



Alterations in strength of the shoulder rotators in young elite swimmers

Alteração da força dos rotadores do ombro em jovens nadadores de elite

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Abstract

Introduction: Shoulder muscle strength imbalance is considered a risk factor for shoulder injuries in athletes, especially in sports involving arm movements above the head. **Objective:** To assess the strength of the external rotators (ER) and internal rotators (IR) of the shoulder in elite swimmers, to determine possible differences between the dominant and non-dominant limbs, and to calculate the shoulder IR/ER ratio. **Methods:** Fifteen athletes participated in the study from age 20 ± 2 years, mass of 76 ± 4 kg, stature of 1.83 ± 4 cm, and BMI of 22 ± 1 kg/m². Duration of practice of 10.74 ± 4.03 years; training frequency 5.95 ± 0.22 days/week, 2.07 ± 0.41 hours/day; and weekly number of meters swum 34.905. An isometric dynamometer (Globus Ergo System®, Codognè, Italy) was used to assess ER and IR strength. Data were analyzed using descriptive statistics (mean and standard deviation), paired-sample t-test, Pearson's correlation coefficient and the Statistical Package for Social Sciences software (SPSS), version 16.0. **Results:** IR and ER strength

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was lower in the left than in the right shoulder of the swimmers ($p < 0.05$). Additionally, ER strength ratio was higher than IR strength ratio ($p < 0.05$). **Conclusion:** The results showed that the swimmers had an alteration of the shoulder ER/IR ratio, especially in the dominant limb.

Keywords: Muscle Strength. Rotator Cuff. Swimming.

Resumo

Introdução: O desequilíbrio da força da musculatura do ombro é considerado um fator de risco para algumas lesões no ombro dos atletas, especialmente em esportes que envolvem movimentos acima do nível da cabeça. **Objetivo:** Avaliar a força da musculatura rotadora externa (RE) e rotadora interna (RI) do ombro em nadadores de elite, verificar possíveis diferenças entre o membro dominante e o não-dominante e determinar a relação RE/RI de ombro. **Métodos:** Participaram 15 atletas (idade: 20 ± 2 anos, peso: 76 ± 4 kg, estatura: $1,83 \pm 4$ cm, IMC: 22 ± 1 kg/m²), tempo de prática de $10,74 \pm 4,03$ anos, frequência de treino/semana = $5,95 \pm 0,22$ vezes, horas/dia = $2,07 \pm 0,41$ hs e metragem semanal = 34.905 m. Para avaliar a força dos RE e RI foi utilizado um dinamômetro isométrico (Globus Ergo System®, Globus Itália). Os dados foram analisados através da estatística descritiva (média e desvio padrão), pelo Teste t para amostras pareadas e pela Correlação de Pearson (r), por meio do programa pelo programa SPSS versão 16.0. **Resultados:** Em relação à força dos rotadores, os nadadores apresentaram uma força menor nos RI e RE do ombro esquerdo quando comparado ao ombro direito ($p < 0,05$). A relação dos RE foi maior que a relação da força dos RI ($p < 0,05$). **Conclusão:** Os resultados revelaram que os nadadores apresentaram uma alteração da relação RE/RI, principalmente no membro dominante.

Palavras-chave: Força Muscular. Manguito Rotador. Natação

Introduction

The shoulder internal and external rotator (IR/ER) muscles play an important stabilizing and mobility role in the glenohumeral joint, especially in athletes who perform overhead motions (1, 2).

Competitive swimming is one of the most popular participation sports in the United States and participation has been growing around the world (3). However, as in any performance-based sport, injuries can happen to the athlete.

Competitive swimmers usually have overuse injuries, especially in the shoulders (4, 5). Studies have shown that 38% to 75% of high-performance swimmers have already had at least one episode of shoulder pain that forced them to abandon training or a competition (6, 7, 8). Most of these injuries is associated with the athlete's shoulder IR or ER muscles, as they cover the glenohumeral joint, afford an important protection to this joint, and help improve the performance of high-performance swimmers (1). However, biomechanical

changes caused by muscle strength imbalance between shoulder internal and external rotators may lead to an increased incidence of injuries to the shoulder of athletes (1, 9).

The ER/IR ratio has been the subject of several studies in various sports. Over the years a change in what are considered to be "ideal" values for an optimal balance of the glenohumeral joint has been discussed. Studies conducted in the 1980s and 1990s considered a ER/IR ratio of 66% to be ideal so that the rotator cuff muscles could balance the glenohumeral joint, thus promoting an increase in the subacromial space (7, 10, 11). These values have currently changed. According to some authors, the ideal balance would only be achieved after reaching a ER/IR ratio between 66% and 75% (12, 13). In addition, a difference of up to 10% of maximum strength between limbs would be deemed "acceptable" or "normal" (14).

Even though very similar movements are produced in both sides of the body during swimming, some changes and imbalances can be found (15, 16). These can

cause the athlete not to reach the desired performance level or may represent risk factors for musculoskeletal injuries. However, to our knowledge, there are no normative data for young adult swimmers, only one study that has assessed isokinetic strength in pubescent swimmers. Since there seems to exist a relationship between low levels of unilateral shoulder proportions and potential injuries, and there are no normative data for young adult swimmers, the aim of this study was to assess the isometric performance of the shoulder ER and IR muscles, comparing the right and the left sides, and to identify the shoulder ER/IR ratio in high-performance swimmers. In Brazil, there are very few published studies on certain issues related to competitive swimming. Thus, further studies are warranted.

Methods

This descriptive, cross-sectional study was conducted in the second half of 2010 with the elite swimming team of the University of Ribeirão Preto (UNAERP), SP, Brazil. We randomly selected 15 of the 20 athletes of the UNAERP team. Inclusion criteria were: voluntary participation in the study, male gender, no musculoskeletal injury, having the necessary performance level to participate in the Brazilian Swimming Championship (being, thus, considered an elite athlete). All athletes agreed to participate in the study on a voluntary basis. The research project was approved by the Ethics Committee for Research with Human Beings of the University of Ribeirão Preto (UNAERP) - protocol number 066/2010. All participants signed an informed consent, according to Resolution 196/96 of the National Health Council. Volunteers were informed that they were free to participate or not in the study and to leave the study at any time.

After signing the consent form, the athletes were taken to a room where they were to be anthropometrically assessed. In each individual, a thorough assessment was made in the morning before swimming training. Next, the participants were instructed about the assessment of the shoulder ER and IR muscles using an isometric dynamometer (*Globus Ergo System*[®] - Codognè, Italy) (17).

Body mass was measured to the nearest 0.1 kg using a portable digital scale (Filizola[®], Sao Paulo, Brazil) with a maximum capacity of 150 kg. Height was measured once with an inelastic tape. Body Mass Index (BMI) was determined as body weight divided by height squared (kg/m^2) (18).

The maximal isometric strength of the shoulder rotators was measured using an isometric dynamometer (*Globus Ergo System*[®] - Codognè, Italy). In some studies, such as the one conducted by Leite and Nonaka (19), investigated the effects of flexibility training on muscle strength in 25 male volunteers using a dynamometer of this type. Sousa et al. (20) have also assessed the muscle strength of shoulder flexors using the aforementioned dynamometer. All athletes were instructed about their positioning during assessment (position and height of the torque wrench, position and height of the seat, lever arm length) and about the test values (isometric torque of the ER and IR muscles of both shoulders).

Prior to testing, participants performed a warm-up consisting of active arm movements, followed by stretching exercises for the shoulder muscles. After warm-up, participants were positioned in the dynamometer and asked to remain seated with their back against the chair and the contralateral upper limb resting on their chest, in order to avoid compensatory movements of the trunk during the test. Participants were also asked to keep both of their legs suspended to avoid compensatory movements during the tests (21).

The shoulder was elevated to 30° in the scapular plane and kept in neutral rotation, with the elbow flexed to 90° and the forearm in neutral position. After positioning of the subject, we checked the alignment of the mechanical and anatomical axes. The upper arm and forearm were attached to the resistance arm using the stabilizing device. Participants were also told to firmly hold the device handle during testing (21).

After the tests, the assessor passively demonstrated the direction of the movement required for the assessment.

Two submaximal isometric contractions served to familiarize the subjects with the test procedure. After this adjustment phase, the gravity correction value was determined by asking the participant to relax the limb attached to the resistance arm and recording the torque created by the weight of the limb. After the gravity correction value was recorded, the digital display was reset to zero and the test was started. During the test, subjects performed three maximal isometric efforts of 5 seconds and the peak of each contraction was recorded (Nm). There was a 10-second rest interval between each effort. During the procedure, participants were verbally guided using commands such as "attention", "contract", "strength, strength, strength", "relax".

The normality of the distribution was tested using the Shapiro-Wilk normality test. Data were analyzed

using descriptive statistics (mean and standard deviation), the t test for paired samples and Pearson's correlation coefficient (which analyzed the correlation between internal and external rotator muscles strength in the right and left shoulders of the swimmers). Participants were also asked about their handedness. Data were analyzed using the Statistical Package for Social Sciences software (SPSS) version 16.0 for Windows. The significance level was set at $p < 0.05$. An external-to-internal rotator muscles strength (ER/IR) ratio > 0.66 was considered adequate.

Results

Sample characteristics are shown in Table 1. Of note, all athletes met the inclusion criteria and were in the age group 18 - 25 years, the predominant age group of elite athletes.

Table 1 - Characteristics of the study participants (n = 15)

Age (years)	20.5 ± 2.47
Body mass (kg)	76.6 ± 4.75
Height (cm)	183.1 ± 4.92
BMI (kg/m ²)	22.80 ± 1.10
Duration of practice (in years)	8.2 ± 1.2

Figure 1 illustrates the graph representation of the shoulder IR strength in the swimmers. IR strength was lower in the left shoulder when compared to the right shoulder, but no significant difference was found. The difference between limbs was also within normal limits (up to 10%). All athletes were right-handed.

Our results have shown an average difference of 3% between shoulder internal rotators. Analyzing only these data, we might conclude that swimming is a sport of symmetrical proportions, in which the propulsion movement performed by both arms promotes an almost perfect muscle balance, which would prevent many injuries.

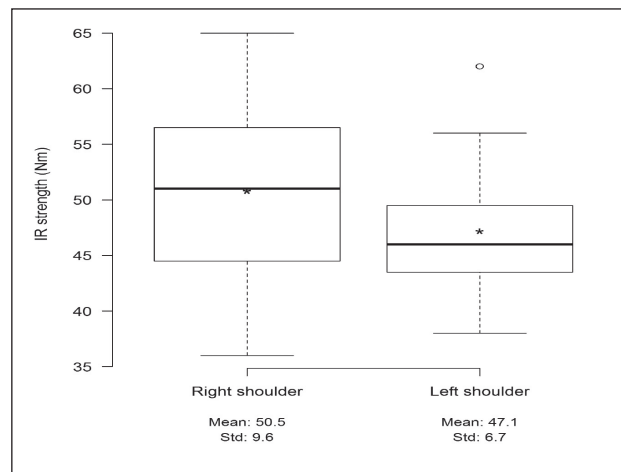


Figure 1 - Comparison between right and left shoulder IR strength in swimmers.

Figure 2 illustrates the graph representation of the shoulder ER strength in the swimmers. ER strength was lower in the right shoulder when compared to the left shoulder, but no significant difference was found.

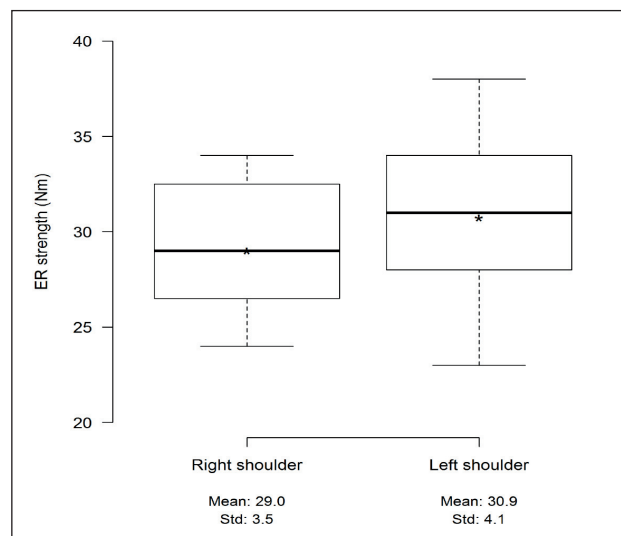


Figure 2 - Comparison between right and left shoulder ER strength in swimmers.

Figure 3 illustrates the graph representation of the right and left shoulder ER/IR strength ratio. We found that the swimmers had a lower ER/IR strength ratio in the right shoulder. Although the difference between limbs was within the normal range (10%), it caused a significant difference when compared to the left shoulder.

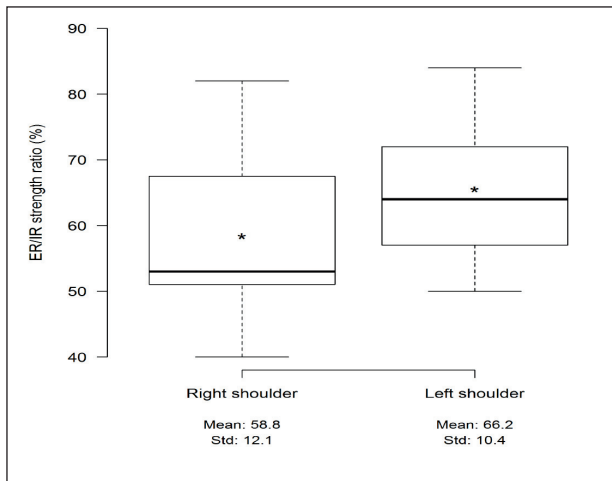


Figure 3 - Comparison between right and left shoulder ER/IR strength ratio in swimmers (* $p < 0.05$).

Finally, Figure 4 shows a dispersion diagram of the ER/IR ratio in the swimmers.

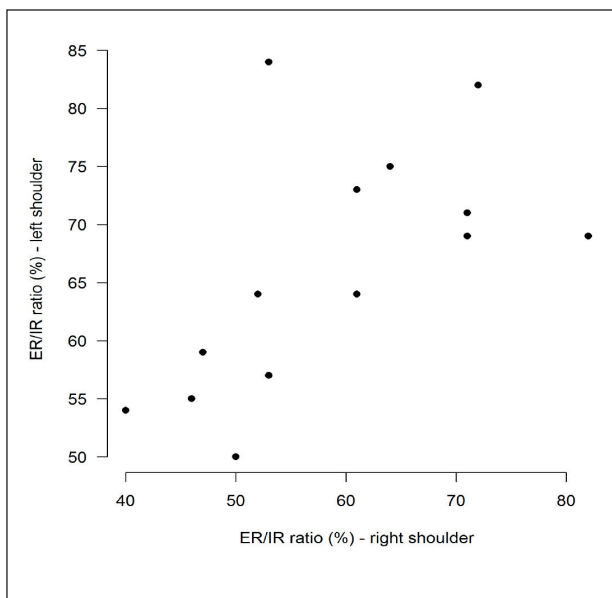


Figure 4 - Dispersion diagram of the right and left shoulder ER/IR ratio in the swimmers ($r = 0.62$; $p < 0.05$).

Discussion

Muscle balance assessment is used in several studies, both in the field of sports (22 - 25) and in the field of health in general (26 - 28). This shows the high reliability and applicability of the tests used. We found that swimmers had lower internal and external rotator strength values in the left shoulder compared to the

right shoulder, and the ER strength ratio was higher than the IR strength ratio.

According to the isokinetic test for the lower limbs, the assessment of a limb in relation to its contralateral homologue forms the basis for the interpretation of standard data. This assessment of the upper extremities is more complicated due to limb dominance, particularly in athletes who practice sports involving predominantly unilateral use of muscles (29).

Usually, a 5% to 10% maximum strength difference between limbs is considered to be normal (14). Previous studies have shown greater IR strength in professional, college and high school baseball pitchers. Nevertheless, although these authors have identified these differences as significant, they have not revealed their actual values (30).

Our results have shown an average difference of 3% between shoulder internal rotators. This result becomes even more interesting when we consider the results of the comparison of the shoulder ER, for which a difference of about 2% was found. Previous studies with baseball and tennis players have also failed to find major differences between the shoulder external rotators (28, 30). In spite of that, we note that the strength displayed by the participants of this study was lower than that found in previous studies conducted with volleyball players (31). This shows that, although there is a good balance between sides, swimmers have weaker shoulder ER and IR when compared with athletes of other sports.

Thus, we cannot say that swimming provides optimal balance of the glenohumeral joint, especially when we analyze the ER/IR ratios found in this study. We can see that only the non-dominant limb (i.e., the left arm) showed an ER/IR ratio within the acceptable range, and, even so, only with a small margin of reliability.

In studying the literature, we found two interesting explanations for these occurrences. Swimmers perform up to 2,500 arm-stroke cycles per day (4, 32). This excessive movement of the glenohumeral joint leads to a wearing of the static shoulder stabilizers (28), which, in turn, overloads the dynamic shoulder stabilizers, resulting in fatigue of these stabilizers and muscle imbalance. Another interesting fact is that some papers have been discussing the idea that swimming is not a sport of symmetrical proportions (9, 16, 33), i.e., the movements made during swimming may lead to muscle imbalances due to the predominant unilateral use of some muscles.

Sports practice is beginning earlier and earlier. This may result in the adoption of patterns that are harmful

to an individual's health, predisposing him/her to injuries (34).

Early diagnosis of changes resulting from sports training and the adoption of effective preventive measures can prevent the occurrence of injuries and contribute to increase athletic performance.

Several studies have assessed the shoulder muscles in swimmers (1, 3 - 9, 15, 16, 25, 32, 33). Nevertheless, in Brazil, only a few studies have been conducted in order to identify changes in the shoulders of elite level swimmers. Thus, the outcome of this study could contribute to the prevention of injuries from a fast growing sport in our nation.

We believe that concurrent physical therapy can be an important prophylactic means of preventing imbalances resulting from swimming and reestablishing muscle balance, especially of the shoulder.

Conclusion

The results of this research revealed that the swimmers had lower internal rotator strength in the left shoulder, and lower ER/IR strength ratio in the right shoulder. These data may serve as reference for other groups of swimmers and for comparisons with related studies of other sports. As a suggestion for further studies, we emphasize the importance of using a prospective, controlled, longitudinal design to promote a better understanding of the shoulder rotator strength in swimmers.

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