ISOKINETIC COMPARISON OF THE ROTATOR CUFF BETWEEN WATERPOLO AND TENNIS PLAYERS

COMPARAREA ISOKINETICĂ A COIFULUI ROTATORILOR ÎNTRE JUCĂTORII DE POLLO ŞI CEI DE TENIS

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Key words: ratio, asymmetry, compensation work, muscular performance.

Introduction. Isokinetic evaluation is an objective method that allows rapid and reliable comparison of the relationship between the muscle groups of the rotator cuff, during dynamic exercise. At shoulder level, balance between the rotator cuff muscle groups is essential for keeping joint stability. **The purpose** of this study is to detect significant differences in muscular performance strength values of the muscles of the rotator cuff by isokinetic tests, in two overhead sport specialities: water polo and tennis. Comparison could be realized analyzing various parameters derivate of the test. **Material and methods.** We undertook an isokinetic study in a group of 36 high-level athletes: 30 water polo players (12 women and 18 men) and 6 tennis players (2 women and 4 men). The parameters analyzed were: peak torque (PT), maximal repetition work (MRW), muscle asymmetry between dominant and no dominant shoulder, and ratio between external and internal rotators.
Results. For all tested values of PT, the dominant limb has always been stronger than the no dominant in both sports, but differences in tennis players were much higher in favor of the dominant than water polo players with specific reference to IR. With regard to MRW, water polo players had values higher than tennis players in ER of both sides, but the IR of the dominant limb is greater in tennis players.

Cuvinte cheie: raport**,** asimetrie, lucru compensator, performanță musculară

Introducere. Evaluarea isokinetică este o metodă obiectivă ce permite compararea rapidă şi sigură a relației dintre grupele muscular ale coifului rotatorilor, în timpul exercițiilor dinamice. La nivelul umărului, echilibrul dintre grupele muscular ale coifului rotatorilor este esențială pentru menținerea stabilității articulare. **Scopul** acestui studiu este de a detecta diferențe semnificative ale valorilor forței musculare a muşchilor coifului rotatorilor prin teste isokinetoce, efectuate în două sporturi solicitante: polo şi tenis. Compararea poate fi posibilă prin compararea parametrilor testului. **Material şi metode.** Am realizat un studiu peun grup de 36 de atleți de înaltă performanță: 30 de jucători de polo (12 femei şi 18 bărbați) şi 6 jucători de tenis (2 femei şi 4 bărbați). Parametrii analizați au ost: peak torque (PT), numărul maxim de repetări (MRW), asimetria musculară între umărul dominant şi cel nondominant, rația dintre rotația internă şi externă. **Rezultate.** Pentru toate valorile testate ale PT, membrul superior dominant a fost întotdeauna mai puternic decât cel nondominant, la ambele categorii de sportivi, dar diferențele au fost mai mari la jucătorii de tenis, față de jucătorii de polo, cu referire specific la rotația internă. Referitor la numărul maxim de repetări, jucătorii de polo au avut valori mia mari decât cei de tenis la rotația externă pe ambele părți, dar rotația internă a membrului dominant este mai mare la jucătorii de tenis.

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Conclusions. In water polo players, due to the environment in which specific work is developed and the symmetrical content of simming, the ratios in both extremities were very symmetrical (related to PT); in tennis players, the dominant limb had more normal ratio values but this doesn't happen in the no dominant possibly because it comes into play shortly.

Concluzii. La jucătorii de polo, datorită unui activități specific şi a caracterului simetric al înotului, raporturile la nivelul celor două extremități au fost de asemenea simetrice; la jucătorii de tenis, membrul dominant a prezentat valori normale ale rapoartelor, lucru care nu se întâmplă la membrul nondominant, posibil deoarece este mai puțin folosit în timpul jocului.

Introduction

Isokinetic dynamometry is a valid method to obtain an objective evaluation that gives a fast and reliable comparison between the agonistic and antagonistic muscles of the rotator cuff during the dynamic exercise. By using isokinetics, it is possible to determine muscular performance of these groups.

In the shoulder, balance between the muscles of the rotator cuff is essential to maintain joint stability (Ainsworth R. et al, 2007), as this musculature maintains the head of the humerus centered during movements. To date, there have been published several studies describing this relations, that demonstrate a predominance of the internal rotation muscles.

However, few of them have been realized in high performance athletes (Cools AM et al. 2004, Hsing-Kwo Wang et al. 2000, Ellenbecker et al. 1997, Codine P et al. 1997).

The shoulder has a very important role in many sport activities (Cools AM, et al 2004), especially in overhead sports, that involve, for example: throwing a ball, with or without implement. An imbalance in the strength developed by the musculature of the rotator cuff can derive in an injury process that makes the athlete unable to keep with her sport practice (Hsing-Kwo W. et al, 1999).

This study analyze two overhead sports that involve throwing a ball in one case, and kicking it in the other case, in two different environments, like water polo and tennis. Ballistic action in these kind of sports place a heavy eccentric load over the musculature of the rotator cuff, leading to a predisposition to injuries.

Many authors agree that weakness in one or more of the rotator muscles can cause an imbalance in the torques around the scapula, leading to abnormal kinematics (Malliou PC et al. 2004, Cools AM et al. 2004, Hsin-kuo Wang et al. 200). On the other hand, an excessive ROM of the scapula due to this imbalance will increase stress in shoulder capsule structures, leading to a higher instability. A malposition of this scapula also will affect the center of rotation of the shoulder that will disturb torques produced around the shoulder (Cools AM, et al 2004).

Aims

The main objective of the study is to identify potential significant differences in muscular performance between both sports. We also want to determine reference values of peak torque, maximal repetition work, ratio and asymmetries for tested velocities. Another aim of this study is to detect significant differences in muscular performance by isokinetic tests between water polo and tennis, and describe characteristic values of such population as values of reference. Comparing such values, may explain the reason for potential differences in two throwing sports, in different environments, one of them with a symmetric component (swimming in water polo). Asymmetric component in throwing is close in both sports, but water polo has a symmetric part of swimming that has to be studied.

Material and methods

For this evaluation, we measured values of 36 subjects, all of them high level athletes trained in the Olympic Training Centre of Sant Cugat del Vallés (Barcelona). These 36 subjects were divided in two sport specialties: 30 water polo players (12 women and 18 men) and 6 tennis players (2 women and 4 men). In high level sports is very difficult to get subjects for a study. Water polo is a sport team that allows us to have more subjects. On the other hand, tennis is an individual sport, so we have les subjects to be tested. Both groups consisted of subjects under 18 years old. *Table 1* shows the characteristic values of this population.

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	Sex		Dominance		Average values		
	Men	Women	RH	LH	Age	Height	Weight
WP	18	12	25	5	15,67 ± 1,12	1,80 ± 0,09	71,6 ± 14,25
Ten	4	2	6	0	16,5 ± 1,38	1,72 ± 0,1	63,33 ± 9,14

Table 1. Values of sex and dominance of the players tested, and average values of age, height and weight. RH denotes Right Handed, and LH denotes Left Handed

Inclusion criteria were based on the absence of shoulder injury in the last 6 month, which could alter the values of measurements. It wasn't considered that age was an exclusion criterion. Another inclusion criterion was that all athletes in the present study should be part of the talented athletes belonging to the groups of the Olympic Training Centre. All of them were minors, but informed consent was obtained for measurement, as well as the consent of their training responsible.

Testing procedures

The isokinetic dynamometer Biodex Pro System 3 was used, able to measure velocities up to 300º/sec, making a weight calibration and position before each measurement. The complete test consisted of completing 3 series of 5 maximal repetitions at the velocities of 60º/sec, 150º/sec and 240º/sec, after an active 5 minutes warm-up on an arm bike.

To implement the test, subjects had to be in the sitting position with the shoulder in abduction 80° in scapular plane and elbow flexed 90° in order to allow full rotation, with the arm indicating the axis of rotation in coincidence with the axis of the dynamometer.

To set properly the subjects there were used velcro strips specifically designed for this isokinetic device around the subjects chest.

In *Figure 1* it is shown the positioning of the subjects while performing the test.

The range of movement was set in 140º, taking as zero the position of maximum external rotation active painless. The starting position of each repetition is the maximum internal rotation.

Fig. 1 Subject positioning while performing the test

The parameters analysed after these measures were: peak torque (PT), maximal repetition total work (MRW), muscle asymmetry between dominant and nondominant shoulder, and index of relationship or ratio between external and internal rotators.

Statistical analysis

Mean and standard deviation were calculated (SD) for each of analyzed parameters.

The statistical significance between groups was determined by Student "t" test and P values less than <0.05 were considered significant.

Results

The results for the values obtained for the PT and çMRW to velocities of 60 ° / sec, 150 ° /sec and 240 ° / sec are shown in *Table 2*.

		60°/second				150°/second				240°/second			
		Dom		Non dom		Dom		Non dom		Dom		Non dom	
		ER	IR	ER	IR	ER	IR	ER	IR	ER	IR	ER	IR
PT (N/m)	WP	33,72	45,89	32,73 (*)	45,3 (*)	31,11	43,89	30,79	42,35 (*)	31,1	43,9	29,05 (*)	43,16 (*)
	Ten	26	41,27	25,62	36,05	25,47	41,45	24,7	33	23,23	39,03	22,53	33,1
MRW (J)	WP	47,73	67,92	44,71	65,26	43,84	62,47	41,92	60,85	43,17	62,62	40,55	61,01
	Ten	43,82	75,25	42,25	59,67	42,48	73	37,82	56,62	38,02	70,47	35,92	56,6

Table 2. The values in the tables represent the mean, and the standard deviation of the mean. (*denotes a P value of ≤ 0,05, "ER" denotes external rotation and "IR" denotes internal rotation, "Dom" denotes dominant limb and "Non dom" denotes nondominant limb.

The table shows that water polo players always had higher values than tennis players in relation to the PT, but only the values of no dominant extremity achieved statistical significance (with the exception of the ER at 150 º / sec.). Regarding water polo players, the loss of strength with increasing velocity is more pronounced in the no dominant limb; in dominant limb is not produced a falling between the velocities of 150 and 240 ° /sec. Regarding tennis players, the loss of strength with increasing velocity occurs similarly in both limbs for all three velocities, with a more pronounced fall at 240 º / sec, which incidentally is the velocity that comes closest to sport reality.

For all tested values of PT, the dominant limb has always been stronger than the no dominant in both sports, but differences in tennis players were much higher in favor of the dominant than water polo players if we make specific reference to IR.

Regarding to MRW, water polo players had values higher than tennis players in ER of both sides, but the IR of the dominant limb is greater in tennis players.

In terms of loss of strength with increasing velocity, shown by graphics in *Figure 2*, in water polo players there is a similar loss of strength between 60 and 150 ° / sec for both IR to ER of both limbs, but this loss of strength is attenuated in the transition to 240 º / sec. With respect to tennis players, there is a loss of force in step 60 to 150 and 240 ° / sec justifiable with a loss of strength in relation to velocity, with the exception of the IR rotation in nondominant limb in step 150 to 240º/sec, were there wasn't a decrease of values.

In *Figure 3*, it is shown the evolution of MRW values with increasing velocity. The tendence of the values is the same as regards to PT; a decrease of PT strength mean a less production of work during the repetition, so with that MRW values also decrease.

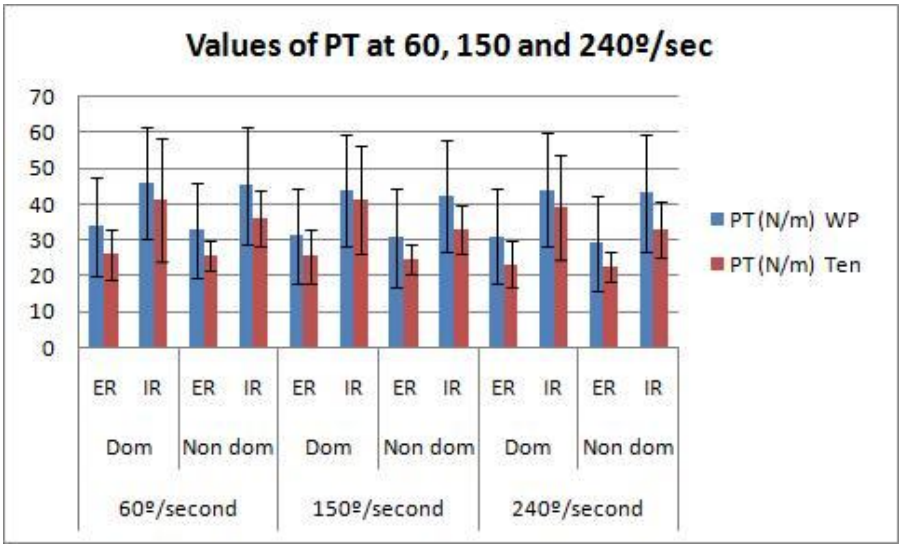


Fig 2. Average of PT values at 60º/sec, 150º/sec un 240º/sec, for IR and ER in dominant and nondominant limbs. It is presented the mean values of all athletes with it's standard deviation.

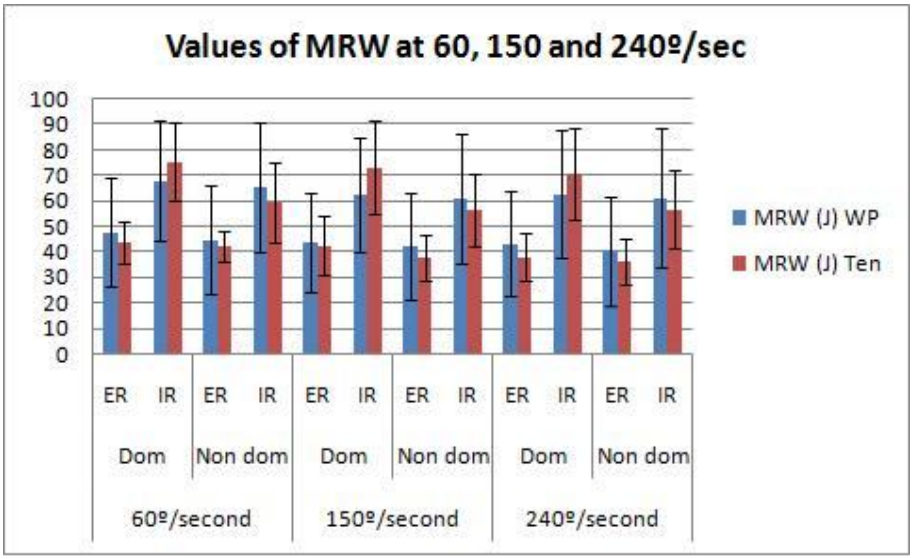


Fig 3. Average of MRW values at 60º/sec, 150º/sec un 240º/sec, for IR and ER in dominant and nondominant limbs. It is presented the mean values of all athletes with it's standard deviation.

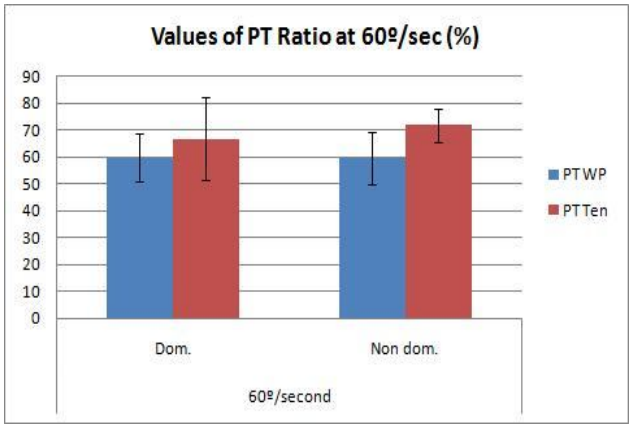


Fig. 4. Ratio values of PT Ratio at 60º/sec for dominant and nondominant limb

The relationship established between the internal rotator muscles and the external rotators of the shoulder girdle, is called ratio. *Figure 4* shows ratio values obtained in the tests. The traditional values described in the literature situate a ration around the 60-65%.

RATIO		60º/second	
		Dom.	Non dom.
PT	WP	59,76	59,45 (*)
	Ten	66,77	71,82
MRW	WP	55,87	54,87 (*)
	Ten	58,57	73,54

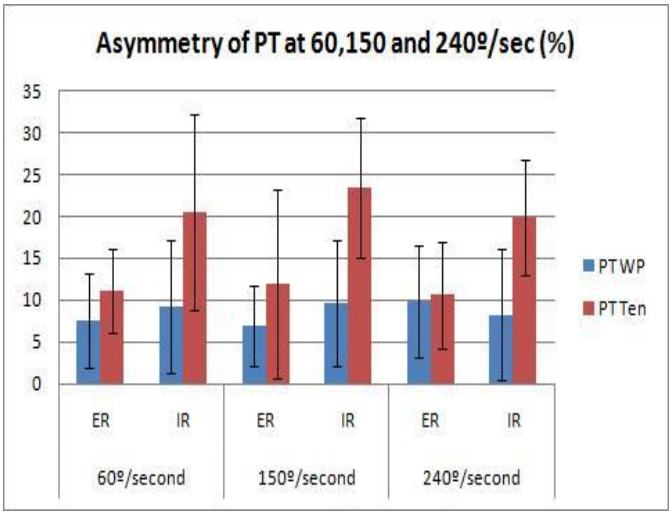
Table 3. Values and statistical significance of PT Ratio at 60º/sec for dominant and nondominant limb.

To make the analysis of this ratio, we have taken as reference velocity 60 ° / sec, because between all the velocities used, is the closest to maximum force values.

With respect to the values of PT ratio between the internal rotator muscles and external rotators, *Table 3* shows that tennis players have a value of Ratio of 66% in the dominant limb and 71% in the no dominant limb; values obtained by water polo players, are 59% for the dominant limb and 59% for the no dominant limb.

These ratio values similar move away from above or below the average values reported in the literature, which are 65%, but it is important that tennis players deviate above, and water polo players below reference values (Huesa F et Carabias A, 2000). Regarding the statistical significance of all these values, only existed in the ratio values for the no dominant limb in the water polo players.

Related to MRW ratio between internal rotator muscles and external rotators, tennis players have some value ratio of 58% in the dominant limb and 73% in the no dominant limb. Water polo players present values of 55% for the dominant limb and 54% for no dominant limb. In terms of statistical significance, and as happened with the ratio of PT values, only existed in the ratio values for the no dominant limb in the water polo players.



With respect to the values of the asymmetry (explained as the relation of the dominant limb divided by the non-dominant in percentage value, with formula: ((DOM / NON DOM) * 100)-100) of PT, tennis players show higher values of symmetry for three velocities tested, but there is only statistical significance in the asymmetry of the IR for velocities of 150 and 240 ° / sec both in PT and in MRW. *Figure 5* and *Table 4* show the graphics and the values of the asymmetry

Fig 5. This graphic show the asymmetries of IR and ER with SD for the three velocities tested.

ASYMMETRY		60°/second		150°/second		240°/second	
		ER	IR	ER	IR	ER	IR
PT	WP	7,5	9,19	6,95	9,55 (*)	9,91	8,23 (*)
	Ten	11,11	20,52	11,9	23,47	10,62	19,87
MRW	WP	10,79	9,27	11	11,62 (*)	12,18	9,65 (*)
	Ten	10	21,07	13,57	22,23	7,58	19,79

Table 4. Asymmetry values between dominant and nondominant limb respect to PT and MRW for the 3 velocities tested

With respect to the asymmetries of MRW, there is not a clear trend about the values evolution. The only values showing a significant difference coincide with those detected in the PT, where the asymmetry values of tennis players are higher than water polo players.

Discussions

Water polo is an asymmetric sport that combines swimming with a specific job for each limb. During the static game, the dominant limb has the responsibility to catch the ball, pass it, throw it; the no dominant limb has the responsibility to keep the body out of the water. This complete work can explain the values much more symmetrical than tennis players.

Despite the importance of swimming in water polo and its highest levels in the PT in the IR of the dominant limb, MRW values are lower than tennis players. In tennis game, most of the actions require ballistic executions, to which is added the attachment of the racquet that lengthens the lever, so that the eccentric work of the muscles to stop the limb after the hit is very strong, and could explain this fact.

In this type of asymmetric sports, the work of compensation is very important to maintain stability between the muscles of the rotator cuff. Tennis players showed good stability in both limbs as far as ER is concerned, but the difference in IR can be explained with specific training in the dominant limb.

The torque is higher for specific actions in tennis players (longer lever). This is caused by a strong activation of the muscles that perform these actions.

In water polo, not all the actions performed with the ball are executed at full intensity (there are Passes, dribbling, vaselines (is an action typical in WP in which the goal is scored throwing the ball over the goalkeeper...); in the modern tennis, however, except for some very specific action, all actions are performed at maximum intensity.

This study evaluates with the same method one sport that uses an implement and one that does not, so that we may be falling into the mistake of making a wrong extrapolation of information. Water polo actions are much closer to the technical evaluation or gesture evaluation than tennis actions.

Conclusions

After evaluation and analysis of the results presented so far, we extract a few conclusions about them.

The asymmetries found in tennis players should be corrected by the compensation work to reduce the risk of injury. Focusing their work on the muscles of ER in order to normalize the ratio, also contribute to this purpose.

The minor fall of PT values of ER and IR in both extremities in waterpolo players at increasing speed of execution, are probably due to the work of rowing and the more time of manual application of force in relation to throwing in water polo and that the sporting gestures are closer to the high speed test.

The range of motion in sport movements during the activity is greater in tennis, and this could lead to an improved ability to maintain strength, that is to say a higher level of MRW.

In tennis players, the asymmetry in RI for the three velocities tested is very high, and this is probably because the most tennis shots are performed one hand at high speed, while the other extremity does not work in all the shots. In water polo, in contrast, although the ball actions are also performed with a single extremity, the work of swimming is bilateral, so that the work between the two extremities becomes equal.

In water polo, ratios in both extremities were very symmetrical due to the content of swimming; on the other hand, in tennis this does not happen, because the no dominant limb possibly comes into play shortly.

It would be necessary to carry out an assessment to more athletes to evaluate whether this trend continues.

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