Intertester and intratester reliability of the standard goniometer and the cybex edi 320 for active and passive shoulder range of motion in normals and patients.

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ABSTRACT - The purpose of this study was (a) to document the intra and intertester reliability of measurements with the standard goniometer and the cybex EDI 320 of shoulder active and passive motion in healthy subjects and in clinical subjects under rigidly standardised condition (b) to study the correlation between both measurements and (c) study if an influence of sex exists on shoulder mobility. We believe that it is possible to measure reliable complex joints with a strictly standardized protocol, but the results obtained for intertester reliability are movement dependent and should be test prior to each study. We preferred the EDI as instrument to collect data because of its practical use. We strongly advice not to interchange the results of both techniques. The intratester reliability in the affected side of our patient population scored much higher than in the normal side. The evaluation of the effect of time intervals on the reliability showed higher values derived after a short interval of ten seconds. We also observed in our study a greater variability in the reliability values for the passive measurements in comparison with the active movements. Further a greater mobility was seen in the female subjects in comparison with the male subjects.

INTRODUCTION

Measurements and evaluation procedures are vital to today's healthcare system. Researchers and clinicians have widely advocated the use of shoulder range of motion (ROM) to objectively assess the function of patients with shoulder problems. All kinds of goniometers have been developed (Clapper and Wolf, 1988; Leighton, 1955; Petherick et al, 1988; Rheault et al, 1988) such as the electronic digital inclinometer (Cybex EDI 320) to make measurements more accurately.

METHODS

For the clinical set up 15 patients (range 23-66) were tested the day before their shoulder operation in the university hospital Pellenberg. Exclusion was made for patients older than seventy year and for those with a frozen shoulder. A sample of 8 normal subjects (4 females, 4 males) without postural abnormalities, shoulder pathology or surgery were tested bilateral. They were all students (age range 20-24 yr) and right handed, who were engaged in athletics favouring the dominant extremity. An informed consent was obtained from each subject. Selection of the optimal starting position was related directly to the design of the Cybex Edi 320 pendulum and determined by trial and error. An upright but relaxed position was requested as they were sitting on a tabouret. The tester palpated and marked the cranial border of the olecranon, the medial epicondylus and the cranial border of the processus styloideus radii on both sides. These marks are necessary for the measurement with the EDI. Instead of placing the instrument directly over the axis of motion, the EDI is placed distal from the axis of movement on the segment so that the pendulum is in a dependent position. The following measurements were taken: active and passive elevation, active and passive abduction, passive horizontal adduction, passive internal and external rotation. For standardisation the starting positions and movements as instructed by Norkins and White (1985) were applied with the goniometer and the same procedure could be used for the measurement with the Cybex EDI 320, with exception for the passive horizontal adduction. In the patient population the non- affected shoulder was measured first with the universal goniometer in the same sequence as mentioned before. Between each movement a rest period of ten seconds was taken and the measurements were repeated twice (with again 10 seconds rest) with the EDI 320. After two hours the same observer went again through the total procedure, including the two measurements with the EDI.

Statistics

For data analysis the INSTAT software package was used. Intratester and intertester reliability for repeated measures obtained by one tester as also the results between the observers were determined by the Pearson product-moment correlation coefficient. This coefficient was also used to examine the existence of the relationship between the values obtained with the standard goniometer and those obtained with the Cybex Edi 320 and to evaluate the effect of two time intervals on the reliability.

Table 1- *Intratester reliability of the measuring procedure with the goniometer and Cybex EDI 320 in the affected and non affected side (patient population). (Pearson' correlation) Correlation between the results obtained by the conventional goniometer (G) and the Cybex EDI 320 (E) by the same tester.*

	Goniometer		Cybex EDI 320		Intra non-affected side		Intra affected side	
Movement	not affec. side	affected side	not affec. side	affected side	G1-E1	G2-E3	G1-E1	G2-E3
active elevation	0.75	0.77	0.90	0.89	0.58	0.50	0.80	0.92
passive elevation	0.69	0.91	0.84	0.84	0.76	0.59	0.80	0.81
active abduction	0.79	0.89	0.87	0.94	0.94	0.85	0.92	0.88
passive abduction	0.74	0.84	0.71	0.90	0.89	0.86	0.84	0.91
passive internal rotation	0.74	0.87	0.74	0.81	0.69	0.49	0.83	0.80
passive external rotation	0.88	0.94	0.87	0.97	0.97	0.96	0.96	0.97
passive horizontal adduction	0.45	0.81	0.84	0.94	0.21	0.28	0.54	0.75

For interpretation of the Pearson product moment correlation coefficient the limit was set at .80 (Aufdemkampe and Meijer, 1989). Significant differences between sexes were determined using a student t-test and between both arms with a t-test for dependent variables.

RESULTS

For active range of motion (elevation and abduction), measured with the goniometer the correlation coefficient for intratester reliability was 0.75 and 0.79 for the non-affected side and 0.77-0.89 for the affected side, whereas for the passive range of motion 0.69-0.74 and 0.91-0.84 were obtained respectively. For the other passive movements the coefficients ranged from 0.45-0.88 and 0.81-0.94 for the affected side. The results of the measurements with the EDI 320 revealed: for the active motion in the non-affected side 0.87-0.90 and for the affected side 0.89-0.94. The Pearson correlation coefficients calculated for the passive movements ranged from 0.71-0.87 and 0.81-0.97, respectively (Table 1).
The intertester reliability for the goniometric measurements ranged from 0.81-0.86 for the active movements and 0.39-0.88 passively in the healthy population. For the EDI 320 these values between 0.82-0.87 were obtained actively and 0.59-0.85 passively (Table 2).
The correlation between the results obtained with the conventional goniometer and EDI 320 by the same tester revealed high values for the affected side, except for the horizontal adduction, whereas in the non-affected shoulder only passive and active abduction and the external rotation showed high values. The evaluation of the effect of time intervals on the reliability showed higher values derived after a short interval of ten seconds than after two hours. The second test-retest (10 sec.) revealed higher values than the first (Table 3).
Significant differences (Table 4) were found between both measurements technique in the younger healthy population for horizontal adduction, and external rotation.
In the patient population (Table 5) internal rotation was significantly lower in the non-affected shoulder when measured by the goniometer in comparison with the results found the cybexEDI 320, whereas in the affected shoulder external rotation and active abduction were significantly different. The comparison between males and females is presented in Table 6. Significant differences were found for all results except for elevation and internal rotation. The movement of horizontal adduction resulted in significant different values obtained with the EDI for males and females, whereas those

Table 2 - *Intertester reliability of both procedure in a healthy population.*

Movement	goniometer	cybex EDI 320
active elevation	0.81	0.87
passive elevation	0.78	0.77
active abduction	0.88	0.82
passive abduction	0.86	0.82
passive internal rotation	0.39	0.59
passive external rotation	0.83	0.85
passive horizontal adduction	0.82	0.79

Table 3 - *Intratester reliability of the Cybex EDI 320 measurements with short (10 seconds=E1-2 and E3-4) and long (2 hours=E1-3 and E2-4) time interval in patient population.*

	non-affected side				affected side			
Movement	E1-2	E1-3	E3-4	E2-4	E1-2	E1-3	E3-4	E2-4
active elevation	0.95	0.90	0.96	0.89	0.97	0.89	0.98	0.88
passive elevation	0.90	0.84	0.90	0.69	0.93	0.84	0.98	0.88
active abduction	0.95	0.87	0.96	0.86	0.99	0.94	0.99	0.97
passive abduction	0.96	0.71	0.96	0.74	0.99	0.90	0.99	0.91
passive internal rotation	0.89	0.74	0.94	0.76	0.94	0.81	0.95	0.88
passive ext. rotation	0.99	0.87	0.97	0.89	0.99	0.97	0.99	0.97
passive hor. adduction	0.91	0.84	0.93	0.83	0.96	0.94	0.98	0.93

obtained with the goniometer showed no differences.

DISCUSSION

Reliability in goniometry simple means the consistency or repeatability of the ROM measurements. The accuracy of a measurement is depending on a lot of factors as the complexity of the joint, active versus passive measurements, population, time interval and material. The literature offers an amount of articles about reliability measurements in the knee and elbow (Rothstein et al, 1983; Gogia et al, 1987; Petherick et al, 1988; Rheault et al, 1988), both considered as single hinged joints. Our results for intrarater reliability are in agreement with those results obtained by Riddle et al.(1987.87-.99). They concluded that the degree for intertester reliability for these measurements in consideration with the low values appears to be specific for the range of motion. For abduction, flexion and external rotation they observed accepTable values, whereas we found only low values for intertester reliability for the measurements of active abduction and passive horizontal adduction. Active versus passive movements can interfere with the obtained results. Gajosik and Bohannon (1987) cited Amis and Miller: ”passive movements are extremely difficult to reproduce because the stretching of soft tissues at the limb, which must therefore be carefully controlled.” We observed in our study also a greater variability in the reliability values for the passive measurements in comparison with the active movements. Another factor, the characteristics of the population, influences the results of repeated measurements. The intratester reliability in the affected side of our patient population scored much higher than in the non-affected side. We believe that the great variability in the pathologic shoulder range of motion gave rise to these results. The evaluation of the effect of time intervals on the reliability in our study showed higher values derived after a short interval of ten seconds than after two hours. The second test-retest (E3-4) of ten seconds revealed higher values

Table 4 - *Mobility of healthy subjectgroup; the results obtained by tester 1 (* $p<0.05$). Go = goniometer, Ed = EDI 320.*

		Mean	SD	SEM	Range	P
active elevation	Go	184.3	10.5	2.7	168-204	0.07
	Ed	181.5	10.5	2.7	161-201	
passive elevation	Go	189.0	8.5	2.2	176-206	0.15
	Ed	186.7	10.6	2.7	167-209	
active abduction	Go	180.1	10.1	2.6	160-190	0.18
	Ed	182.6	11.0	2.8	165-203	
passive abduction	Go	186.5	12.4	3.2	165-203	0.21
	Ed	184.8	11.5	2.9	166-202	
passive int. rotation	Go	58.6	9.8	2.5	45-85	0.32
	Ed	59.9	7.5	1.9	50-84	
passive ext. rotation	Go	115.5	11.0	2.8	100-135	0.0005*
	Ed	119.0	10.6	2.7	104-138	
passive horizontal adduction		64.6	6.1	1.5	53-75	0.016*
	Ed	68.4	5.4	1.4	62-78	

Table 5 - *Mobility of patients not affected side and affected side; the results obtained by tester 1. (* p<0.05), Go = goniometer, Ed = EDI 320.*

		non-affected side			affected side		
		Mean	SD	P	Mean	SD	P
active elevation	Go	176.4	7.2	0.83	123.4	22.8	0.62
	Ed	176.8	8.4		120.4	36.2	
passive elevation	Go	179.1	8.0	0.44	122.6	26.7	0.61
	Ed	177.9	8.6		125.6	37.7	
active abduction	Go	174.9	9.3	0.96	112.3	29.5	0.01*
	Ed	174.8	12.1		101.3	36.6	
passive abduction	Go	179.4	8.9	0.56	119.3	30.7	0.22
	Ed	178.6	12.1		113.1	34.8	
passive internal rotation	Go	54.4	12.3	0.02*	31.0	14.8	0.50
	Ed	60.6	9.5		29.6	11.6	
passive external rotation	Go	104.8	18.6	0.20	57.4	29.0	0.008*
	Ed	103.3	20.0		51.6	27.7	
passive horizontal adduction		51.4	7.5	0.08	26.0	14.8	0.88
	Ed	56.6	9.0		26.6	17.4	

than the first trial (E1-2), probably caused by a learning effect of both, patient and therapist. The most accurate evaluation of the reliability of the instrument and procedures is dertermined when short time intervals separate test (Koes et al, 1989). Reliability studies over days are clinically necessary to assess the stability for objective evaluation of follow-up studies or patient's improvements during the course of rehabilitation programs (Gajdosik and Bohannon, 1987). The EDI was used for determination of the reliability of measuring the cervical, thoracic and lumbar spine (Koes et al, 1989) and of the knee joint range of motion (Oosterveld and Overmars, ?) and they preferred the EDI as instrument to collect data. In our study we came to the same conclusion. We were able to demonstrate that women are more lax and possess a greater range of motion than men in most of the measured motions.

CONCLUSION

We believe that it is possible to measure reliable complex joints with a strictly standardised protocol, but the results obtained for intertester reliability are movement dependent and should be tested prior to each study. We preferred the EDI as instrument for collect data, because of its practical use especially with the passive movements. We strongly advice not to interchange the results of both techniques. The intratester reliability in the affected side of our patient population scored much higher than in the normal side. The evaluation of the effect of time intervals on the reliability showed higher values derived after a short interval of ten seconds. In our study we also observed a greater variability in the reliability values for the passive measurements in comparison with the active movements. Further a greater mobility is seen in the female subjects in comparison with the male subjects.

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Table 6 - Mobility of males and females healthy people; the results obtained by tester 1 (p<0.05), A=active, P=passive, F=females, M=males, Go= goniometer; Ed=Edi 320.*

		F	M	Mean	SD	SEM	Range	P
active elevation	Go	X		189.7	8.2	3.1	182-204	0.06
			X	179.6	10.3	3.6	168-196	
	Ed	X		186.7	8.6	3.2	178-201	0.07
			X	177.0	10.2	3.6	161-191	
passive elevation	Go	X		193.1	7.6	2.8	184-206	0.08
			X	185.5	8.0	2.8	176-197	
	Ed	X		192.1	10.7	4.0	182-209	0.06
			X	182.0	8.6	3.0	167-194	
active abduction	Go	X		186.4	2.7	1.0	183-190	0.018*
			X	174.6	11.1	3.9	160-186	
	Ed	X		190.5	9.2	3.4	175-203	0.004*
			X	175.7	7.5	2.6	165-186	
passive abduction	Go	X		194.4	6.8	2.5	186-203	0.015*
			X	179.6	12.4	4.4	165-195	
	Ed	X		193.5	5.9	2.2	185-202	0.002*
			X	177.1	9.4	3.3	166-192	
passive int. rotation	Go	X		62.8	12.8	4.8	45-85	0.12
			X	54.8	4.0	1.4	49-62	
	Ed	X		63.0	9.9	3.7	57-84	0.15
			X	57.2	3.2	1.1	50-61	
passive ext. rotation	Go	X		124.4	6.6	2.5	113-135	0.0006*
			X	107.7	7.5	2.6	100-121	
	Ed	X		128.1	5.9	2.2	119-138	0.0002*
			X	111.2	6.4	2.2	104-123	
passive hor. adduction	Go	X		67.4	6.8	2.5	58-75	0.098
			X	62.1	4.6	1.6	53-67	
	Ed	X		73.1	3.5	1.3	69-78	0.0001*
			X	64.3	2.7	0.9	62-69	