

Original Article (short paper)

Predictors associated with a range of motion of shoulder rotation in competitive high school water polo players: a cross-sectional study

Amanda Gomes de Assis Couto¹ , Júlia Gonzalez Fayão¹ , Felipe de Souza Serenza¹ ,
Anamaria Siriani de Oliveira¹ 

¹Universidade de São Paulo, Faculdade de Medicina de Ribeirão Preto,
Departamento de Ciências da Saúde, Ribeirão Preto, SP, Brasil

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Abstract - Aims: To investigate the factors associated with shoulder rotational range of motion and its correlation with the self-reported function scale and functional assessment of the shoulder (closed kinetic chain upper extremity stability, peak torque of shoulder rotators, glenohumeral internal rotation deficit - GIRD, and pectoralis minor length index) in competitive water polo players. **Methods:** Thirty-four competitive water polo players (age: 15 +/- 1.6 years) participated in this study. The shoulder rotational range of motion, closed kinetic chain upper extremity stability, pectoralis minor length index, isokinetic torque of shoulder internal and external rotations, and self-reported upper limb function were assessed. The Pearson correlation coefficient was used to test the linear correlation before the multiple linear regressions, that were used to predict the variables associated with the external rotation and internal rotation range of motion ratio (ER/IR ratio) of the throwing limb. **Results:** A significant association was identified between the throwing limb ER/IR ratio and GIRD, and this observation allows us to infer that GIRD was responsible for 18.4% ($p=0.01$) of the variation. No associations between ER/IR ratio and the variables closed kinetic chain upper extremity stability, peak torque of shoulder internal rotation, and pectoralis minor length index were identified. **Conclusion:** Anatomical GIRD was the only factor associated with the ER/IR ratio in asymptomatic competitive water polo players from high school, indicating the beginning of the typical adaptations to increase performance without significantly altering the self-perception and functionality of their upper limbs.

Keywords: athletes; range of motion; shoulder joint; swimming.

Introduction

The body part most affected by injuries in competitive water polo players is the shoulder¹⁻³, due to the nature of the sporting movement that involves swimming, throwing, and defending. The leading cause of these injuries is shoulder overuse³. Other possible causes are the loss of the glenohumeral internal rotation range of motion (IR ROM) and increased glenohumeral external rotation (ER ROM)⁴, previous history of pain⁵, and muscle weakness of the external rotators of the shoulder^{6,7}.

Glenohumeral internal rotation deficit (GIRD) is defined as a condition where there is a loss in the degree of shoulder IR ROM of the throwing limb, compared with the non-throwing limb⁸. Anatomical GIRD is a loss of internal rotation with deficits in the total rotation motion of the glenohumeral joint that does not exceed five degrees⁹⁻¹¹. It can be considered an expected variation in IR ROM and is usually observed in asymptomatic overhead athletes. Pathologic GIRD is a significant loss of internal rotation ($\leq 18^\circ$) with deficits in the total rotation motion exceeding five degrees⁹. The literature shows evidence that GIRD is associated with decreased external rotators shoulder strength, functional deficits, and a higher risk of shoulder injury in young baseball and volleyball players¹⁰⁻¹².

Swimming athletes have a decreased IR ROM; however, that deficit occurs bilaterally^{5,13,14}. The GIRD values in these athletes are lower when compared to other modalities of overhead athletes¹⁵. In water polo, few studies have shown that GIRD is typical in this athlete population³. However, there is no significant correlation with pain/injuries¹⁶.

Decreased IR ROM, shortening of the pectoralis minor muscle, and scapular muscle weakness can lead to scapular dyskinesia. As a consequence, a cascade of biomechanical changes in the shoulder of overhead athletes were observed¹⁷⁻¹⁹. The shortening of the pectoralis minor can change the glenohumeral arthrokinetic, favoring the impact of the rotator cuff, and consequent shoulder joint pain²⁰.

Altered scapular positioning, shortening of the pectoralis minor muscle, and increase of ER ROM can lead the rotator cuff muscles to a mechanical disadvantage; thus, the shoulder loses a dynamic joint stabilizer^{21,22}. In swimming, studies show that athletes with instability have shoulder rotator weakness²³ by evaluating the external and internal glenohumeral rotators in different injury conditions. However, concerning upper labrum injuries and impingement syndrome, athletes have changes in the isokinetic torque of the internal rotators but have no significant imbalance in the rotator cuff muscle strength^{23,24}.

Studies have been conducted relating the GIRD to clinical shoulder assessments such as range of motion and muscle strength in baseball athletes. However, few studies have evaluated the effect that decreased IR ROM has on shoulder function in competitive water sports athletes^{13,15}. Consequently, there are no studies in the literature to explain whether the decrease in IR ROM is related to GIRD, strength assessment, functional test Closed Kinetic Chain Upper Extremity Stability (CKCUES)²⁵⁻²⁷, and self-perception of function in these athletes²⁸. This relationship is essential to understand better how much the loss of IR ROM hinders the overall performance of the athletes from their self-perception and functionality of their upper limbs.

Therefore, the present study aimed to investigate the factors associated with shoulder rotational range of motion and its correlation with the self-perception of shoulder function and objective findings from the physical examination of the shoulder (CKCUES, peak torque of shoulder rotators, GIRD, and pectoralis minor length index) in competitive high school water polo players. The secondary aim was to compare the shoulder IR ROM, ER ROM, and total rotation motion between the throwing and non-throwing upper limbs.

We hypothesized that those functional factors, like pectoralis minor length and peak torque, would explain the shoulder rotational range of motion, measured with a goniometer, in competitive high school water polo players. A secondary hypothesis was that the scores on self-reported function scales and functional testing would be correlated with shoulder rotational range of motion.

Materials and Methods

Participants

This study used a cross-sectional design and followed the recommendations of the Strengthening the Reporting of Observational Studies in Epidemiology²⁹. The local Research Ethics Committee, the protocol number (12195/2015), approved the study.

In the present study, athletes were recruited by convenience from a competitive high school water polo team. On average, the athletes had trained five times a week, three hours per day, for two consecutive years, and had participated in competitions at the national, state, or regional levels. In order to be included, the athletes had to be between 12 and 18 years old.

Thirty-six competitive high school water polo players were consecutively enrolled; one player was excluded because he had not trained in water polo for at least two consecutive years. Another player was excluded because their undue data influence the regression model (Cook's distance and standardized DFBETA values were > 1). Therefore, 34 competitive high school water polo players (31 boys, three girls; age = 15.0 ± 1.6 years, height = 174.0 ± 7.2 cm, body mass index (BMI) = 22.89 ± 2.68 kg/m²) without shoulder pain at the moment of assessment participated in the study. The dominant shoulder

was defined as that of the hand used for throwing; 32 athletes identified themselves as right-handed and two as left-handed. The water polo players evaluated in the present study reported swimming an average of 2,000 - 5,000 m per day, generally 5 to 7 days per week, and up to one hour during matches. They reported training in throwing skills for water polo at least five times a week for one hour a day.

All participants signed informed consent forms. Additionally, the consent of guardians/parents (for athletes under 18 years old) was obtained before proceeding with the study.

The exclusion criteria were a history of traumatic injuries to the trunk, elbow, or hand; a history of posterior luxation of the shoulder or osteoarthritis in the glenohumeral or acromioclavicular joints; and positive findings in the epicondylitis, Jerk, and Phalen's tests. Participants with symptoms of posterior glenohumeral instability, epicondylitis, and carpal tunnel syndrome were excluded since the CKCUES could be irritating for these participants. The inclusion and exclusion criteria were evaluated by clinical history and clinical assessments conducted by an experienced physical therapist. The evaluation of the criteria was performed before carrying out the experimental procedures.

Data Collection

All the evaluations were performed before training sessions and at least 12 hours after the last training session. The range of motion measures of glenohumeral joint rotation was performed with a goniometer. The functional assessment included the pectoralis minor length index, shoulder internal-external rotator isokinetic peak torques, CKCUES, and Athletic Shoulder Outcome Rating Scale (ASORS). The assessment sequence was drawn at random from among the goniometric measurements, CKCUES, pectoralis minor length measurement, and assessment of self-reported shoulder function. Assessment with the isokinetic dynamometer was scheduled for a day other than the first assessment day to make sure that the accumulated fatigue due to the set of torque tests would not interfere with the functional assessment. All the athletes ($n=34$) who agreed to participate in the study completed assessments over the two proposed days (the evaluation on the isokinetic dynamometer was performed in isolation on the second day).

Range of motion

A trained examiner blinded to the data from the clinical history and general physical examination of the participants performed the range of motion measures of glenohumeral joint rotational motion with a plastic baseline goniometer marked in increments of 2°. The measurement of shoulder range of motion with a goniometer is valid, reliable (Intraclass Correlation Coefficient - ICC = 0.85 to 0.99), and has acceptable absolute reliability for internal and external rotation of the glenohumeral joint^{30,31}. The literature has shown that the inter-rater reliability of measurements with the goniometer increases with scapular and trunk stabilization³². Therefore, it is recommended that the

measurements be performed in the supine position to ensure stabilization^{31,32}. The minimum detectable change is 8.03° for external shoulder rotation and 4.93° for internal shoulder rotation³¹.

Accordingly, participants were placed in a supine position with the shoulder at 90° of lateral abduction, and the elbow kept at 90° of flexion to ensure scapula and trunk stabilization^{31,32}. Subsequently, measurements of glenohumeral joint rotational motion were performed in the coronal plane. A small rolled-up towel was used to stabilize the humerus. Stabilization of the scapula was achieved by grasping the coracoid process posteriorly with the thumb and grasping the spine of the scapula caudally with the other four fingers of the hand³². The goniometer was positioned with the stable arm perpendicular to the floor, the fulcrum placed at the olecranon, and the moving arm placed along the forearm with the *processus styloideus* ulna as a reference point and following the rotational movements. Passive internal and external rotation movements of the glenohumeral joint were performed, and three measures of range of motion were taken^{31,32}.

The passive movement was carried out until firm end-feel was achieved for both internal and external shoulder rotation, considered as the tension in the soft tissues surrounding the glenohumeral joint. For internal rotation, firm end-feel occurred after the examiner felt the participant's coracoid process passing through the examiner's thumb while being careful to avoid scapular compensations, such as scapula protraction or an anterior tilt. For external rotation, the firm end-feel occurred after the examiner felt that the spine of the participant's scapula began to move away from the examiner's fingers, while being careful to avoid scapular compensations, such as scapula retraction or posterior tilt³³.

The average of three measures and the standard deviations of the range of motion measures were calculated for the throwing and non-throwing shoulders. The total rotational motion of the glenohumeral joint was calculated as the sum of the ER ROM average and IR ROM average ($ER + IR$)³⁴. The ratio between the external and internal rotations (ER/IR ratio) was calculated by dividing the ER ROM by the IR ROM. The outcome variables of interest were the means of IR ROM, ER ROM, total rotational motion, and ER/IR ratio.

Pectoralis minor length index (IPM)

A trained and experienced examiner blinded to the data from the clinical history and general physical examination of the participants performed measures of the IPM³⁵. The measure of the pectoralis minor muscle length was taken between two points of anatomical reference, the coracoid process, and the fourth rib. This method has been validated and has presented good measurement accuracy when comparing measurements taken by physicians and those performed by electromagnetic motion capture systems ($ICC > 0.90$)³⁵. Participants were placed in a sitting position, and two anatomical locations were marked: the medial-inferior aspect of the coracoid process and one finger width lateral to the sternum of the anterior-inferior edge of the fourth rib³⁴. Participants were then instructed to maintain a

relaxed posture, and three measures of pectoralis minor muscle length were taken with a standard tape measure, always starting with the non-throwing side³⁵.

The measurement of the pectoralis minor muscle length at rest was normalized by participant height to determine the relative length of the muscle. The outcome variable of interest was the IPM, which was calculated by dividing the value of the resting muscle length by participant height, both in centimeters and then by multiplying it by 100 ($[IPM/participant\ height] * 100$)³⁵

Isokinetic assessment of muscular strength around the shoulder

A trained and experienced examiner blind to the data from the clinical history and general physical examination of the participants performed measures of muscle strength. The isokinetic peak torque was evaluated during the internal rotation of the glenohumeral joint using an isokinetic dynamometer, Biodex Multi-Joint System 4 Pro (Biodex Medical Systems Inc., Shirley, New York, United States). Peak torque measurements are considered reliable when performed in a sitting position and with the Biodex® isokinetic dynamometer. These measurements have shown high ICC values, ranging from 0.87 to 0.97³⁶.

Before starting tests with the isokinetic dynamometer, participants performed warm-up exercises (a series of 15 active, free movements of flexion-extension, adduction-abduction, and circumduction of the shoulder) for 10 minutes. The participants remained in a sitting position (dynamometer chair positioned at 90°) with 90° shoulder abduction in the coronal plane, and the elbow flexed to 90°; the olecranon was aligned with the rotational machine axis of the dynamometer. Velcro belts were placed transversely across the chest and horizontally at the pelvis to stabilize the trunk in the seat.

Correction for gravity was performed with the arm relaxed at 90° shoulder abduction, 90° elbow flexion, and neutral shoulder rotation. Correction performed at this position generates the highest rotation moment³⁷. Early in the evaluation, the participants performed three repetitions of external rotation and internal to familiarize themselves with the equipment and for a better understanding of how to perform the test. During the evaluation, five repetitions were performed in a 90° range of motion in a concentric mode at an angular speed of 60°/s, beginning with the dominant arm and with one-minute rest between throwing shoulder and non-throwing shoulder assessment. Participants received standard verbal encouragement to achieve maximum strength and to maintain it during the repetitions³⁷.

The peak torque data for the shoulder internal rotation was obtained using the Biodex® software. The isokinetic peak torque was determined from the interval in which the target speed remained constant. After the peak torque determination, it was normalized by participant body mass, yielding the peak torque variable normalized by body mass (NmKg-1100), which was considered as the outcome variable of interest³⁷.

Closed Kinetic Chain Upper Extremity Stability (CKCUES)

The CKCUES is a reliable and valid performance test that provides quantitative data for an upper limb task in the closed kinetic chain³⁸. The test consists of counting the number of times the participants can touch the contralateral supporting hand with their swinging hand, in a push-up position, in 15 seconds. It presents high values of ICC, 0.92 to 0.96, along with excellent inter- and intrasession reliability for all test scores for young and active populations of both sexes²⁵.

Two examiners conducted the CKCUES test. The first examiner counted the number of touches performed by the participants. The second examiner was responsible for checking the digital stopwatch and for verbally informing the first examiner and the participant of the time to start and finish the test. Only the first examiner was blind to the data from the clinical history and general physical examination of the participants. Men performed the CKCUES by assuming a push-up position, and women performed the test by assuming a kneeling push-up position. The participants were advised to keep the back flat and parallel to the floor, with a distance of 90 cm between the hands. Moreover, they were instructed to support their body weight on the upper limbs and hands, which were positioned perpendicular to the floor. During the 15-second test time, the participants were instructed to move one of the hands and touch the back of the contralateral hand that was on the floor, and return to the starting position, alternating between hands as quickly as possible²⁵. Participants performed three repetitions of the test, with an interval of 45 seconds between each repetition.

The CKCUES provides the number of touches that the participant performs during each repetition of 15 seconds. Subsequently, the outcome variables of interest are calculated: a score for the number of touches. The score for the number of touches is obtained by calculating the simple average of the number of touches of the three repetitions $([R1+R2+R3]/3)$ ²⁵.

Athletic Shoulder Outcome Rating Scale (ASORS)

The cross-culturally adapted version²⁸ of the ASORS was used. The scale was applied via an interview as recommended by the local version of the scale. The scale was applied after the clinical history evaluation and physical examination; therefore, the interviewer was not blinded to the participant's clinical data.

The ASORS is a reliable scale; it has moderate to strong values for inter- and intrasession reliability (ICC = 0.48 to 0.88)²⁸. The scale consists of six questions on the shoulder functionality of competitive athletes, divided into two parameters, subjective and objective. The subjective parameters are divided into five categories: 1) pain, 2) strength/endurance, 3) stability, 4) intensity, and 5) sports performance. The objective parameters consist of goniometric measurements of ER ROM and forward flexion range of motion. The

categories of pain, strength/endurance, stability, intensity, and range of motion can be scored 0-10 points, where zero is the lowest score, and 10 is the highest score. However, the sports performance category can be scored at 0-50 points, where zero is the lowest score, and 50 is the highest score achieved. The total score of the scale was calculated by adding the scores from each category. The total score can range from 0 points, indicating weak results, to 100 points, indicating excellent results²⁸.

Statistical analysis

The Shapiro-Wilk test was used to determine the normal distribution of the data. The exploratory analysis showed that the inclusion of the three women did not add heterogeneity to the distribution of the observations. Descriptive statistics (means and standard deviations) and the paired t-test was used to compare the IR ROM, ER ROM, total rotation motion (TROM), RE/RI ratio, peak torque of internal rotation, and peak torque of external rotation between the throwing and non-throwing upper limbs. Pathologic GIRD was identified in athletes presenting an internal rotation deficit greater than 18° and a total rotation motion difference of more than five degrees between the shoulders⁹.

Multiple linear regression analysis was used to model the relationship among the ER/IR ratio of the throwing limb (dependent variable or output) and the independent variables: GIRD, CKCUES, IPM, ASORS, and peak torque of internal rotation of the throwing limb (predictors).

First, Pearson's correlation coefficients were used to determine the relationship. The results of this correlation analysis are presented as Pearson product-moment correlation coefficients (r), and the magnitude of the correlations was classified as high ($r > 0.70$), moderate ($r > 0.40$, and < 0.70), and low ($r < 0.40$)³⁹.

Second, the forward regression method was applied when the predictor ER/IR ratio was entered into the linear regression model; the forced entrance method was applied with the other predictors. The results of the regression analysis are presented in B values, standard error of B, β coefficient, and variations of R^2 . Analysis of regression standardized residuals demonstrated that if the errors or residuals of the linear regression equation did not follow a homogeneous (normal) distribution, it would not be able to establish an association between the TROM, IPM, and peak torque of internal rotation. Since a non-homogeneous distribution indicates that the variables are not related linearly, it would be impossible to use a linear regression model for these data. Nevertheless, the analysis of regression standardized residuals demonstrated that the residuals followed an approximately normal distribution, presenting a curve close to the standard normal curve, providing evidence that the data fit in with the linear regression model used for data analysis. An alpha level of 0.05 was used to determine the statistical significance for all tests. Statistical Package for the Social Sciences version 22 for Windows (SPSS IBM, New York, United States) was used for all statistical analyses.

Results

Comparisons of the IR ROM, ER ROM, TROM, ER/IR ratio, and internal and external rotation peak torque between the throwing and non-throwing upper limbs are presented in Table 1. There was evidence of statistical difference ($p < 0.05$) in both internal rotation and external range of motion, ER/IR ratio, and peak torque of external rotation between the non-throwing and throwing shoulders. The ER ROM was greater ($p < 0.05$) in the throwing shoulder when compared to the non-throwing shoulder. The mean difference value between the non-throwing and throwing IR ROM shows deficits. However, it did not fit into the definition of pathological GIRD as the mean of the TROM was not less than five degrees. The ER/IR ratio was significantly higher in the throwing shoulder, thereby demonstrating a higher

proportion of external rotation compared to internal rotation, and also the external rotation peak torque was significantly higher in the throwing shoulder.

Pearson's Correlation Coefficients analysis found weak correlations³⁹ among the ER/IR ratio and GIRD ($r = 0.429$; $p < 0.01$) and ER/IR ratio and peak torque of shoulder internal rotation ($r = 0.324$; $p = 0.03$), displayed in Table 2.

Multiple linear regression analysis found a significant association between the throwing ER/IR ratio and GIRD. We found that GIRD was responsible for 18.4% of the variation ($r^2 = 0.184$; $p = 0.01$) in the ER/IR ratio, displayed in table 3. The analysis resulted in a statistically significant model in which the ER/IR ratio = $1.8 + 0.02 \times (\text{GIRD})$. Also, there was no association between the ER/IR ratio and the CKCUES performance, peak torque of internal shoulder rotation, ASORS, and IPM.

Table 1 - Non-throwing shoulder and throwing comparisons [mean and (standard deviation)] (n=34).

	Non-throwing shoulder	Throwing shoulder	Mean difference	95% confidence interval of the difference
Internal rotation 90°	56.9° (±9)	45.7° (±10)	11.18*	[7.59 14.78]
External rotation 90°	83.7° (±6)	92.5° (±5)	-8.84*	[-10.65 -6.71]
Total rotational motion	140.6° (±9)	138.3° (±10)	2.34	[-1.59 6.64]
ER/IR ratio	1.5 (±0.3)	2.1 (±0.5)	-0.62*	[-0.80 -0.45]
Internal rotation peak torque	60.0 kgf (±14.8)	60.7 kgf (±13.6)	-0.68	[-3.54 2.18]
External rotation peak torque	41.0 kgf (±8.7)	45.9 kgf (±9.1)	-3.93*	[-5.54 -2.32]

* $p < 0.05$

Table 2 - ER/IR ratio Pearson's correlation coefficients [r(p)] (n = 34).

	RE/RI ratio
GIRD	0.43(0.01)*
Internal rotation peak torque	0.32(0.03)*
IPM	-0.02(0.44)
CKCUES	0.22(0.11)
ASORS	0.06(0.37)

GIRD = Glenohumeral internal rotation deficit; IPM = Pectoralis minor length index; CKCUES = Closed Kinetic Chain Upper Extremity Stability; ASORS = Athletic Shoulder Outcome Rating Scale. * $p < 0.05$

Table 3 - Regression analysis (n = 34).

	R ²	B	SE	β	95% CI
GIRD	0.18	0.02	0.00	0.43*	[0.00 0.03]

* $p < 0.05$. R²: standardized coefficient of determination. B: unstandardized coefficient of the linear regression model. SE: standard error of B. β: standardized coefficient of the linear regression model. 95% CI: 95% confidence interval for β.

Discussion

The only variable analyzed related to the ER/IR ratio was the GIRD. Besides, GIRD explains 18.4% of the ER/IR ratio variation. The sample of our study was composed of asymptomatic high school water polo players who demonstrated decreased IR ROM and increased ER ROM in the throwing shoulder compared with the contralateral side. However, the reduction in the IR ROM observed in our sample did not fit in the definition of pathological GIRD as the mean difference between the sides in the total rotation motion was less than five degrees.

The imbalance between the ER/IR ratio is found in athletes of various sports, whereas the presence of GIRD depends on the asymmetry between the throwing shoulder and the non-throwing shoulder. The shoulder of swimmers may suffer anatomical changes related to sports movements, such as decreased internal rotation. However, GIRD, as it is classically proposed, is not suitable for bilateral overload sports. The purpose of using the ER/IR ratio was precisely to take into account the changes in each shoulder.

The IR ROM values found in the sample of the present study were lower than those found in the baseball players¹⁰. However, a statistically significant difference was found between the IR ROM values for the throwing shoulder compared to the non-throwing shoulder, showing that even though on a smaller scale, the IR ROM deficit was present. Additionally, the value of difference was greater than the least detectable change. This is probably since besides swimming, water polo athletes present throwing with part of the sports movement, and such movement is performed primarily by the dominant limb.

A previous study with baseball athletes indicated that the quality of life and functionality of the shoulder in these athletes had a relationship with the range of motion only when the values of GIRD were higher than 20°⁴⁰. According to Manske et al.⁹, athletes with anatomical GIRD have a normal adaptation that should be expected. As these motions require an increase of the ER ROM and a consequent laxity of the anterior glenohumeral ligament, the athletes would not have the ability to perform overhead sports motions without the shoulder rotational range of motion adaptation. Consequently, this adaptation allows the performance of high-speed movements of the arm, such as throwing and swimming. This observation should be considered when the range of motion of the shoulder is assessed in young and asymptomatic athletes. However, regarding pubertal status, the literature shows that the presence of GIRD is lower in the age group studied in our sample⁴¹, probably due to the relatively short time of exposure to found relevant bone changes such as retroversion of the humeral head⁴². Therefore, the fact that our sample is composed of young asymptomatic players could explain our findings of non-association between the ER/IR ratio and scores of the ASORS and the CKCUES.

The presence of muscle imbalances is common in several overhead sports. In volleyball, Lira et al.⁴³ found an increase in the strength of the internal rotation on the dominant limb, with no differences for the external rotation⁴³. This can be explained by the movement performed in the attack, which requires proper power generation and is performed only on the dominant limb⁴².

In overhead sports, in which the sportive movements favor technique over strength, as in basketball and synchronized swimming, studies do not show significant differences in the strength of the internal rotation and external.

Decreases in shoulder IR ROM may be related to strength in overhead athletes. A previous study demonstrated that the presence of GIRD decreases the ER/IR strength ratio, that is, the decrease by external rotation to the detriment of internal rotation¹². However, similar to the results of the present study, in athletes without the presence of the GIRD, these changes were not detected. Regarding water polo, a study found a strong correlation between pitch speed and performance during swimming⁴⁴. This reinforces the importance of constant assessment in general expenses since imbalances can affect performance and predispose injuries to the shoulder joint.

The limitations of the present study include the limited sample size of asymptomatic athletes. For this reason, caution is needed in extrapolating the data from the present study to the general population of water polo athletes or those complaining of shoulder pain. Future studies should assess symptomatic athletes and observe how a change in the ER/IR ratio presents itself in the population of symptomatic water polo athletes.

Conclusion

The present study showed that ER/IR ratio was associated with the anatomical GIRD and no associated with functional variables of the shoulder. Therefore asymptomatic competitive high school water polo players had a loss of internal rotation range of motion in throwing limb, indicating the beginning of the typical adaptations to increase performance without significantly altering the self-perception and functionality of their upper limbs.

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Corresponding author

Anamaria Siriani de Oliveira
 Universidade de São Paulo, Faculdade de Medicina de Ribeirão Preto, Departamento de Ciências da Saúde. R. Miguel Covian, 120 - Campus da Usp, Ribeirão Preto - SP, 14049-900. Telephone: +55 (16) 3315-4413
 E-mail: siriani@fmrp.usp.br

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