Eur J Anat, 3 (1): 41-49 (1999)

Isokinetic handedness in the abduction-adduction movement of shoulder

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SUMMARY

In view of the heterogeneity of samples and the diversity of the results reflected in the literature. The aim of our study was to examine the behaviour of handedness in the upper limbs using isokinetic analysis.

We took a sample of 30 men and 30 women, each group comprising of 20 right-handed and 10 left-handed subjects. Using a BIODEX 2000 dynamometer (Biodex Medical Systems, Inc. Brookhaven R&D Plaza 20 Ramsay Road. Box 702 Shirley. New York. 11967-0702), the individuals were subjected to an isokinetic evaluation of the abduction-adduction movement of each upper limb, at a speed of 60 and 120°/s, following a rigorous protocol.

The sample was divided by sex and handedness, after which both extremities were compared at both speeds and movements. In the right-handed subjects of both sexes, the mean values of the isokinetic parameters regarding force and work were significantly higher in their dominant limb. However, in the left-handed group, these statistical differences did not appear; therefore, the handedness of their left upper limb was not shown.

Key Words: Handedness - Isokinetics - Abduction-adduction movement - Shoulder.

INTRODUCTION

Knowledge of the biomechanical parameters that maintain the balance between mobility and stability in the shoulder joints is crucial when their integral rehabilitation is intended (Dvir and Berme, 1978; Poppen and Walker, 1978; Howell et al., 1988; Speer and Garret, 1993).

One of these factors is the synchronization and coordination of the joints comprising the shoulder complex, with a different contribution to the movement of the upper limb by each of them (Inman et al., 1944; Poppen and Walker, 1976). Another factor is the periarticular muscles, which play a crucial role in shoulder function as glenohumeral dynamic stabilizers (Saha, 1971; Itoi et al., 1993). In consequence, the quantification of muscular force and ranges of movement is essential for any study of rehabilitation.

We studied the abduction-adduction movement because there were few studies on this type of movement in non-professional sports players (Ivey et al., 1985; Reid et al., 1989; Connelly-Maddux et al., 1989; Otis et al., 1990; Cahalan et al., 1991; Tata et al., 1993; Shklar and Dvir, 1994; Whitcomb et al., 1995) and because the abductor muscles are good markers of the global function of the shoulder, since any injury will limit complete abduction (Mac Donald, 1996).

There is no consensus as to whether there is isokinetic handedness in the upper extremities or not. Some authors have found some differences between the dominant and non-dominant

Submitted: March 2, 1999
Accepted: May 24, 1999

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limb (Ivey et al., 1985; Reid et al., 1989) while others have found these differences only in particular movements (Otis et al., 1990; Cahalan et al., 1991). This is why in our study the upper extremities were compared independently in right-handed and left-handed subjects in order to determine their possible isokinetic bilateral equivalence when rehabilitating these muscular groups.

Materials and Methods

Sample

We used a homogeneous sample of 60 subjects (30 male and 30 female) from 18 to 25 years old with no visible pathology of the locomotor apparatus nor any specific sports activity; 20 of them were right-handed and 10 left-handed. Their handedness was determined according to everyday skills such as eating and writing. The mean values of their weights and heights are shown on table 1.

The study was performed in the isokinetic analysis laboratory of the Department of Morphological Sciences and Surgery of the School of Medicine at Alcalá de Henares (Madrid).

Measurement system

A Biodex 2000 Multi System Joint dynamometer was used for the study. This biodex system comprises:

- An electromagnetic dynamometer.
- Fixed accessories to the dynamometer for the isokinetic evaluation of certain joints, and other accessories to be fitted to the system, such as a chair used for the study of the abduction-adduction movement.
- A control board to select the exercise modality and the angular speed for the test analysis.
- A processor to analyze the test results.

Statistical Program

The SPSS software package was used for the analysis of the results.

Protocol

A rigorous protocol was accomplished systematically by each subject in the isokinetic exercise. Certain factors regarding the dynamometer itself, which we have called "mechanical", such as the calibration and inclination of the dynamometer axis (15° to coincide with the optimum position of the chair) were controlled. Additionally, the accessory arm was equilibrated to perform the movement. "Physical and biological factors" such as subject position (sitting with his/her back close to the back of the chair) and subjection (by means of a pelvic belt and a belt passing over shoulder contralateral to the one evaluated) were also carefully considered. The dynamometer axis was aligned to the acromioclavicular joint; the movement range was determined by the subject in an active way, and the effect of gravity was corrected (with the weight of the limb).

The "psychological factors" which influence the results of an isokinetic evaluation were also taken into account. The subjects were systematically informed of the purpose of the test. To get them accustomed to the device, previous exercises, also intended to warm up the joint and to check the accommodation of the device resistance to the individual's force were performed. Finally, the subjects were verbally encouraged to make their maximum effort at all times.

The isokinetic study began with the right extremity regardless of the dominant limb. With a selected modality of concentric exercise and a slow speed of 60°/s, 5 performances were made. After a rest, a speed of 120°/s was selected and the abduction-adduction movement was sequentially repeated 15 times in the coronal or frontal plane. Once the right extremity had been analyzed, the same systematic was followed with the left one.

Measure	Sex	Mean	S.D.	Max.	Min.	S.E.
Age (years)	Male	19.50	1.59	25	18	0.29
	Female	19.23	1.10	23	18	0.20
Weight (Kg)	Male	76.88	17.59	132.5	53	3.21
	Female	56.95	7.92	76	43	1.44
Height (cm)	Male	175.93	6.24	186.3	166.5	1.14
	Female	162.28	7.05	173.8	147	1.28

Table 1.– Mean values of age, weight and height

Variables quantified

The following force variables were analyzed for each movement, speed and extremity:

- Peak torque: the maximum value of the torque reached along the repetitions of a particular movement. This was expressed in newton per metre (N.m.).
- Torque/body weight ratio:This represents the percentage of the peak torque normalized to body weight.

Certain work variables were also quantified:

- Total work: the result of the sum of all the work performed in each of the repetitions of a movement. Work is considered as the area below the torque/angular displacement (time) curve, and is expressed in joules.
- Work/body weight ratio: The percentage of the maximum work with respect to the body weight.

		Dominant (R)			***Non-dominant (L)***				
Speed	**Measures**	**$\bar{x}$**	**(S.D.)**	**S.E.**	**$\bar{x}$**	**(S.D.)**	**S.E.**	**t- value**	**p**
120°/s	Peak Torque	50.54	(9.4)	2.12	47.75	(10.5)	2.37	2.09	S
120°/s	Torque/body weight	67.38	(10.3)	2.32	63.78	(12.9)	2.90	2.06	S
120°/s	Total Work	851.02	(187.2)	41.86	747.51	(194.9)	43.54	5.65	S
120°/s	Work/body weight	91.80	(20.6)	4.61	80.56	(19.9)	4.45	4.71	S
60°/s	Peak Torque	56.35	(9.6)	2.16	52.28	(10.7)	2.39	2.75	S
60°/s	Torque/ body weight	75.30	(11.0)	2.47	69.69	(11.5)	2.59	2.76	S
60°/s	Total Work	400.59	(85.0)	19.02	337.40	(81.4)	18.20	6.98	S
60°/s	Work/body weight	117.27	(22.9)	5.14	95.89	(22.2)	4.97	7.25	S

Table 2.– Abduction movement in the right-handed men. S= significant ($p \leq 0.05$)

		Dominant (R)			***Non-dominant (L)***				
Speed	**Measures**	**$\bar{x}$**	**(S.D.)**	**S.E.**	**$\bar{x}$**	**(S.D.)**	**S.E.**	**t- value**	**p**
120°/s	Peak Torque	75.43	(9.2)	2.06	65.65	(8.4)	1.89	5.91	S
120°/s	Torque/body weight	101.38	(14.1)	3.15	87.87	(9.5)	2.13	5.73	S
120°/s	Total Work	1550.84	(294.7)	65.92	1238.99	(227.5)	50.88	7.78	S
120°/s	Work/body weight	162.43	(34.6)	7.75	131.72	(25.2)	5.65	7.54	S
60°/s	Peak Torque	77.63	(12.5)	2.81	64.28	(9.6)	2.17	7.63	S
60°/s	Torque/ body weight	104.52	(18.8)	4.21	86.26	(13.0)	2.91	7.49	S
60°/s	Total Work	664.69	(118.1)	26.43	511.56	(93.7)	20.97	9.49	S
60°/s	Work/body weight	193.65	(40.2)	9.00	150.99	(29.7)	6.66	9.05	S

Table 3.– Adduction movement in the right-handed men. S= significant ($p \leq 0.05$)

Statistical Method

In each group of the study, the isokinetic variables were compared between both extremities with Student's t-test, after verification of normality with Kolmogorov-Smirnov's test, and with an accuracy interval of 95%.

Previously, ANOVA had been implemented for the total sample to confirm the influence of sex on the parameters; the results pointed to a highly significant difference between men and women. Likewise, ANOVA was performed to confirm the influence of the effect of handedness on men and women.

		Dominant (R)			***Non-dominant (L)***				
Speed	**Measures**	**$\bar{x}$**	**(S.D.)**	**S.E.**	**$\bar{x}$**	**(S.D.)**	**S.E.**	**t- value**	**p**
120°/s	Peak Torque	44.12	(7.5)	2.39	45.29	(7.3)	2.33	-1.05	N.S
120°/s	Torque/body weight	58.99	(15.0)	4.76	60.47	(14.5)	4.60	-0.89	N.S
120°/s	Total Work	727.54	(148.8)	47.07	645.9	(144.6)	45.74	5.25	S
120°/s	Work/body weight	77.93	(19.3)	6.12	71.51	(18.1)	5.73	2.78	S
60°/s	Peak Torque	48.21	(11.0)	3.49	51.11	(12.6)	4.00	-2.06	N.S
60°/s	Torque/ body weight	63.14	(13.4)	4.25	66.27	(11.1)	3.54	-2.01	N.S
60°/s	Total Work	339.98	(70.8)	22.39	314.09	(76.1)	24.07	2.85	S
60°/s	Work/body weight	99.35	(20.4)	6.47	92.22	(22.8)	7.24	3.40	S

Table 4.– Abduction movement in the left-handed men. S= significant ($p \leq 0.05$) N.S= non significant ($p > 0.05$)

		Dominant (R)			***Non-dominant (L)***				
Speed	**Measures**	**$\bar{x}$**	**(S.D.)**	**S.E.**	**$\bar{x}$**	**(S.D.)**	**S.E.**	**t- value**	**p**
120°/s	Peak Torque	66.21	(15.6)	4.94	65.63	(20.4)	6.48	0.16	N.S
120°/s	Torque/body weight	86.56	(20.6)	6.54	85.12	(22.7)	7.19	0.30	N.S
120°/s	Total Work	1210.90	(328.3)	103.83	1098.12	(307.5)	97.25	2.81	S
120°/s	Work/body weight	130.34	(41.9)	13.28	115.53	(36.0)	11.41	1.96	N.S
60°/s	Peak Torque	66.31	(16.2)	5.13	62.42	(12.2)	3.86	1.30	N.S
60°/s	Torque/ body weight	88.46	(27.9)	8.85	83.25	(21.5)	6.80	1.20	N.S
60°/s	Total Work	520.38	(130.6)	41.31	484.46	(108.0)	34.17	3.05	S
60°/s	Work/body weight	149.81	(44.8)	14.20	143.16	(39.6)	12.54	1.53	N.S

Table 5.– Adduction movement in the left-handed men. S= significant ($p \leq 0.05$) N.S= non significant ($p > 0.05$)

RESULTS

Right-handed Men

From the statistical analysis of the isokinetic variables between both extremities in the group of right-handed men, we found highly significant differences in all the force and work variables studied (peak torque, torque/body weight, total work and work/body weight), with a higher mean value for the right extremity in both movements and speeds. In consequence, handedness was evident for this limb, both in abduction and adduction, and at both 60°/s and 120°/s (Tables 2 and 3). Figure 1 shows the

		Dominant (R)			***Non-dominant (L)***				
Speed	**Measures**	**$\bar{x}$**	**(S.D.)**	**S.E.**	**$\bar{x}$**	**(S.D.)**	**S.E.**	**t- value**	**p**
120°/s	Peak Torque	23.98	(3.8)	0.86	21.57	(5.4)	1.23	3.70	S
120°/s	Torque/body weight	42.01	(6.3)	1.43	37.45	(7.8)	1.75	3.92	S
120°/s	Total Work	385.33	(81.3)	18.20	294.15	(110.7)	24.77	7.41	S
120°/s	Work/body weight	56.85	(11.1)	2.49	43.75	(12.6)	2.84	6.72	S
60°/s	Peak Torque	25.00	(4.2)	0.95	24.02	(5.7)	1.29	1.47	N.S
60°/s	Torque/ body weight	43.70	(6.3)	1.41	41.64	(8.1)	1.83	1.68	N.S
60°/s	Total Work	197.39	(34.5)	7.72	158.48	(45.2)	10.11	7.62	S
60°/s	Work/body weight	75.03	(11.6)	2.61	59.58	(13.8)	3.10	6.79	S

Table 6.– Abduction movement in the right-handed women. S= significant ($p \leq 0.05$) N.S= non significant ($p > 0.05$)

		Dominant (R)			***Non-dominant (L)***				
Speed	**Measures**	**$\bar{x}$**	**(S.D.)**	**S.E.**	**$\bar{x}$**	**(S.D.)**	**S.E.**	**t- value**	**p**
120°/s	Peak Torque	33.91	(7.9)	1.78	30.45	(6.9)	1.55	3.39	S
120°/s	Torque/body weight	59.08	(11.5)	2.58	53.00	(10.1)	2.28	3.62	S
120°/s	Total Work	613.42	(172.3)	38.54	535.08	(151.5)	33.89	3.86	S
120°/s	Work/body weight	85.99	(20.9)	4.68	76.21	(17.1)	3.83	3.84	S
60°/s	Peak Torque	34.52	(8.3)	1.86	31.25	(6.0)	1.35	2.79	S
60°/s	Torque/ body weight	60.10	(12.0)	2.70	54.51	(8.7)	1.95	2.88	S
60°/s	Total Work	280.19	(67.1)	15.02	255.45	(49.5)	11.08	2.64	S
60°/s	Work/body weight	106.73	(22.3)	4.99	99.18	(15.7)	3.52	2.15	S

Table 7.– Adduction movement in the right-handed women. S= significant ($p \leq 0.05$)

comparison of peak torque between both extremities at 60°/s and 120°/s in the abduction movement. Peak torque can be seen to be higher in the right limb than in the left one for both speeds (60°/s and 120°/s).

Tables 2 and 3 show the Student's t-test values, being statistically significant for all the variables explored with an accuracy interval of 95%.

Left-handed Men

For this group we found differences between both limbs in the work variables (among them total work) at both movements and speeds, with significantly higher mean values in the right limb.

However, there were no statistical differences in the isokinetic variables related to force and

		Dominant (R)			*Non-dominant (L)*				
Speed	**Measures**	**$\bar{x}$**	**(S.D.)**	**S.E.**	**$\bar{x}$**	**(S.D.)**	**S.E.**	**t- value**	**p**
120°/s	Peak Torque	26.28	(4.2)	1.33	25.04	(2.7)	0.87	1.18	N.S
120°/s	Torque/body weight	47.23	(5.6)	1.79	45.43	(6.7)	2.12	0.98	N.S
120°/s	Total Work	409.87	(71.2)	22.53	323.06	(74.4)	23.54	7.07	S
120°/s	Work/body weight	59.83	(7.1)	2.26	47.89	(7.9)	2.52	6.08	S
60°/s	Peak Torque	28.66	(4.0)	1.28	26.85	(4.3)	1.39	1.29	N.S
60°/s	Torque/ body weight	51.61	(5.4)	1.71	48.53	(7.9)	2.50	1.28	N.S
60°/s	Total Work	198.85	(24.2)	7.65	161.07	(33.0)	10.47	6.01	S
60°/s	Work/body weight	78.13	(8.9)	2.83	62.24	(11.5)	3.64	4.75	S

Table 8.– Abduction movement in the left-handed women. S= significant (p≤0.05) N.S= non significant (p>0.05)

		Dominant (R)			*Non-dominant (L)*				
Speed	**Measures**	**$\bar{x}$**	**(S.D.)**	**S.E.**	**$\bar{x}$**	**(S.D.)**	**S.E.**	**t- value**	**p**
120°/s	Peak Torque	37.90	(8.0)	2.53	35.12	(7.2)	2.29	1.16	N.S
120°/s	Torque/body weight	67.63	(9.8)	3.11	63.36	(12.9)	4.09	1.01	N.S
120°/s	Total Work	643.6	(152.4)	48.22	530.19	(115.0)	36.38	3.72	S
120°/s	Work/body weight	96.37	(16.3)	5.18	81.72	(12.4)	3.93	3.20	S
60°/s	Peak Torque	39.25	(7.9)	2.52	36.77	(7.3)	2.33	1.37	N.S
60°/s	Torque/ body weight	70.35	(11.9)	3.79	65.76	(9.0)	2.87	1.20	N.S
60°/s	Total Work	308.2	(58.8)	18.62	260.87	(49.9)	15.78	3.75	S
60°/s	Work/body weight	123.9	(18.3)	5.80	107.29	(16.3)	5.18	3.52	S

Table 9.– Adduction movement in the left-handed women. S= significant (p≤0.05) N.S= non significant (p>0.05)

nor did we observe any clear handedness in their left limb; at least it was less marked than in the right-handed men (Tables 4 and 5).

Right-handed Women

The variables regarding force and work (peak torque, torque/ body weight, total work and work/body weight) revealed the existence of statistically significant differences between both limbs, with higher mean values in the right one, except for the peak torque of abduction at 60°/s.

Here, the different behaviour of the upper limbs was evident, with a clearly dominant right limb (Tables 6 and 7).

Figure 2 shows the comparison of peak torque in the adduction movement between both limbs at 60°/s and 120°/s.

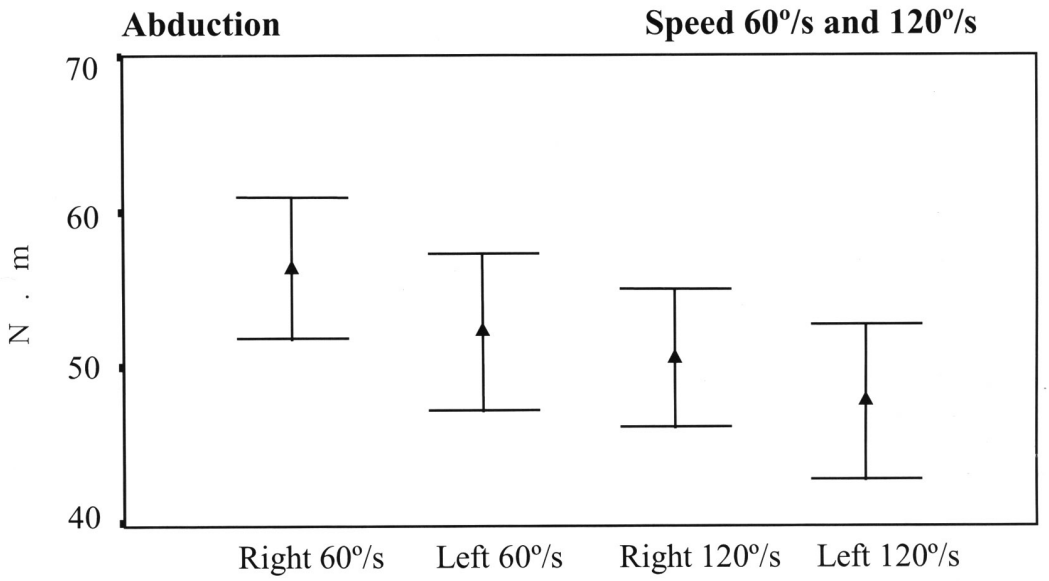

Fig. 1.– Means with 95% confidence interval of peak torque in the abduction movement between both extremities in the right-handed men. p≤0.05

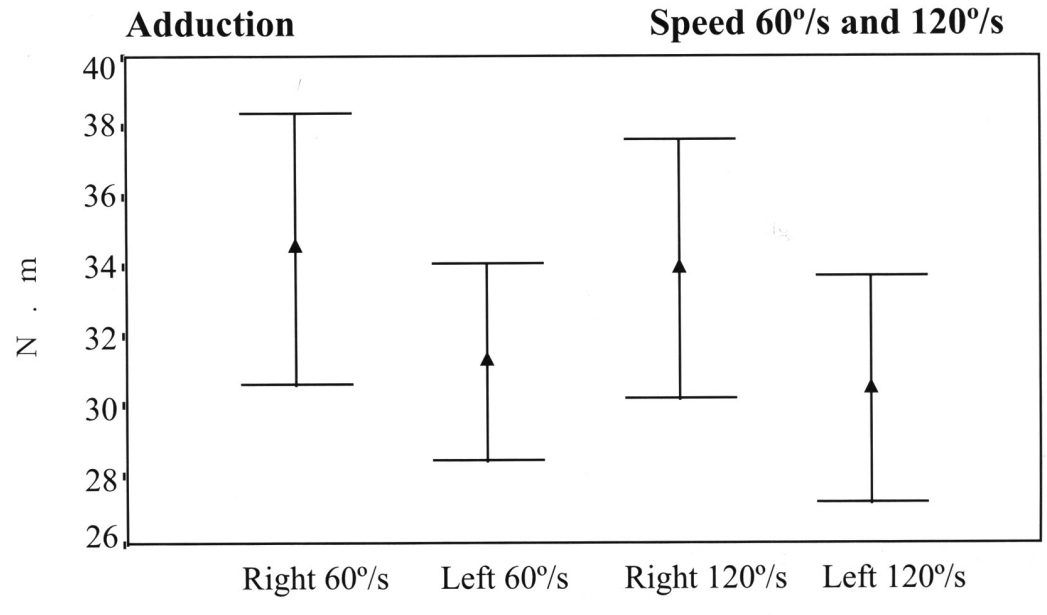

Fig. 2.– Means with 95% confidence interval of peak torque in the adduction movement between both extremities in the right-handed women. p≤0.05

Left-handed Women

The work variables (total work and work/body weight ratio), as the most representative variables, showed the existence of statistically significant differences between both limbs at both movements and speeds, with higher values in the right extremity. However, there were no statistical differences in the force variables. In consequence, handedness could not be confirmed in the left-handed women, whose behaviour was similar to that of the male group (Tables 8 and 9).

Work depends on force and also on the range of the arch described by the movement. In our opinion, the work of the right limb in the left-handed subjects may appear to be quantitatively higher because of the wider articular motion described by this extremity.

Discussion

After a review of the literature on isokinetic analyses of the shoulder, we cannot generalize and accept or reject a bilateral equivalence of the upper extremities and thus speak of handedness. This handedness appears in relation with the muscular group and sample evaluated, but specially in terms of sports activities. However, there is no consensus regardnig this. Some studies report statistically significant differences when comparing both upper limbs, force being greater in the dominant limb (Perrin et al., 1987; Cahalan et al., 1991; So et al., 1995). By contrast, in other studies the statistical differences between the dominant and non-dominant side do not appear in a global form (Ivey et al., 1985; Reid et al., 1989; Connelly-Maddux et al., 1989), even though in most of them force is described to be greater in the dominant limb.

The stronger muscular force in the shoulder corresponds to the adductor and extensor groups, precisely the groups in which some differences related to handedness have been shown. In these cases the samples comprised baseball players, particularly pitchers, who necessarily have well- trained adductor muscule groups (Alderink and Kuck, 1986; Wilk et al., 1995). For the same sample, in the abductor group no differences between the dominant and non-dominant side were reported.

Likewise, differences in isokinetic force appear in the flexo-extensor groups, with higher values in the dominant limb (Perrin et al., 1987; Otis et al., 1990).

On comparing the isokinetic force of the abductor-adductor muscule groups, between both upper limbs in our sample, the results were quite different for right-handed and left-handed subjects. The right-handed group was seen to have complete right handedness in both sexes, as reflected in the different isokinetic behaviours of both limbs. However, in the left-handed individuals, both men and women, left handedness was not so developed as to allow different isokinetic values regarding muscular force to be detected. Nevertheless, left handedness was evident in movement coordination, since all of them wrote and ate with the left hand.

Conclusions

The isokinetic handedness of the right upper limb of right-handed subjects is reflected in the abduction-adduction movement at both speeds assayed.

In the left-handed individuals, the isokinetic handedness of their left upper limb does not appear in the abduction-adduction movement at either of the speeds studied.

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