalence of shoulder pain was 43.5%. Athletes between 15 and 19 years, handball and judo practitioners, are 1.86, 2.14 and 3.07 more likely to report shoulder pain, respectively, when compared with other sports and ages. Shoulder pain reduced function scores ($p < 0.001$) and increased changes in the range of motion ($p < 0.04$).
Conclusion: Shoulder pain is highly prevalent and is associated especially with older adolescent athletes of handball and judo, and affects the levels of function and the range of the shoulder.

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Introduction

Shoulder pain is a reality not only of professional athletes and/or adults. The immaturity of the musculoskeletal system, when followed by motor sports disability, can expose young athletes to pain and musculoskeletal injuries.[1–5] Most studies in the literature have been concerned with analyzing the prevalence or incidence of already diagnosed shoulder injuries.[6–8] However, it is known that pain is one of the first signs of damage. In this sense, few studies have addressed the prevalence of shoulder pain in adolescent athletes and those that evaluated such occurrence were limited to the analysis of only one sport. Data showed that 18.6% to 39.6% of adolescent swimmers complained of shoulder pain,[9–11] while 5.5–12.5% of adolescents who practiced volleyball reported pain.[12] Personal and sports characteristics and upper limb performance measures have been mentioned as factors that might be associated with the presence of pain in athletes.[9,12–15]

However, it is possible to observe that the studies involving adolescents and shoulder pain were limited to evaluating individual sports. Based on the above considerations, the present study aimed to evaluate the prevalence of shoulder pain in adolescent athletes involved in different sports and to identify possible associated factors. In addition, we sought to assess whether adolescents with and without complaints of shoulder pain differed in certain measurements related to shoulder function.

Methods

This study was an observational, correlational cross-sectional study, composed of adolescents, amateur athletes, aged between 10 and 19 years old, and participants in sports that required the use of the upper limb (i.e. volleyball, handball, basketball, swimming and judo). The sample size calculation was performed using the WinPepi program, using the following criteria: a population of 521 athletes, a confidence interval of 95%, a sampling error of 5%, prevalence estimated at 21.4%,[14] a sample loss of 10% and a sample design effect established at 1.5 times the size of the sample. The sampling method was a probability sample in order to maintain a representative sample of athletes involved in each of the five sports. Thus, a minimum sample of 290 athletes proportionally distributed in the five sports was required.

The study was approved by the Ethics Committee of the University of Pernambuco under the CAAE 38321114.0.0.0000.5207 Protocol. All subjects under the age of 18 years received the Consent Statement and their legal representatives received Informed Consent which they were asked to sign and return to the researchers before the athletes were included in the study.

The study included adolescent athletes of both sexes who practiced for at least a year in one of the following sports: volleyball, handball, basketball, swimming, or judo. Exclusion criteria were inappropriate filling out of the questionnaires, or a refusal to perform any assessment activity of the study.

A structured questionnaire with personal information, sports and data about shoulder pain was given to each subject to complete. To verify the presence or absence of shoulder pain, the subjects answered the Corlett Body Diagram[16] questions. To assess the upper limb as a functional unit, the Quick Disability Arm Shoulder Hand questionnaire (Quick-DASH) and its optional sports module (optional Quick-DASH) were applied. This questionnaire has been translated into Portuguese[17–19] and validated for children and adolescents.[20] The total score ranges from zero (no dysfunction) to 100 points (severe dysfunction).

Body mass and height were measured according to the standardization of the International Society for the Advancement of Kinanthropometry (ISAK), and body mass index (BMI) was calculated using the equation BMI = body mass/(Height)^2. For the classification of the nutritional status of the adolescents, the criteria suggested by the International Obesity Task Force (IOTF) were used. The passive range of internal and external rotation of the shoulder was measured with a goniometer.[21] For this, the subjects were positioned in a supine position with knees and hips flexed and the arm abducted to 90° and elbow flexed at 90° while the evaluator aligned the goniometer axis on the olecranon process with the goniometer arms perpendicular to the ground and parallel to the ulnar styloid process of the subject. The maximum external rotation was established by the stopping sensation at the end of motion (end feel). For internal rotation, a combination of the final stopping sensation, and the scapular compensation view (anterior tilt) was used to determine the end of the range of motion. For both rotations, in the case of subjects with shoulder pain, the range of motion limitation was established by the initial pain sensation reported by the participant. Three measurements were taken in each arm, and the final value was obtained by the average of the three values. The calculation of the glenohumeral internal rotation deficit (GIRD) was made by subtracting the internal rotation average of the three values of the dominant and non-dominant arm respectively.

Finally, the subjects performed the Closed Kinetic Chain Upper Extremity Stability Test (CKCUES Test), which assesses shoulder stability. In this test, the boys had to assume the traditional push-up position, while the girls assumed a modified push-up position (i.e. using the knees for support instead of the feet), both with hands supported on two pieces of tape fixed on the ground at a distance of 91.4 cm apart. Each subject was asked to perform, alternately for 15 s, the movement of touching the opposite hand. The number of touches or crossovers in 15 s was counted. The test was repeated 3 times and the 3 scores were averaged to give a mean test score which was multiplied by 68% of body mass divided by 15.[22] Before the execution, a submaximal test was performed for familiarization.

Previously, a pilot study ($n = 25$) was conducted to evaluate the intraclass correlation coefficient ($ICC_{3,3}$), the inter-day (seven days) and intra-rater measures with a confidence interval at 95% (CI95%) and the standard error of measurement (SEM), obtaining the following values: Quick-DASH (ICC = 0.81; 95% CI = 0.56–0.92; SEM = 4.2), Optional Quick-DASH (ICC = 0.73; 95% CI = 0.38–0.88; SEM = 7.0), CKCUES-test (ICC = 0.87; 95% CI = 0.64–0.95; SEM = 6.5) and shoulder range of motion (ICC = 0.82–0.91; 95% CI = 0.59–0.96; SEM = 4.2–7.1).

Table 1 Anthropometrics and sports characteristics of the sample of both sexes and stratified by sex represented on average, standard deviation, absolute and relative frequency (n = 310).

	Total	Male	Female	*p*
Personal characteristics				
Age (years)	14.16 (2.12)	14.59 (2.15)	13.58 (1.95)	0.001*
Body mass (kg)	58.92 (14.88)	63.35 (15.55)	52.79 (11.37)	0.001*
Height (m)	1.65 (0.12)	1.70 (0.12)	1.59 (0.08)	0.001*
BMI (kg/m²)	21.29 (3.77)	21.62 (3.93)	20.82 (3.49)	0.060
Sports characteristics				
Sport				
Basketball	58 (18.7%)	44 (24.4%)	14 (10.8%)	
Handball	78 (25.2%)	49 (27.2%)	29 (22.3%)	
Judo	34 (11.0%)	18 (10.0%)	16 (12.3%)	0.001*
Swimming	42 (13.5%)	32 (17.8%)	10 (7.7%)	
Volleyball	98 (31.6%)	37 (20.6%)	61 (46.9%)	
Practice time				
1 year or less	69 (22.3%)	42 (23.3%)	27 (20.8%)	0.691
More than 1 year	241 (77.7%)	138 (76.7%)	103 (79.2%)	
Years of practice	3.45 (2.71)	3.76 (3.04)	3.04 (2.16)	0.225
Frequency of training (times/week)				
Up to 3	234 (75.5%)	136 (75.6%)	98 (75.4%)	1.000
More than 3	76 (24.5%)	44 (24.4%)	32 (24.6%)	
Duration of training session (h/day)				
Up to 1 h	49 (15.8%)	30 (16.7%)	19 (14.6%)	0.741
More than 1 h	261 (84.2%)	150 (83.3%)	111 (85.4%)	
Medical support on the team				
No	307 (99.4%)	177 (98.9%)	130 (100%)	0.624
Yes	2 (0.06%)	2 (1.1%)	–	

* Statistical difference – $p < 0.05$, when male compared to female

Statistical analysis

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 20. The distribution of the data was verified by the Kolmogorov–Sminorv test. Then, the Chi-square test, independent *t*-test and Mann–Whitney were performed to observe the differences between the sexes. For the association between shoulder pain and personal and sports characteristics, a bivariate association model was constructed to analyze which variables to enter into the model ($p \leq 0.20$). In this analysis, an estimate of the odds ratio (OR) and 95% confidence intervals were performed. Then, a binary logistic regression was performed to explore possible confounding and interaction factors and to identify the need for statistical adjustment.

For the final logistic regression model, multilevel modeling was chosen. This model was added in two blocks: (1) an anthropometric characteristics block (sex, age and BMI) and (2) a sports block (sport, practice time, training frequency and duration of the session). The conditional background method was used in both blocks, only the variables that presented $p < 0.10$ being included in the model. The Omnibus test and Hosmer–Lemeshow and Nagelkerke values were analyzed to confirm the validity of the model. For comparison of shoulder function measurements in adolescents with and without pain, an independent *t*-test and Mann–Whitney test were used, adopting $p < 0.05$

Results

This study included 317 adolescents; however, seven were excluded for refusal to submit or for submitting an incomplete questionnaire. Thus, the total sample was composed of 310 adolescents. Anthropometric characteristics, sports and their respective frequencies according to sex are shown in Table 1. Noteworthy is the difference between sexes in the sport, with volleyball being the most practiced sport among girls, and handball and basketball being the most practiced sports among boys.

In Table 2, the overall prevalence of shoulder pain and the presence of shoulder pain by sport are shown. The prevalence of current pain and pain in the last year corresponds to 43.5% and 54.2% of cases respectively, and the sports of judo and handball had the most frequent complaints.

The descriptive analysis of the characteristics related to shoulder pain among adolescent athletes is shown in Table 3. There were no differences between the sexes.

Multilevel multiple logistic regression analysis revealed that the age variables (OR = 1.86; 95% CI = 1.16–2.97), judo (OR = 3.07; 95% CI = 1.23–7.65) and handball (OR = 2.14; 95% CI = 1.06–4.32) remained in the final model (Table 4). It was possible to confirm that the final model was valid using the Omnibus test ($p = 0.001$). The explanatory power of the model was 99% using the Hosmer–Lemeshow method, and the variance explained in the final model by Nagelkerke R^2 was 91%.

Table 2 Absolute values (relative) of shoulder pain prevalence in the last year and current year among adolescent athletes of both sexes by sport.

Period of prevalence	Basketball	Handball	Judo	Swimming	Volleyball	Total
Current	24 (41.4%)	38 (48.7%)	21 (61.8%)	13 (31.0%)	39 (39.8%)	135 (43.5%)
Last year	27 (46.6%)	49 (62.8%)	24 (70.6%)	17 (40.5%)	51 (52.0%)	168 (54.2%)

Table 3 Absolute and relative frequency of variables related to shoulder pain and performance among adolescent athletes ($n = 168$) of both sexes.

Characteristics	Total	Male	Female	*p*
Pain laterality				
Dominant	97 (64.7%)	58 (64.4%)	39 (65.0%)	
Non-dominant	21 (14.0%)	11 (12.2%)	10 (16.7%)	0.628
Both	32 (21.3%)	21 (23.3%)	11 (18.3%)	
Time of pain				
Training/competition	99 (68.8%)	62 (72.1%)	37 (63.8%)	0.384
Other situation	45 (31.3%)	24 (27.9%)	21 (16.0%)	
Pain mechanism				
Direct	23 (15.4%)	13 (14.4%)	10 (16.9%)	
Indirect	95 (63.8%)	64 (71.1%)	31 (52.5%)	0.178
Other situation	31 (20.8%)	13 (14.4%)	18 (30.5%)	
Use of medication for shoulder pain				
With prescription	11 (7.4%)	6 (6.7%)	5 (8.5%)	
Without prescription	37 (24.8%)	19 (21.1%)	18 (30.5%)	0.213
Never used	101 (67.8%)	65 (72.2%)	36 (61.0%)	
Pain severity[a]				
No pain	121 (82.3%)	72 (81.8%)	49 (83.1%)	
Light	21 (14.3%)	13 (14.8%)	8 (13.6%)	0.878
Moderate	5 (3.4%)	3 (3.4%)	2 (3.4%)	
Severe	–	–	–	
Physical therapy treatment for pain				
No	143 (96.0%)	87 (96.7%)	56 (94.9%)	0.916
Yes	6 (4.0%)	3 (3.3%)	3 (5.1%)	
Return to sport activities				
No pain	123 (82.6%)	75 (83.3%)	48 (81.4%)	
Without pain	18 (12.1%)	10 (11.1%)	8 (13.6%)	0.866
With pain	8 (5.4%)	5 (5.6%)	3 (5.1%)	
Pain recurrence				
No	75 (50.3%)	48 (53.3%)	27 (45.8%)	0.461
Yes	74 (49.7%)	42 (46.7%)	32 (54.2%)	

[a] Lightweight Severity: sports clearance 1–7 days; moderate severity: clearance 8 to 21 days; severe severity: clearance greater than 21 days.

A comparison between subjects with pain and without pain and among the shoulder function characteristics is shown in Table 5. The subjects with pain had significantly lower values for external rotation of the right shoulder, greater internal rotation deficits, and higher scores in the Quick-DASH. For the other variables, no statistical differences were observed.

Discussion

Our results showed that shoulder pain was a common condition among adolescents, independent of the sport. The prevalence of shoulder pain over the last year and currently was equivalent to 54.2% and 43.5% respectively. Comparisons of these results are limited because, the authors were not aware of any studies that had evaluated shoulder pain in adolescents in terms of different sports that require the use of the upper limb. However, the high values observed were an indication of the need for the development of evaluative and preventive measures for shoulder pain for this population.

The sport of judo (61.8%), followed by handball (48.7%), and basketball (41.4%), presented the highest frequency of complaints of shoulder pain. However, studies that assess the adolescent population and pain have portrayed specific values only for swimming and volleyball.[9,15] Among the athletes who reported shoulder pain, training and competition were most commonly related to the onset of pain

Table 4 Association of independents variables with the presence of shoulder pain in adolescent's athletes of both sexes (n = 310).

Independents variables	Presence of pain	Absence of pain	OR [95% CI]	OR adjusted [95% CI]
Sex				
Female	67 (39.9%)	63 (44.4%)	0.83 [0.53–1.31]	
Male	101 (60.1%)	79 (55.6%)	1	
Age				
10–14 years	77 (45.8%)	86 (60.6%)	1 [1.15–2.86]	1.86 [1.16–2.97]
1–19 years	91 (54.2%)	56 (39.4%)	1.82	
Body mass index				
Normal	122 (72.6%)	105 (73.9%)	1 [0.56–1.55]	
Overweight	46 (27.4%)	37 (26.1%)	0.94	
Modality				
Basketball	27 (16.1%)	31 (21.8%)	0.83 [0.42–1.54]	2.14 [1.06–4.32]
Handball	49 (29.2%)	29 (20.4%)	1.56 [0.85–2.86]	3.07 [1.23–7.65]
Judo	24 (14.3%)	10 (7.0%)	2.21 [0.96–5.11]	
Swimming	17 (10.1%)	25 (17.6%)	0.63 [0.30–1.30]	
Volleyball	51 (30.4%)	47 (33.1%)	1	
Practice time				
Up to 1 year	40 (23.8%)	29 (20.4%)	0.82 [0.48–1.41]	
More than 1 year	128 (76.2%)	113 (79.6%)	1	
Frequency of training (times/week)				
Up to 3	133 (79.2%)	101 (71.1%)	0.65 [0.39–1.09]	
More than 3	35 (20.8%)	41 (28.9%)	1	
Duration of training session (h/day)				
Up to 1 h	27 (16.1%)	22 (15.5%)	0.96 [0.66–1.39]	
More than 1 h	141 (83.9%)	120 (84.5%)	1	

OR: odds ratio; CI: confidence interval.

Table 5 Comparison of shoulder function measures: Quick-DASH, Quick-DASH sports optional, glenohumeral internal rotation deficit and CKCUES-test (median and interquartile range) and external rotation range of motion (mean and standard deviation) between with and without shoulder pain groups ($n = 135$).

Shoulder function measures	Without pain	With pain	p	Statistical test
Quick-DASH score	4.50 (6.80)	11.40 (11.40)	0.001*	*U*
Quick-DASH sports score	0.00 (6.30)	6.25 (18.80)	0.001*	*U*
Internal rotation ROM deficit	7 (8)	10 (7)	0.036*	*U*
Right external rotation ROM	124.50 (14.61)	120.11 (16.85)	0.015*	*t*
Left external rotation ROM	114.64 (14.01)	112.97 (14.63)	0.308	*t*
CKCUES-test score	67.90 (30.10)	69.10 (39.50)	0.482	*U*

* Statistical difference $p < 0.05$.
t: independent *t* test; *U*: Mann–Whitney.
ROM: range of motion.

(68.8%), and an indirect mechanism (overuse injuries) prevailed in 63.8% of cases. This finding corroborated other studies[15,23] who indicated that most sports injuries in adolescents occurred from indirect mechanisms and it is believed that the training load and lack of rest between competitions may have contributed to the high rate of shoulder pain. Most athletes preferred to continue their sports even with pain, and 49.7% of those who stayed in the sport reported that the shoulder pain recurred. Merkel[2] claimed that a rapid return to sport with inadequate rehabilitation might result in pain chronicity, dysfunction, increased sports withdrawal and cases of recurrence.

The age group of 15–19 years was 1.86 times more likely to report shoulder pain in the present study. Tate et al.[9] showed that athletes older than 12 years presented with more complaints of pain and higher levels of dysfunction and shoulder performance dissatisfaction, compared to younger athletes. Spinks and McClure[13] showed that, in general, a higher rate of sports injury in children and adolescents was associated with increasing age.

Athletes between 15 and 19 years of age who were involved in judo (OR = 2.14) or handball (OR = 3.07) were more likely to report shoulder pain. Pocecco et al.[24] indicated that judoka adolescents referred to the shoulder and

arm as the most common sites of injury. The authors indicated that judokas of younger age were more susceptible to injury because they had immature techniques and poor tactical skills. From the point of view of the sport of handball, current studies have revealed a higher occurrence of pain and shoulder injuries in elite adult athletes[14,21]; however, to date, this complaint in young amateur athletes has not been addressed. Considering that pain was found in most athletes and that this had an association with the sport of handball, the importance of the expansion of this research topic is clear.

The present study also found that, for adolescents, the rotation values were lower among athletes with shoulder pain. Recently, several studies have addressed joint changes in young athletes and have stated that bone and soft tissue adaptations impacted negatively on range of shoulder motion, which, in turn, increased the chances of shoulder pathologies.[26–28] Additionally, the present study demonstrated higher internal rotation deficits in adolescents with shoulder pain. This internal rotation deficit, commonly referred to as GIRD (Glenohumeral Internal Rotation Deficit) has been well documented in the literature as an adaptation of the joint to activities in sports, since such sports can lead to capsular stiffness and, consequently, limited range of internal rotation, increasing the risk of pain or chronic shoulder injuries.[24,25,27–30] Guney et al.[26] and Astolfi et al.[27] found that the deficit in internal rotation in adolescent athletes was associated with lower levels of muscular strength, and greater humeral torsion, factors that could influence the emergence of joint pain.

Finally, adolescents with shoulder pain showed lower levels of upper limb function, reflecting negatively on daily activity and sports skills. The claim that shoulder pain has an effect on the performance of routine tasks and the reports of a significant prevalence of shoulder pain among adolescent athletes could raise questions about the assistance that these athletes receive in terms of injury prevention and management. In our sample, 99.4% related that have no medical support in their team. Although athletes specifically were not delineated as part of the population evaluated, Koh et al.[31] claimed that education strategies were able to reduce the prevalence of shoulder and neck pain in adolescents. This finding shows the need for implementing preventative educational methods of identification of and assistance for shoulder pain in schools and sports centers.

The present sample was representative for the areas of the body and sports evaluated, limiting the extrapolation of results to other sports and sample characteristics. Being a cross-sectional study, it was impossible to establish any causal relationship. It was only possible to infer the odds of occurrence. Moreover, it was recognized that the lack of control over the use of drugs at the time of evaluation could affect the results of goniometry and the CKCUES-test. The limitations described might serve as a suggestion for future studies that could be performed longitudinally or to assess the effect of interventions in this population.

Conclusion

Shoulder pain had a high prevalence among the adolescent athletes assessed, especially for older adolescent athletes and for practitioners of the sports of judo and handball. In addition, the presence of pain reduced the scores of upper limb function and the range of external rotation and increased the deficit of shoulder internal rotation for the sample studied.

Conflicts of interest

The authors declare no conflicts of interest.

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