COMPARISON OF GLENOHUMERAL JOINT ROTATION RANGE OF MOTION IN YOUNG ATHLETES

COMPARAÇÃO DA AMPLITUDE DE MOVIMENTO DE ROTAÇÃO DA ARTICULAÇÃO GLENOUMERAL EM ATLETAS JOVENS

COMPARACIÓN DE LA AMPLITUD DE MOVIMIENTO DE ROTACIÓN DE LA ARTICULACIÓN GLENOHUMERAL EN ATLETAS JÓVENES

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ABSTRACT

Introduction: Overhead-throwing athletes undergo changes in shoulder range of motion (ROM) due to sports activities, such as excessive amplitude, lateral rotation (LR) increase and medial rotation (MR) restriction. Asymmetry greater than 20° may render athletes more prone to injuries. There are similarities among sports featuring overhead throwing due to the considerable amount of movements involving maximum lateral rotation. In these sports, medial rotation (MR) restriction, excess of lateral rotation (LR) and shoulder pain are common, particularly in overhead-throwing athletes. Objective: To assess shoulder MR and LR ROM in athletes participating in different sports, considering the influence of these variables on injuries and functional performance. Methods: The rotation ROM of the glenohumeral joint was assessed in 477 young athletes, who were categorized in three sports groups: swimming, overhead-throwing and non-overhead throwing, distributed by age group. Analyses of Variance (ANOVA) were performed to verify if there were differences in MR and LR between groups and paired Student t test was used to verify differences between sides (asymmetry). Results: Youngest athletes showed significant shorter LR than the oldest, in both sides. This study demonstrated that the right side has less MR and greater LR in all groups. Conclusion: The findings showed that overhead-throwing and swimming groups have similarities in shoulder rotation ROM. ***Level of evidence III; Diagnostic Studies - Investigating a Diagnostic Test.***

Keywords: Adolescent; Swimming; Shoulder.

RESUMO

Introdução: Os atletas arremessadores sofrem adaptações na amplitude de movimento (ADM) do ombro, como amplitude excessiva, ganho de rotação lateral (RL) e restrição de rotação medial (RM) devido à prática esportiva. Uma assimetria maior que 20° pode tornar o atleta mais suscetível a lesões. Existem semelhanças entre os esportes que utilizam arremesso devido à ampla quantidade de movimentos em rotação lateral máxima. Nesses esportes, a restrição de rotação medial (RM), o excesso de rotação lateral (RL) e as dores no ombro são frequentes, principalmente, em atletas que são expostos aos arremessos. Objetivo: Avaliar a ADM de RM e RL do ombro de atletas de diferente modalidades esportivas considerando sua influência nas lesões e no desempenho funcional. Métodos: Avaliou-se a ADM de rotação da articulação glenoumeral em 477 atletas jovens. Os atletas foram categorizados em três grupos de esportes: natação; arremesso e não-arremesso, distribuídos em relação à faixa etária. As Análises de Variância (ANOVA) foram realizadas para verificar diferenças nas RM e RL entre os grupos e o Teste t Student pareado para verificar diferenças entre os lados (assimetria). Resultados: Os atletas mais novos apresentaram média de RL significativamente menor em relação aos mais velhos, em ambos os lados. O presente estudo demonstrou que o lado direito possui menor RM e maior RL em todos os grupos. Conclusão: Os achados desse estudo comprovaram que os grupos de arremesso e natação têm características semelhantes quanto à ADM de rotação do ombro. ***Nível de evidência III; Estudos diagnósticos – Investigação de um exame para diagnóstico.***

Descritores: *Adolescente; Natação; Ombro.*

RESUMEN

Introducción: Los atletas lanzadores sufren adaptaciones en la amplitud de movimiento (ADM) del hombro, como amplitud excesiva, aumento de rotación lateral (RL) y restricción de rotación medial (RM), debido a la práctica deportiva. Una asimetría mayor que 20° puede hacer que el atleta sea más susceptible a las lesiones. Hay similitudes entre los deportes que utilizan el lanzamiento debido a la gran cantidad de movimientos en rotación lateral máxima. En estos deportes, la restricción de rotación medial (RM), exceso de rotación lateral (RL) y dolores en el hombro son frecuentes, principalmente en atletas que están expuestos a los lanzamientos. Objetivo: Evaluar la ADM de RM y RL del hombro de atletas de diferentes modalidades deportivas teniendo en vista su influencia en las lesiones y en el desempeño funcional. Métodos: Se evaluó la ADM de rotación de la articulación glenohumeral en 477 atletas jóvenes. Los atletas se clasificaron en tres grupos de deportes: natación; lanzadores y no Lanzadores, distribuidos con relación al grupo de edad. Los análisis de varianza (ANOVA) se realizaron para verificar diferencias en las RM y RL entre los grupos y el test t Student pareado para verificar diferencias entre los

lados (asimetría). Resultados: Los atletas más jóvenes presentaron un promedio de RL significativamente menor con relación a los más viejos, en ambos lados. Este estudio demostró que el lado derecho posee menor RM y mayor RL en todos los grupos. Conclusión: Los hallazgos de este estudio comprobaron que los grupos de lanzadores y natación tienen características similares cuanto a la ADM de rotación del hombro. ***Nivel de evidencia III; Estudios de diagnósticos - Investigación de un examen para diagnóstico.***

Descriptores: *Adolescente; Natación; Hombro.*

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INTRODUCTION

Adaptations to the range of motion (ROM) of the glenohumeral joint, which are characterized by excessive lateral rotation (LR) and restriction of medial rotation (MR),[1,2] are commonly found in overhead throwing athletes, such as baseball, handball, volleyball, and tennis players and swimmers because of the movements involved in their sports. Such adaptations are more frequent in these athletes than in individuals that are not exposed to throwing or in the non-dominant limbs of athletes.[1,3-6] Similarities in the usage patterns of extreme lateral rotation in throwing sports explain the large ROM of LR found in these athletes. On the other hand, the restriction of ROM of LR of the glenohumeral joint can occur by the restriction of the posterior capsule of the shoulder.[5] Thus, the repetitive throwing motion can lead to joint adaptations that may predispose athletes to injuries.

Several studies indicate possible causes for malfunctions in the shoulder complex, such as rigidity of the posterior capsule,[3,5,7,8] impact of the rotator cuff,[7,9] looseness of the anterior capsule,[10] and changes in humeral head retroversion[4,11], among others.[1,3] Recent studies suggest that such changes may generate a biomechanical imbalance [3,12] and consequently severely injure the tissue.[13] However, it is worth noting that the increase in the ROM of LR is not always harmful. Some studies show that an increase in LR improves performance.[14,15] The greater the range of motion available to accelerate the arm in MR, the greater the velocity of the hand and, consequently, the ball. For example, in a tennis serve, the main contribution of the upper limb to the speed of the ball comes from the MR of the shoulder.[3,16] Clearly, other parts of the body help increase the velocity of the throw; however, improving the speed of MR by increasing the LR available is essential for throws.[3,14,15,16]

Given the influence of the ROM of MR and LR of the glenohumeral joint on injuries and functional performance, one must evaluate shoulder rotation ROM in athletes to identify whether or not there is restriction of MR and excess LR, as proposed by the literature [1,] and determine when these changes begin. Thus, the objectives of this study were to analyze the ROM of MR and LR of the shoulder in young athletes and assess the difference of this ROM between dominant and non-dominant limbs, among overhead-throwing- and non-overhead-throwing athletes and swimmers, as well as assess the difference between age groups.

METHODS

The ROM of MR and LR of the shoulder was evaluated during the pre-season in 477 athletes aged 11 to 19 years practicing men's futsal, men's and women's artistic gymnastics and trampoline, men's basketball, men's and women's judo, men's and women's volleyball, men's and women's tennis, and men's and women's swimming. The athletes were divided into three groups of sports: (a) swimming (n = 158); (b) throwing (men's and women's tennis and volleyball) (n = 175); (c) non-throwing (men's futsal, artistic gymnastics and men's and women's trampoline, men's basketball, and men's and women's judo) (n = 144).

Further subdivision was performed according to age, with the groups comprising athletes aged between 11 and 13 years of age, 14 and 15 years of age, and 16 and 19 years of age. This division also ensured that the groups that had similar numbers of subjects and were compatible with the intensity the training, i.e., the athletes were divided according to the intensity and volume of sports training as follows: low training volume two times per week (11 to 13 years), moderate volume with training four times per week (14 and 15 years), and heightened volume of five times per week (16 to 19 years).

In order to evaluate the shoulder rotation ROM, each athlete was placed in the supine position with 90° abduction of the shoulder and 90° elbow flexion and the scapula was stabilized by the examiner.[1,3,5] The initial position of the forearm was considered to be zero degrees for both MR and LR. ROM was measured when the first resistance in MR or LR occurred. A flexometer (*Sanny* ®) was used to measure ROM values in degrees. The examiners underwent a training session before commencing measurements. This study was approved by the Research Ethics Committee of the Federal University of Minas Gerais, process number 4592, project 493/2009. All athletes signed an informed consent form authorizing participation in the research.

Statistics

To determine whether there was a difference in the ROM of the MR and LR between the sides in each sports subgroup, paired Student t tests were performed. Analyses of variance (ANOVAs) were carried out in order to verify differences in the MR and LR variables, on both sides, and the MR asymmetry and LR asymmetry variables between the sports subgroups and between the age groups. Pre-planned comparisons were performed to identify the mean pairs where the differences identified by ANOVA analysis were observed. A value of $\alpha = 0.05$ was set for all analyses. To account for the number of comparisons performed in the ANOVAs, both among the sports groups and between the age groups, a Bonferroni correction was used, which adjusted the alpha value to 0.008. The statistical software SPSS version 17.0 was used in all analyses.

RESULTS

The descriptive data with information on sample size (n) of each group, MR, LR, and asymmetries are shown in Tables 1 and 2.

Asymmetry

The asymmetry between the right and left sides for both MR and LR was calculated for each subject. The average MR was 18.8% and the average LR was 11.3%. The highest asymmetry was found in the MR of overhead-throwing athletes with ages between 14 and 15 years (21.8%), with the right side displaying a mean asymmetry of 53.3° and the left side one of 65.1°.

The comparative analyses between the sides by the Student t-test revealed that, for MR, the right side had a lower average ROM in all groups ($p < 0.000$) and for LR, the right side had a higher mean ROM, also in all groups ($p < 0.000$). The ANOVAs showed no significant differences between the sports groups in either the asymmetry of MR ($p = 0.444$) or that of LR ($p = 0.138$). The mean values and standard deviations of the asymmetries of MR and LR in each sports group are presented in Tables 3 and 4.

Table 1. Mean Values (± standard deviation) of medial rotation (MR) and asymmetry, separated by type of sport and age group.

	Range Age Group	N	Right MR (°)	Left LR (°)	LR asymmetry (%)
Swimming	11-13	76	51,46 (10,98)	62,05 (11,15)	19,21 (12,86)
	14-15	50	53,90 (10,72)	64,32 (13,26)	21,71 (14,69)
	16-19	32	58,28 (11,40)	62,48 (12,44)	17,64 (18,38)
	Total	158	53,61 (11,22)	62,86 (12,07)	19,68 (14,68)
Throwing	11,13	49	56,71 (15,68)	64,00 (13,52)	17,87 (10,55)
	14-15	59	53,34 (14,51)	65,13 (11,41)	21,76 (16,26)
	16-19	67	54,58 (13,15)	63,34 (14,45)	17,54 (12,30)
	Total	175	54,76 (14,33)	64,12 (13,18)	19,05 (13,42)
Non- Throwing	11-13	56	47,93 (11,95)	58,79 (12,43)	20,93 (15,19)
	14-15	43	49,33 (11,11)	58,40 (13,01)	18,26 (14,88)
	16-19	45	52,49 (8,86)	57,42 (11,59)	13,36 (9,99)
	Total	144	49,77 (10,91)	58,24 (12,28)	17,77 (13,95)

Table 2. Mean Values (± standard deviation) of lateral rotation (LR) and asymmetry, separated by sports group and age range.

	Age Range	N	Right LR (°)	Left LR (°)	LR asymmetry (%)
Swimming	11-13	76	99,11 (8,73)	89,00 (9,87)	11,90 (8,01)
	14-15	50	96,62 (11,20)	85,60 (15,51)	14,22 (14,10)
	16-19	32	96,84 (10,84)	90,58 (7,46)	11,63 (17,02)
	Total	158	97,86 (10,01)	88,23 (11,69)	12,58 (12,29)
Throwing	11,13	49	102,57 (12,96)	99,84 (10,37)	9,39 (6,68)
	14-15	59	99,53 (11,53)	92,21 (11,55)	11,87 (13,77)
	16-19	67	96,07 (10,29)	87,31 (11,50)	12,13 (8,68)
	Total	175	99,06 (11,74)	92,47 (12,24)	11,27 (10,27)
Non- Throwing	11-13	56	102,43 (10,54)	94,82 (8,91)	9,29 (6,94)
	14-15	43	99,67 (10,07)	92,62 (11,17)	10,58 (6,87)
	16-19	45	96,13 (10,42)	89,33 910,40)	10,70 (6,71)
	Total	144	99,64 (10,62)	92,45 (10,28)	10,12 (6,83)

Table 3. Mean Values (± standard deviation) of medial rotation (MR) for comparisons between sports groups.

	N	Right MR (°)	Left MR (°)	MR asymmetry (%)
Swimming	158	53,61 (11,22)	62,86 (12,07)	19,68 (14,68)
Throwing	175	54,76 (14,33)	64,12 (13,18)	19,05 (13,42)
Non- Throwing	144	49,77 (10,91)	58,24 (12,28)	17,77 (13,95)

Table 4. Mean Values (± standard deviation) of lateral rotation (LR) for comparisons between sports groups.

	N	Right LR (°)	Left LR (°)	LR asymmetry (°)
Swimming	158	97,86 (10,01)	88,23 (11,69)	12,58 (12,29)
Throwing	175	99,06 (11,74)	92,47 (12,24)	11,27 (10,27)
Non- Throwing	144	99,64 (10,62)	92,45 (10,28)	10,12 (6,83)

The ANOVA between the age groups revealed a significant difference only for MR asymmetry between the 14-15 and 16-19 groups. The 14-15 group presented a difference of 20.75%, while that of the 16-19 group was 16.25% ($p = 0.008$). The mean values and standard deviations of the asymmetries of MR and LR in each age group are shown in Tables 5 and 6.

Differences between sports

With respect to MR, ANOVA showed that the swimming group presented a significantly higher mean than the non-throwing group bilaterally ($p = 0.002$ on both sides). Furthermore, the throwing group presented a higher MR than the non-throwing group in both limbs ($p < 0.000$ on both sides). The comparison between the swimming group and the throwing group was not significant, both on the right shoulder ($p = 0.813$) and in the left shoulder ($p = 0.405$).

In the analysis of the LR, the ANOVA analysis showed no difference between the groups in the right shoulder ($p = 0.226$). For the left shoulder LR, the swimming group displayed a significantly lower mean than the throwing group ($p < 0.000$) and a lower mean than the non-throwing group ($p = 0.004$). There was no significant difference between the throwing and non-throwing groups in the left shoulder LR ($p = 0.492$).

The mean values and standard deviations of the mean ROM of MR and LR in each sport group are shown in Tables 3 and 4.

Differences between ages

The ANOVAs indicated that there was no significant difference in the MR values between the age groups, both in the right shoulder ($p = 0.061$) and the left ($p = 0.584$). With regard to the LR, the 11-13 years group presented a significantly higher mean than the 14-15 years group in the left shoulder ($p < 0.000$), but due to the Bonferroni correction, this difference was not statistically significant in the right shoulder ($p = 0.021$). Furthermore, the 11-13 age group also presented a significantly higher mean LR than the 16-19 group, bilaterally ($p < 0.000$ in both sides). The comparison between the 14-15 years and 16-19 years groups was not significant, on both sides ($p = 0.078$ in the right shoulder and $p = 0.419$ in the left shoulder). The mean values and standard deviations of the MR and LR in each age group are shown in Tables 5 and 6.

DISCUSSION

The objective of this study was to analyze the ROM of MR and LR of the glenohumeral joint in young athletes from different sports. The findings of this study show that the throwing and swimming groups had similar characteristics regarding the ROM of shoulder rotation. Swimmers perform a maximal LR movement in the recovery phase

Table 5. Mean Values (± standard deviation) of medial rotation (MR) for comparisons between age ranges.

Age Range	N	Right MR (°)	Left MR (°)	MR asymmetry (%)
11-13	181	51,79 (13,07)	61,57 (12,32)	19,38 (13,06)
14-15	152	52,39 (12,50)	62,94 (12,76)	20,75 (15,35)
16-19	144	54,75 (11,69)	61,29 (13,35)	16,25 (13,33)

Table 6. Mean Values (± standard deviation) of lateral rotation (LR) for comparisons between age ranges.

Age Range	N	Right LR (°)	Left LR (°)	LR asymmetry (%)
11-13	181	101,07 (10,65)	93,73 (10,65)	10,41 (7,41)
14-15	152	98,61 (11,04)	90,14 (13,21)	12,28 (12,35)
16-19	144	96,26 (10,39)	88,66 (10,42)	11,57 (10,57)

with the arm out of the water and the throwers perform maximal LR to "lock" the shoulder.[1,17] Therefore, both groups are expected to have similar ROM. However, the LR in the left shoulder was higher in the throwing group than in the swimming group. It should be noted that the LR of the right shoulder of swimmers is larger than that of the left side, a finding that was repeated in all groups. It was expected that swimmers, using both arms with the same intensity during sports practice, would have similar SR and RI ROMs. However, kinetic, coordinate, and force asymmetries have been observed in swimmers and may be caused by deficits of motor strength and control, dominance, or factors associated with the swim technique itself,[18,19] which may lead to changes in shoulder rotation.

When the throwing and non-throwing groups were compared, a higher ROM of MR was found in the throwing group bilaterally. This finding was in contrast to literature reports, where studies point to a reduction in MR in the shoulders of throwers when compared with those of non-throwers.[1,3,7,20] However, in these studies, the athletes assessed were professionals, which is not the case in the present study. In addition, it is likely that the training intensity is different, even for different sports. Baseball has a similar, but not identical, movement to tennis and volleyball. In baseball, after the ball is thrown, a vigorous eccentric action is needed to brake the MR of the shoulder.[15] In volleyball and tennis after the ball is hit, much of the MR energy is transferred to the ball, consequently reduced eccentric action is required.[21] The repetitive eccentric action performed by the cuff muscles can lead to a thickening of their tendons and fibrosis in the muscle belly, which may be associated with a reduction in MR, especially in baseball pitchers.

The comparative analysis between the swimming group and the non-throwing group revealed similar data to those obtained in the comparison between the throwing and non- throwing groups. The swimming group had a higher mean MR on both sides. Another unexpected finding was that the non-throwing group displayed a higher mean LR than the swimming group on the left side. One can assume, once more, an interaction of the environment outside of sports practice. Therefore, regardless of the similarities of movement between sports, data from the present study demonstrated that the young overhead-throwing athletes and swimmers still did not present the sharp reduction of MR as suggested by the literature. This may be due to the lower age of the athletes, the shorter practice time, the reduced intensity of training, and the fact that they were not professionals.

Asymmetry

This study showed that the right side, dominant in the vast majority of athletes, has reduced MR in swimming, throwing and non-throwing groups compared to the left side. However, it was expected that the non-throwing group would have a significantly lower asymmetry. The same was found for LR, which was higher on the right side in all groups. Probably, sports practice had not yet influenced shoulder ROM and, moreover, the asymmetries found between the sides are within the threshold suggested by the literature.

Borsa[1] indicated that asymptomatic shoulders of throwing athletes had a loss of MR of approximately 10° or 12-17%, when compared with the contralateral limb, while the shoulders of symptomatic athletes had 20°-25° or 30% loss of MR. Borsa[1] suggests a threshold of loss of MR of 19°, where those who have asymmetry greater than 19° or 30% are more susceptible to shoulder dysfunctions. Therefore, it was shown that the average asymmetry of athletes assessed was within this suggested threshold. Only the 14-15 group presented a mean slightly above 20%. Thus, it would be of use for physiotherapists to develop an approach to prevent possible injuries in this age range.

Although the difference of 10° found in the asymmetry of MR in the 14-15 group is low, it is important to alert this age group to the importance of maintaining this ROM of MR and LR throughout the individual's sporting career. A study[3] with 124 baseball pitchers with arthroscopic-proven SLAP injury had a MR loss of 53°, which is quite significant and considerably higher than the values found in this study. It was also found that the loss of MR in the shoulders of symptomatic pitching athletes is much higher than the gain in LR.[3]

Differences between ages

The data obtained in this study revealed that the lower age groups presented a lower LR. This finding is most evident when comparing the 11-13 group with the 16-19 group. This finding can be explained by the greater ligamentous laxity found in children. Another possibility for the larger ROM of LR in the 11-13 group might be the humeral retroversion.[22] Edelson [22] examined several humeri from different ethnic groups and ages and concluded that the reduction of retroversion occurs naturally with aging. Newborns had a mean retroversion of 78°, while adults had from 25° and 35°. That is, younger people have increased humeral head retroversion and consequently greater LR.

The data from this study could be explored more specifically, with the retrieval of information from time of practice and dominance. However, we know that the percentage of left-handers in the general population is 10%, which is likely to be reflected in this study. Information on with bone age, humeral head retroversion and ligamentous laxity would also be of benefit, which may require additional instrumentation and may make the project unviable. Despite these limitations, the present study allowed an assessment of MR and LR ROM values of the shoulder in young athletes, which may aid in the development of effective preventive measures in sports physiotherapy to reduce shoulder injuries. Thus, it is important to note that MR reduction is related to subacromial clamping and rotator cuff lesions [3,5] and adaptations in the ROM of the glenohumeral joint are only one of the factors to be considered in the prevention of sports injuries. Scapular dyskinesia and weakness of the scapular muscles may also contribute to overload in the shoulder complex due to sports training.[1]

CONCLUSION

The athletes evaluated presented an increase of LR and reduction of MR on the right side compared to the left. However, throwing and non-throwing athletes exhibited a similar asymmetry between sides. The group with the lowest age showed higher LR than the group with the highest age, probably because of humeral retroversion, typically higher in younger individuals. Furthermore, data analysis revealed that, despite the increase in LR and reduction of MR, the athletes evaluated were within the threshold suggested by the literature to be normal.

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