COMPARISON OF ISOKINETIC FORCE OF THE INTERNAL AND EXTERNAL ROTATORS OF THE SHOULDERS BETWEEN SWIMMERS OF ALTERNATE AND SIMULTANEOUS TECHNIQUES

Yves Santos[1]; Neicivana Carneiro[1]; Marcos Franken[2]; Kelly de Jesus[1]; Karla de Jesus[1]; Alexandre Medeiros[3]

[1] Federal University of Amazonas
[2] Integrated Regional University of Alto Uruguay and Missions
[3] Federal University of Ceará

The aim of this study was to compare the peak torque and the strength ratio between the external and internal swimmers' right and left shoulder rotators between alternate and simultaneous swimming techniques. Sixteen competitive swimmers (3 females and 13 males) were divided equally into two groups, alternate and simultaneous swimming techniques. The experimental protocol consisted of three maximum concentric repetitions of internal rotation and external rotation of the shoulder at an angular velocity of 60°/s and twenty repetitions at a velocity of 180°/s, with a two minutes interval between speeds and four minutes in the change of laterality of the upper limbs on a Biodex isokinetic dynamometer (Biodex System 4.0, Biodex Corp., Shirley, NY, EUA).The peak torque and the strength ratio between the external and internal swimmers' right and left shoulder rotators were measured. No difference was obtained between swimming techniques for peak torque and the strength ratio between the external and internal swimmers' right and left shoulder rotators ($p > 0.05$), except for the right shoulder internal rotation at 180º/s (alternate: 44.13 ± 11.58; simultaneous: 56.25 ± 8.83; $p < 0.05$). Based on our results, peak torque and the strength ratio between the external and internal swimmers' right and left shoulder rotators do not seem to be influenced by the athlete's predominant swimming technique, with alternate (front crawl and backstroke) or simultaneous (breast and butterfly) strokes. The main findings of this study show that the balance relationships between the ER/IR rotators of the shoulders do not seem to be differentiated by the alternate and simultaneous swimming techniques. However, observing only the PT/IR at a speed of 180°/s of the right shoulders, there was a significant difference between the groups and, therefore, the ER/IR balance ratio was at the maximum limit of normality. Regardless of the specialization of the swimming technique, that is, alternate or simultaneous, swimmers can present imbalances in the internal and external rotators of the shoulders, which reveal the need for compensatory strength training focused on the rotator muscles of the shoulder.

KEYWORDS: Dynamometry, upper limbs, swimming, performance, injury.

INTRODUCTION: Competitive swimming performance is influenced by factors such as anthropometry, body composition and upper limb strength (Lawsirirat & Chaisumrej, 2017). Swimmers usually perform a daily training routine that requires high shoulder joint loads, since the propulsive force is generated mainly by the upper limbs (Batalha et al., 2020). The propulsive force of the upper limbs in cyclical movements has a significant contribution from the internal rotation (IR) and external rotation (ER) muscles of the shoulder (Wiazerwicz & Eider, 2021), and the IR tend to be stronger when compared to the ER (Batalha et al., 2021). al., 2014).

These strength imbalances in the rotator muscles of the shoulder, along with the training season, can trigger chronic injuries to the strength responses of the upper limbs (Batalha et al., 2013). Studies mention that the ER and IR muscles, associated with imbalance and injuries in swimmers, were evaluated mainly in concentric and eccentric contractions, where there are functional and conventional reasons between the strengths of the ER and IR to indicate probable injury risks due to muscle imbalance. However, the functional relationship, performed with eccentric peak torque (PT)/RE contractions, is considered more adequate to assess the dynamic stability of the glenohumeral joint, while the conventional relationship, performed with concentric contractions of ER and RI, is indicated. for injury prevention (Drigny et al., 2020), where the ER:IR ratio should be between 0.66 and 0.75 (Ellenbecker & Davies, 2000).

In this sense, it is understood that the measurement of maximum strength levels in the upper limbs of swimmers is necessary considering that the internal rotators of the shoulder are the muscles that act directly on the propulsive force, precisely in the concentric contractions of the arms. Batalha et al., 2014).
According to Secchi et al. (2015) alternating (i.e. crawl and backstroke) and simultaneous (i.e. breaststroke and butterfly) swimming techniques may act differently on the shoulder propulsion muscles and require different strength training to improve performance and prevent injuries. The aim of this study was to compare the PT of the RI and ER muscles and the balance ratio between the rotators (ER/IR) of the right and left shoulders of swimmers between alternating and simultaneous swimming techniques. It was hypothesized that the alternating and simultaneous swimming technique groups do not differ in relation to the muscular balance ratio (RE/RI), however, the PT of the RE and RI movements may present significant differences between the groups.

METHODS: Sixteen competitive swimmers (3 females and 13 males) with a minimum of eight hours of training per week were divided equally into two groups: alternating (front crawl and backstroke) and simultaneous (breast and butterfly) swimming technique groups (G1 and G2 respectively), according to Table 1. To be included in the study, swimmers had to be free of shoulder injuries and had been training and competing in the last 3 years. For the selection of groups, the swimmers included in the study informed their main competitive events. The experimental procedures were approved by the local Ethics Committee and were in accordance with the Declaration of Helsinki of 1975. All participants and their respective guardians (when under 18 years of age) were instructed on the objectives and possible difficulties in implementing the protocols, after who signed the consent form.

Table 1: Means and standard deviations (SD) of the anthropometric characteristics of the participants differentiated by groups (G1= Alternate; G2= Simultaneous) and sex.

	G1 (Males): Means ± SD	G1: (Females) Means ± SD	G2 (Males): Means ± SD	G2 (Females): Means ± SD
1. Age	21.50 ± 7.23	18.00 ± 2.83	19.14 ± 3.02	22.00 ± *
2.Body Mass (kg)	65.57 ± 4.04	60.85 ± 1.48	66.70 ± 9.61	52.30 ± *
3. Stature (cm)	173.8 ± 5.41	165.5 ± 0.71	172.24 ± 7.01	160.50 ± *
4. Arm Span (cm)	178.78 ± 5.79	170.25 ± 0.35	176.89 ± 4.52	163.40 ± *

*** There is no SD in G2 (Females) as there is only one woman in the group.**

An isokinetic dynamometer Biodex (Biodex System 4.0 Biodex Corp., Shirley, NY, EUA) properly calibrated was used to assess the isokinetic shoulder IR and ER force profile. The participants were placed in a seated and stabilized position in an isokinetic chair, aligning the evaluated shoulder joint with the dynamometer axis (cf. manufacturer's recommendations). Each swimmer performed three maximum concentric repetitions of IR and ER of the shoulder at an angular velocity of 60°/s and twenty repetitions at a velocity of 180°/s, with passive intervals of two minutes between speeds and four minutes in the change of laterality of the upper limbs (Batalha et al., 2020). The force ratio between the right and left shoulder of the ER and IR swimmers was calculated [(ER/IR) x100] (Cingel et al., 2007).
Data normality was tested using the Shapiro-Wilk test. Descriptive statistics were performed using means and standard deviations (SD). Comparisons between groups alternate vs. simultaneous were performed using the t-test for independent samples. The significance level was set at 0.05. Effect size (ES) was calculated using Cohen's *d* and classified as trivial (0 - 0.19), small (0.20 - 0.49), medium (0.50 - 0.79) and large (> 0.80; Cohen, 1988). Calculations were performed using the software IBM SPSS *Statistics Base* 23.0.

RESULTS: Descriptive statistics (mean and SD) for isokinetic force values at 60°/s and 180°/s and respective comparisons between alternate and simultaneous swimming techniques for right and left shoulder are show in Table 2.

Table 2: Mean ± Standard deviations (SD) of the external (ER) and internal (IR) right and left shoulder rotators peak torque (PT) and the strength ratio between the ER and IR swimmers' right and left shoulder rotators (ER/IR) for alternate and simultaneous swimming techniques, *p*-value and effect size (ES).

		Variables				
Shouder Side	Swimming Techniques	PT/ER (60°/s)	PT/IR (60º/s)	PT/ER (180º/s)	PT/IR (180º/s)	Ratio ER/IR
Right Shoulder	Alternate	30,13 ± 4,91	41,50 ± 11,07	33,38 ± 8,26	44,13 ± 11,58	0,75 ± 0,12
	Simultaneous	38,00 ± 14,58	52,50 ± 11,92	34,75 ± 4,37	56,25 ± 8,83	0,75 ± 0,36
	p	0,170	0,076	0,684	0,034*	0,978
	ES	-0,724	-0,956	-0,208	-1,178	-0,015
Left Shoulder	Alternate	27,75 ± 4,53	42,13 ± 8,94	29,13 ± 3,56	45,63 ± 7,69	0,67 ± 0,08
	Simultaneous	31,25 ± 7,05	48,75 ± 12,84	32,63 ± 4,69	51,38 ± 11,48	0,65 ± 0,09
	p	0,257	0,251	0,115	0,259	0,723
	ES	-0,591	-0,599	-0,841	-0,589	-0,235

*Significant difference ($p < 0,05$).

DISCUSSION: The results showed that there is a difference in the PT value of the RI at 180°/s of the right shoulder (p = 0.034) between the alternating and simultaneous swimming techniques. Probably the swimmers evaluated have the right arm as the dominant limb and, therefore, greater proficiency on the right side, which justifies the PT/IR of the right shoulder being stronger when compared to the left shoulder. For this reason, the ER/IR balance ratio on the right side presented higher values compared to the left shoulder. It is recommended that PT/ER values be at least ⅔ of PT/IR to avoid injury (Drigny et al., 2020). Differences were also observed between the PT means in both the RI and the RE performed at 60°/s and 180°/s, where the means were higher in the right shoulders in both groups.

As in the study by Lawsirirat and Chaisumrej (2017), where short and medium-distance swimmers obtained differences in PT only in the right shoulder and ankle extensors, as they had a similar training structure. It is believed that there were no further differences in our study for this same reason.

There is only one study that compared shoulder muscle strength between alternating and simultaneous swimming techniques (Secchi et al., 2015), which observed that there was no difference in muscle strength in the adductor, abductor, and ER and IR muscles of the shoulders. However, this study used the protocol of 5 repetitions at 60º/s and 20 repetitions at 300º/s, and the literature indicates that angular velocities above 180º/s are not properly indicated due to excess torque that can make the PT calculation difficult. (Mayer et al., 2001). The present study was not able to reveal differences in the isokinetic strength profile of alternating and simultaneous upper limbs as well as the previous study (Secchi et al., 2015), which may be due to the use of alternating swimming techniques even by specialized swimmers in swimming techniques simultaneous.

A swimming training macrocycle is sufficient to produce muscle imbalances between the shoulder rotators, as there is a significant increase in RI strength without a proportional increase in ER strength, which can lead to joint injuries and dysfunctions (Batalha et al., 2013; Batalha et al. al.2014). In the present study, the values of the ER/IR ratio are at the upper limit of normality, which seems to be due to the higher qualitative PT of the right shoulder of the RI muscle group. Further studies should consider a sufficient sample size with different training levels (ie from age group to elite) to separately analyze the influence of each swimming technique on the isokinetic strength profile.

CONCLUSION: The main findings of this study show that the balance relationships between the ER/IR rotators of the shoulders do not seem to be differentiated by the alternate and simultaneous swimming techniques. However, observing only the PT/IR at a speed of 180°/s of the right shoulders, there was a significant difference between the groups and, therefore, the ER/IR balance ratio was at the maximum limit of normality. Regardless of the specialization of the swimming technique, that is, alternate or simultaneous, swimmers can present imbalances in the internal and external rotators of the shoulders, which reveal the need for compensatory strength training focused on the rotator muscles of the shoulder.

REFERENCES

Batalha, N. M., Raimundo, A. M., Tomas-Carus, P., Barbosa, T. M., & Silva, A. J. (2013). Shoulder rotator cuff balance, strength, and endurance in young swimmers during a competitive season. *Journal of Strength and Conditioning Research*, *27*(9), 2562–2568. https://doi.org/10.1519/JSC.0b013e31827fd849

Batalha, N., Marmeleira, J., Garrido, N., & Silva, A. J. (2014). Does a water-training macrocycle really create imbalances in swimmers' shoulder rotator muscles? *European Journal of Sport Science*, *15*(2), 167–172. https://doi.org/10.1080/17461391.2014.908957

Batalha, N., Paixão, C., Silva, A. J., Costa, M. J., Mullen, J., & Barbosa, T. M. (2020). The effectiveness of a dry-land shoulder rotators strength training program in injury prevention in competitive swimmers. *Journal of Human Kinetics*, *71*(1), 11–20. https://doi.org/10.2478/hukin-2019-0093

Carvalho, D. D., Soares, S., Zacca, R., Marinho, D. A., Silva, J., Pyne, D. B., Vilas-Boas, J. p., & Fernandes, R. J. (2019). In-water and on-land swimmers' symmetry and force production. *International Journal of Environmental Research and Public Health*, *16*(24), 1–9. https://doi.org/doi:10.3390/ijerph16245018

Cingel, R. van., Kleinrensink, G. J., Mulder, P., Bie, R. de., & Kuipers, H. (2007). Isokinetic strength values, conventional ratio and dynamic control ratio of shoulder rotator muscles in elite badminton players. *Isokinetics and Exercise Science*, *15*(4), 287–293. https://doi.org/10.3233/ies-2007-0285

Cohen J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed). Hillsdale, NJ: Lawrence Erlbaum.

Collado-Mateo, D., Dominguez-Muñoz, F. J., Batalha, N., Parraça, J., Tomas-Carus, P., & Adsuar, J. C. (2018). Test-retest reliability of isokinetic arm strength measurements in competitive swimmers. *Journal of Human Kinetics*, *65*(1), 5–11. https://doi.org/10.2478/hukin-2018-0035

Ellenbecker, T., & Roetert, E. P. (2003). Age specific isokinetic glenohumeral internal and external rotation strength in elite junior tennis players. Journal of Science and Medicine in Sport, 6(1), 63–70. https://doi.org/10.1016/S1440-2440(03)80009-9

Lawsirirat, C., & Chaisumrej, P. (2017). Comparison of isokinetic strengths and energy systems between short and middle distance swimmers. *Journal of Physical Education and Sport*, *17*(3), 960–963. https://doi.org/10.7752/jpes.2017.s3147

Mayer, F., Horstmann, T., Baurle, W., Grau, S., Handel, M., & Dickhuth, H. H. (2001). Diagnostics with isokinetic devices in shoulder measurements - potentials and limits. *Isokinetics and Exercise Science*, *9*(1), 19–25. https://doi.org/10.3233/ies-2001-0059

Secchi, L. L. B., Brech, G. C., & Greve, J. M. D. (2015). Isokinetic dynamometry on the internal rotator and adductor muscles of the swimmers' shoulders: no differences between asymmetrical and symmetrical swimming strokes. *Medical Express*, *2*(2), 1–5. https://doi.org/10.5935/medicalexpress.2015.02.02

Wiazerwicz, A., & Eider, J. (2021). The relationship between swimming performance and isokinetic shoulder strength of elite swimmers. *Human Movement*, *22*(4), 10–19. https://doi.org/doi.org/10.5114/hm.2021.103285

ACKNOWLEDGEMENTS: Amazonas Research Support Foundation for Research Support of the State of Amazonas (FAPEAM), Infrastructure Program for Young Researchers – First Project Program PPP, no. 004/2017 under grant [062.01554/2018].