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ORIGINAL ARTICLE

Isokinetic performance of shoulder external and internal rotators in adolescent female handball athletes



Performance isocinétique des rotateurs internes et externes des épaules chez les handballeuses adolescentes

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KEYWORDS

Shoulder;
Isokinetic;
Muscle strength;
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Summary

Objectives. – The aim of this study was to analyse the difference between the dominant and non-dominant shoulder's external and internal rotators in adolescent female handball players. **Methods.** – The information provided by database concerning the isokinetic evaluation of shoulder muscles from 21 female handball athletes between the ages of 14–17 years old were analyzed. The isokinetic dynamometer was used in a concentric-concentric mode for the shoulder external and internal rotators muscles at angular velocities of 60°/s and 180°/s. **Results.** – Isokinetic peak torque for external and internal rotators was not different between upper limbs. For external/internal rotators ratio, no difference was shown between the dominant and non-dominant limbs for the both angular velocities studied. **Conclusion.** – This study demonstrated that despite repetitive overhead throwing performed by the dominant upper limb, it was not the cause of limbs isokinetic imbalances for adolescent female handball players.

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MOTS CLÉS

Épaule ;
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Handball

Résumé

Objectifs. – Le but de cette étude a été d’analyser les différences entre le membre dominant et non dominant au niveau des rotateurs internes et externes de l’épaule chez les joueuses adolescente de handball.

Méthodes. – Les informations fournies par la base de données au sujet de l’évaluation isocinétique des muscles de l’épaule chez 21 joueuses de handball âgées de 14 à 17 ans ont été analysées. Le dynamomètre isocinétique a été utilisé en mode concentrique-concentrique pour les muscles rotateurs externes et internes de l’épaule à des vitesses angulaires de 60°/s et de 180°/s.

Résultats. – La force isocinétique des rotateurs internes et externes n’a pas été différentes entre les deux membres supérieurs. Pour les ratios rotateurs internes/rotateurs externes, aucune différence n’a été montrée entre le membre dominant et non dominant pour toutes les vitesses angulaires étudiées.

Conclusion. – Cette étude a démontré que malgré la répétition des lancer de balle réalisés par le membre supérieur dominant, ceux-ci n’ont pas été la cause de déséquilibres de force isocinétique entre les deux membres chez la handballeuse adolescente.

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1. Introduction

Handball is one of the most popular sports worldwide [1–3], practiced by both genders and by children, adolescents, and adults [3,4]. From the point of view of physical performance, handball requires high intensity maximum effort and during short periods of time [5]. Furthermore, an extensive amount and variety of specific movements occur during the handball practice: the most frequent ones are the throwing, the shots, the jumps, the accelerations, and the changes of direction [2,5,6]. Consequently, there is a high incidence of musculoskeletal injuries—the knee and ankle joints are the most affected by these acute injuries [7–9], and the shoulder joint is the most affected by overuse injuries [9–11]. Giroto et al. [9] demonstrated that in the analysis of 339 athletes from 21 Brazilian handball teams during a season, 44% of the overuse injuries affected the shoulder joint.

The throw is the main specific sporting gesture of the handball [12] and it is a complex gesture that, for it to occur successfully, it depends on adequate strength, power, and coordination of the shoulder muscles [13,14]. Handball athletes use much more the dominant limb to throw the ball during the season [15,16] and it can selectively develop more the muscles of the dominant arm [17]. According to Andrade et al. [16] and Edouard et al. [18], the imbalances between the shoulders’ strength is an indicative of a higher injury risk in youth female handball players. Moreover, athletes who use overhead movements (overhead athletes), such as during handball throwing, tend to have muscular imbalances between external and internal rotators of the shoulder, and, consequently, have poorer muscle stabilization [19]. Therefore, the dynamic balance between the rotator muscles of the shoulder is crucial for both good throwing performance and injury prevention [20].

Considering the importance for the throw and for the stabilization of the shoulder, the detailed study of the external and internal rotator muscles of the shoulder is fundamental for the improvement of muscular performance and prevention of overuse injuries of the shoulder in handball athletes. Specifically for adolescent athletes, shoulder’s injury in this skeletally immature athlete have become a significant health concern [21,22]. Moreover, the most commonly used tool for the specific muscular analysis of athletes is the isokinetic dynamometer, considered the gold standard method due to the high validity and reliability [23]. Specifically, for the shoulder joint, isokinetic evaluation is extensively used and the two most accessed muscle groups are the external and internal rotators [24]. Thus, this study aimed to analyze, through information from a database, the unilateral differences and relationships between the shoulders’ external and internal rotators in adolescent female handball players. Despite the previous studies have shown controversial results in the analysis of shoulder muscle performance in amateur adolescent [18,25,26] and handball professionals athletes [16,17,19], we hypothesized that repetitive throwing realized by the dominant limb would cause increase strength of this limb when compared to the non-dominant limb in these athletes.

2. Methods

2.1. Design

This quantitative, cross-sectional and retrospective study was conducted at the Instituto de Medicina do Esporte e Ciências Aplicadas ao Movimento Humano da Universidade de Caxias do Sul (IME-UCS) in the city of Caxias do Sul, Rio Grande do Sul, Brazil. It was approved (protocol number 967.527) by the Ethical Research Committee of the

Table 1 Mean and standard deviation values for peak torque of the external and internal rotators musculatures of the dominant limb and the non-dominant limb's shoulder.

Angular velocities	PT External rotators (N/m)			PT Internal rotators (N/m)		
	DL	NDL	<i>P</i>	DL	NDL	<i>P</i>
60°/s	17.0 (±0.8)	16.6 (±0.9)	0.73	22.4 (±0.8)	22.3 (±0.9)	0.89
180°/s	16.9 (±0.6)	16.3 (±0.5)	0.47	20.4 (±0.8)	20.1 (±1.0)	0.81

DL: dominant limb; NDL: non-dominant limb; PT: peak torque.

Faculdade Cenecista Bento Gonçalves (Bento Gonçalves, Rio Grande do Sul, Brazil), and conducted according to the 2012 Law N° 466 of the National Health Council, which approves the guidelines and rules for research involving human beings.

2.2. Participants

For this study, the IME-UCS' database was used to obtain information regarding the concentric isokinetic evaluation of the shoulder external rotators (ER) and internal rotators (IR) muscles. The study sample included evaluations from 21 adolescents female handball athletes between the ages of 14–17 years old from the Universidade de Caxias do Sul. The number of included evaluations was conveniently established and, therefore, determined intentionally and not by probability according to the number of available evaluations in the IME-UCS's database. Two evaluations, for which the respective IME-UCS consent term for future publications had not been authorized by the athletes and their legal responsible, were excluded from this study. WHO [27] defines an adolescent as any person between ages 10 and 19. The mean age of the athletes was 14.33 (±1.28; range 14.20–17.10) years, mean height was 1.62 (±0.07) meters, the mean weight was 60.65 (±9.65) kilograms, and the mean body mass index (BMI) was 23.11 (±3.44) kg/m², which is considered normal [28]. Twenty athletes reported dominance of the right limb and one of the left limb while playing.

2.3. Procedures

These evaluations were made with the IME-UCS' isokinetic dynamometer (Biodex System 4[®], Biodex Medical Systems, Shieley, New York, USA) according to Mendonça et al. [29]. The athletes first underwent warmup exercises on a stationary bicycle for 8 minutes with no resistance at moderate velocity (70–80 rounds per minute). The athletes were then led through the isokinetic dynamometer. The athletes sat on the dynamometer chair with their torsos at positioned at 85°, and they were stabilized by means of belts around the torso and pelvis to avoid compensatory movements. The positioning of the superior limb to assess the shoulders' external and internal rotators was as follows: 60° shoulder abduction in the scapular plane (30° ahead of the frontal plane) and 90° elbow flexion; the wrist was stabilized to avoid substitution of movement. The amplitude of the movement was limited at 40° external and 50° internal rotation. The order of the tests was conducted randomly, some times the first evaluated limb was the dominant limb (DL) and some times was the non-dominant limb (NDL). The athletes

performed three sub-maximal repetitions (50% of their maximum effort) and a previous maximal for each test on the two velocities to familiarize themselves with the procedures and warmup. Protocol during the test demanded 5 and 10 maximal repetitions of shoulder external and internal rotators in concentric-concentric mode on an angular velocity of 60°/s and 180°/s, respectively. A 1-minute rest period was set between evaluations of the two velocities, and a 3-minute rest period between DL and NDL evaluations. Athletes were tested by the same examiner with the use of verbal incentives for stimulation and encouragement to their maximum strength.

2.4. Statistical analysis

Isokinetic variables—peak torque (PT, N/m) and the external/internal rotator ratio (ER/IR ratio) (%)—were used for the analysis. The means values for PT and the ER/IR ratio for the shoulder joint musculature were evaluated statistically on the SPSS 17.0 software (Statistical Package to Social Science for Windows). To verify the normality of the data distribution, the Shapiro-Wilk test was used, and the mean values for the DL and NDL tests were evaluated with paired version of student's *t* test at the significance level of 0.05.

3. Results

We accessed isokinetic evaluations from 21 adolescent female handball athletes. The concentric isokinetic data results of the PT of the DL and NDL are presented in Table 1. At an angular velocity of 60°/s and 180°/s, the mean values for PT shoulder external and internal rotators showed no significant differences between the limbs.

(Table 1: mean and standard deviation values for peak torque of the external and internal rotators musculatures of the dominant limb and the non-dominant limb's shoulder).

Table 2 shows the results of the external/internal rotators ratio. No significant difference between the DL and NDL

Table 2 Mean and standard deviation values for external/internal rotators ratio (ER/IR ratio) of the dominant limb and the non-dominant limb's shoulder.

Angular velocities	ER/IR ratio (%)		<i>P</i>
	DL	NDL	
60°/s	75.2 (±2.6)	75.2 (±2.2)	0.99
180°/s	86.1 (±3.4)	85.3 (±3.6)	0.87

DL: dominant limb; NDL: non-dominant limb; ER/IR ratio: external/internal rotators ratio.

mean value for the angular velocities of 60°/s and 180°/s was found.

(Table 1: mean and standard deviation values for external/internal rotators ratio (ER/IR ratio) of the dominant limb and the non-dominant limb's shoulder).

4. Discussion

The purpose of this study was to analyze the unilateral differences and relationships between the shoulders' external and internal rotators in adolescent female handball players. In the analysis of the mean values of peak torque (PT) of external and internal shoulder rotator muscles and the mean values of external/internal rotators (ER/IR ratio), no statistically significant differences between the limbs at the two angular velocities analyzed were found. The rotator muscles of the shoulder being stabilizers and motors throughout all the range of motion, it is of utmost importance to study their muscular strength, both for performance improvement and for injury prevention in athletes [30,31]. When it comes to overhead throwing athletes, this kind of assessment becomes even more important because of the repetitive micro traumas that affect the articular structures of the shoulder, which occur both by the movement itself and by the large number of throwing done during the practice and the games.

The bilateral comparison of muscle strength between the upper limbs is often performed because there is a relationship between the limb's asymmetry and a greater risk of injury [32], which in handball athletes may represent 2.5 times more chances of shoulder injury [18]. In the literature, sports that present unilateral upper limb demands often report asymmetries, such as in the study of adolescent volleyball athletes [33,34], tennis [35,36] and baseball [37,38]. Due to the overhead throwing performed extensively by the dominant limb, this limb had been expected to have higher strength values. However, our results did not support this hypothesis. Nevertheless, we believe that the symmetry between the limbs is associated to the short training experience and to the age of the athletes evaluated in this study. Studies on young male athletes with mean age of 14.6 years at 60, 90, and 240°/s [17] and 22 years at 60, 180, and 240°/s [26] did not demonstrate differences between limbs. Even older high-level male athletes of Brazil National Handball Team at 60, and 300°/s [19] did not show differences between limbs either. Edouard et al. [18] and Andrade et al. [16] also evaluated the strength of rotators muscle of with young handball female athletes with the mean age of 18.1 and 23 years old, respectively. Nonetheless, these two studies showed asymmetry between the upper limbs when compare the mean values of PT of the ER and IR at 60, 120, and 240°/s [18]; and at 60, 180, and 300°/s [16]. For both studies, the DL values were significantly higher when compared to the NDl for the ER and IR in all velocities. Furthermore, for ER the NDl exhibited 94.6% (at 60°/s), 91.7% (at 120°/s) and 93.9% (at 240°/s) [18], 95.2% (at 60°/s), 82.4% (at 180°/s), 85.2% (at 300°/s) [16] of the DL's PT values; while for IR the NDl presented 86.5% (at 60°/s), 86.5% (at 120°/s) and 87.5% (at 240°/s) [18], 89.6% (at 60°/s), 88.4% (at 180°/s), 83.2% (at 300°/s) [16] of the DL's PT values.

Regarding the agonist/antagonist ratio of the shoulder muscles, represented here by the analysis of the conventional ratio of external/internal rotators (ER/IR ratio), the mean values of the DL and the NDl did not show differences between them either, both at 60°/s and at 180°/s. The other studies on handball athletes who also compared the ER/IR ratio values between the limbs also did not show asymmetries, both in the analysis of male [16,17,19] and female athletes [16]. The exception was the study by Edouard et al. [18] in which female athletes presented differences between the limbs in the ER/IR ratio analysis. Furthermore, the conventional ratio ER/IR analysis, which represents the proportion of concentric muscle strength of ER in relation to the concentric muscle strength of the IR, is extremely important because it reflects the muscular balance between the rotators of the shoulder during the movements [39]. The values recommended by the literature for the prevention of shoulder joint injuries are between 66 and 75% [35,40,41]. Values above or below the suggested are considered risk factors for the shoulder injuries, mainly for handball athletes [11,16,18,25]. However, the mean values presented in this study were between 75.22 and 86.11%, that is, above the normative values. These conventional ratio ER/IR values above the values suggested in the literature indicate that these athletes' IR muscles are weak in relation to their ER muscles. Other studies on female handball athletes also showed mean values above, as the studies by Andrade et al. [25] 79 to 83%, Andrade et al. [16] 79 to 85% and Edouard et al. [18] 69 to 77%. In contrast, studies with male athletes showed values within or below the suggested, Andrade et al. [19] 72 to 74%, and Pontaga and Zidens [17] 64 to 72%, and Andrade et al. [25] 60 to 66%.

Therefore, the results of this study have demonstrated symmetries between the limbs in the analysis of the concentric PT of the ER and IR as well as the analysis of the ER/IR ratio. These results established that despite the excessive performance of overhead throwing performed by the dominant upper limb, it was not decisive for the adolescent female athletes to acquire imbalances between the limbs. Regardless of these positive results, handball practice has caused adaptations and imbalances between ER and IR, with ER being proportionally stronger in relation to IR. This result has also been found in other studies on female handball athletes, and because of this, strengthening exercises for the ER muscles are important to generate the ideal balance between these muscle groups. However, the limitations of this study are related to the small sample size, the difficulty to represent the throwing movement and throwing velocity during an isokinetic evaluation.

Disclosure of interest

The authors declare that they have no competing interest.

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