The effects of age, sex, and shoulder dominance on range of motion of the shoulder

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To determine the effects of age, sex, and arm dominance on shoulder range of motion, we measured active and passive forward elevation, abduction, internal and external rotation at 90° of abduction, external rotation with the arm adducted, and extension bilaterally in 280 subjects ranging in age from 4 to 70 years. Linear regression analyses were performed for all motions except forward elevation. This motion, which showed a nonlinear pattern of decline with age, was evaluated with 3-way analysis of variance. Shoulder range of motion decreased with age for all measured motions with the exception of internal rotation, which increased with age. Female subjects had a significantly greater range of motion than male subjects for all motions measured. Dominant arms displayed significantly greater external rotation than nondominant, regardless of whether the arm was abducted or adducted at the time of measurement. However, nondominant shoulders demonstrated significantly greater internal rotation and extension than dominant. No significant differences were found between dominant and nondominant sides for forward elevation or abduction. (J Shoulder Elbow Surg 2001;10:242-6.)

INTRODUCTION

Knowledge of normal shoulder range of motion (ROM) is useful when assessing clinical pathology, evaluating impairment, and determining the effects of treatment. As clinical outcome studies become more common, knowledge of the variables that affect shoulder motion may become even more important.

Clinical observations suggest that age, sex, and hand dominance affect normal shoulder ROM. Although previous studies have sought to establish a relationship between these variables and joint movement,[1,6,9,11-13,16] the data thus far have been inconsistent. The purpose of this study was to determine to what degree, if any, these variables affect normal shoulder ROM.

MATERIALS AND METHODS

We measured shoulder ROM in 40 subjects (20 male subjects and 20 female subjects) in each of the following age groups: 0 to 10 years, 11 to 20 years, 21 to 30 years, 31 to 40 years, 41 to 50 years, 51 to 60 years, and 61 to 70 years. These 280 subjects ranged in age from 4 to 70 years. Participants were excluded from the study if there was a history of shoulder surgery, dislocation or fracture, or recent shoulder pain. Age, sex, race, occupation type, history of sports participation, the throwing arm, and the hand used for writing were recorded for all subjects. If the throwing arm and the hand used for writing were different, then the throwing arm defined dominance. With this method of classification, 254 subjects were classified as right arm dominant and 26 subjects were classified as left arm dominant. Two hundred fifty-eight subjects were white, 13 were African American, and 9 were Asian.

Bilateral active and passive forward elevation, abduction, internal and external rotation at 90° of abduction, external rotation with the arm adducted, and extension were measured once in all subjects. Within each age group, one half of the subjects had active motion measured first and the other one half had passive motion measured first to minimize the effects of warm-up on subsequent shoulder ROM. All measurements were made with a 360° clinical goniometer with 10-inch movable arms with standard techniques.[2,15] Participants were supine on an examination table for all motions except extension, for which they were prone. While supine, subjects flexed their hips and knees so that their feet were flat on the table to prevent them from arching their backs. Maximum forward elevation was recorded rather than flexion exclusively in the sagittal plane. When measuring internal rotation, we allowed motion to occur until the spine of the scapula began to lift off the examination table. This defined the maximum value for internal rotation. One author measured all participants to eliminate interobserver error.

After all data were recorded, means ± SDs for all 6 measured motions were calculated for dominant and nondominant shoulders in both the active and passive modes. Linear regression analyses were used to determine the effects of age, sex, and shoulder dominance on shoulder ROM. ROM was regressed against the quantitative vari-

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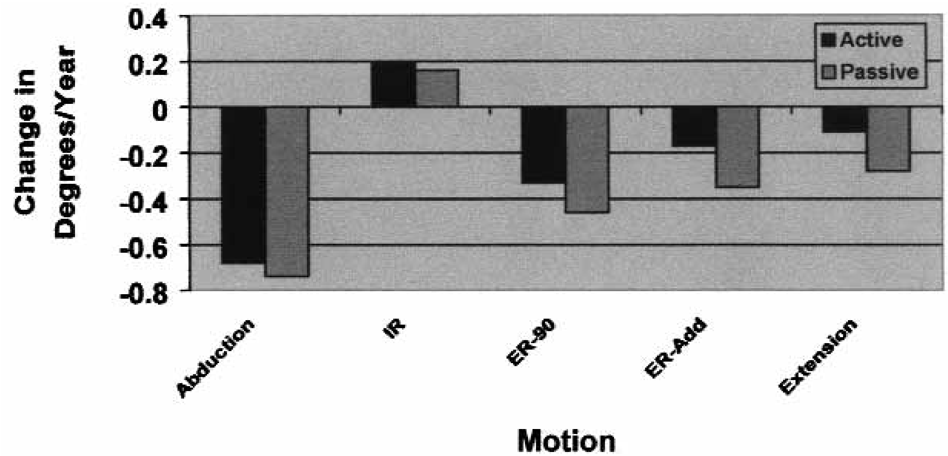

Figure 1 Results of regression analyses. *IR,* Internal rotation; *ER,* external rotation; *Add,* adduction.

able age and the qualitative variables dominance and sex for each motion measured. Additional variables were defined as measuring mode (active or passive), race, history of sports participation, and occupation type.

There were 2 limitations to the analyses described above. First, forward elevation was eliminated from regression analyses because most subjects in the younger age groups were able to achieve 180° of forward elevation—the clinical maximum. This truncated value precluded the use of a linear regression model for this motion. Therefore 3-way, nested analysis of variance (ANOVA) was used to examine the relationship between age and forward elevation. The variables in these analyses were sex, shoulder dominance, and age by decade. Second, for abduction measurements, separate linear regression analyses were performed that excluded the 0- to 10-year-old age group. This was done because the maximum value of abduction of several of the young children was limited by their proportionally large head sizes.

After data analysis was completed, separate analysis of variance studies were performed on the 0- to 10-year-old age group to determine whether the significant results obtained for shoulder dominance in the study population as a whole could be demonstrated at an early age. The variables in this analysis were arm dominance and sex. In all cases we defined significance as a P value < .05.

RESULTS

Age was found to have a statistically significant effect on all motions analyzed (P < .01, in both the active and passive measuring modes). Although the values for forward elevation, abduction, external rotation with the arm abducted, external rotation with the arm adducted, and extension predictably decreased with age, active and passive internal rotation increased with age (Figure 1).

Female subjects had statistically greater motion than male subjects for all motions measured. This was true in both the active and passive modes (P < .01 for all motions except active extension, for which P = .021) (Table I, Figures 2 and 3).

The nondominant shoulder had greater active internal rotation (P < .01), passive internal rotation (P < .01), active extension (P < .01), and passive extension (P = .013) than the dominant shoulder (Table I, Figures 2 and 3). However, the dominant shoulder displayed significantly greater active and passive external rotation than the nondominant shoulder, regardless of whether the arm was abducted or adducted at the time of measurement (P < .01 in all cases) (Table I, Figures 2 and 3). No significant differences were found between dominant and nondominant sides for forward elevation or abduction (Table I, Figures 2 and 3). Race, occupation type, and sports participation all had no statistically significant effect on shoulder ROM. However, passive ROM was greater than active ROM for all measured motions (P < .01).

In the 0- to 10-year-old age group, the mean age was 7.38 years (range, 4 years 1 month to 10 years 11 months). Within this age group, the nondominant shoulder had greater active internal rotation (P < .01) and passive internal rotation (P = .026), whereas the dominant shoulder had greater active external rotation with the arm abducted (P < .01) and passive external rotation with the arm abducted (P < .01). However, the effects of shoulder dominance on external rotation with the arm adducted and extension were not statistically significant when this age group alone was analyzed.

DISCUSSION

Prior studies have attempted to establish norms for shoulder ROM and to determine whether age, sex, or hand dominance influences shoulder motion.[1,6,9,11-13,16] However, the data thus far have conflicted. Although some authors have reported a consistent decrease in ROM with aging,[1,9] others have found that only some shoulder motions are significantly affected by age.[6,16]

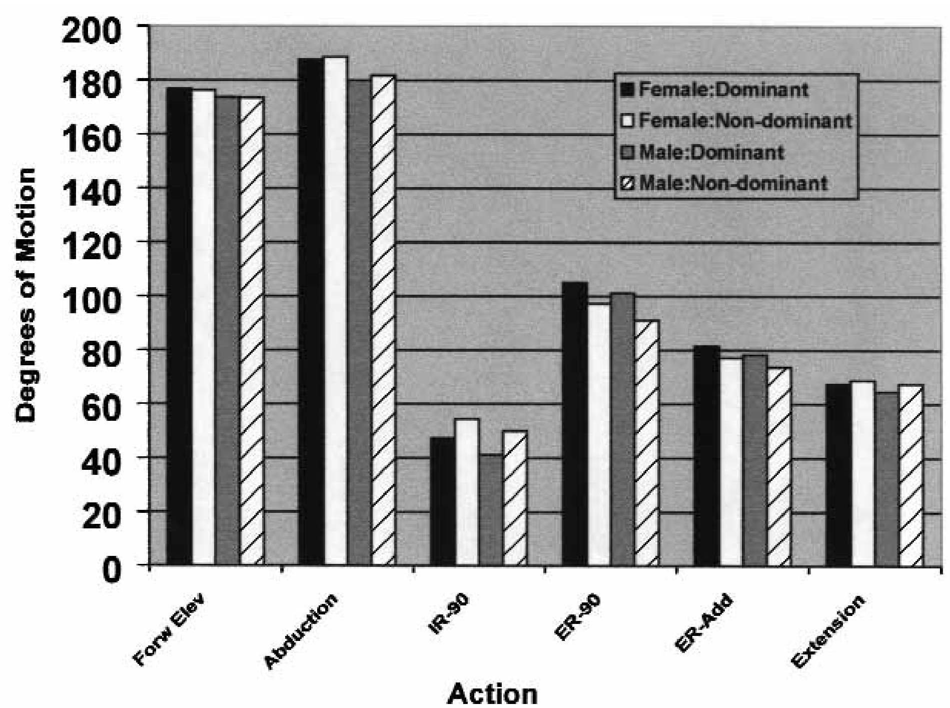

Figure 2 Mean active motion. *Forw Elev,* Forward elevation; *IR,* internal rotation; *ER,* external rotation; *Add,* adduction.

Table I Mean active and passive motion

	Female subjects		Male subjects	
	Dominant	**Nondominant**	**Dominant**	**Nondominant**
Active ROM				
Forward elevation	176.7 ± 5.5	176.2 ± 5.9	173.6 ± 8.0	173.5 ± 7.6
Abduction	187.6 ± 16.1	188.6 ± 15.4	180.1 ± 18.2	181.8 ± 17.1
IR-90°	47.5 ± 11.2	54.5 ± 11.3	41.2 ± 9.3	50.1 ± 10.2
ER-90°	104.9 ± 12.0	97.3 ± 11.3	101.2 ± 11.6	91.1 ± 12.0
ER-adduction	81.4 ± 13.0	77.2 ± 12.1	78.3 ± 10.6	73.7 ± 11.7
Extension	67.3 ± 8.7	68.7 ± 9.3	64.6 ± 9.6	67.3 ± 9.2
Passive ROM				
Forward elevation	178.7 ± 3.5	178.3 ± 4.4	176.2 ± 7.4	176.1 ± 6.6
Abduction	194.6 ± 16.5	195.0 ± 16.6	187.4 ± 18.9	189.0 ± 18.3
IR-90°	57.5 ± 12.3	65.4 ± 12.2	48.6 ± 7.0	63.5 ± 8.2
ER-90°	118.0 ± 15.5	110.2 ± 15.1	113.8 ± 15.7	101.9 ± 15.5
ER-adduction	92.3 ± 13.2	87.3 ± 12.5	87.2 ± 12.9	82.2 ± 13.4
Extension	83.2 ± 11.2	84.6 ± 11.3	77.4 ± 11.8	80.0 ± 10.1

ER, External rotation; *IR,* internal rotation.

Several authors have found that female subjects have greater shoulder ROM than male subjects.[1,9,13] However, Johnson et al[12] reported that values for externally rotated abduction were greater in male subjects than in female subjects, and Murray et al[16] found sex-related differences to be minimal. Although some authors have found ROM to be similar in dominant and nondominant shoulders,[1,6,9,13] increased outward rotation of the dominant arm has been reported.[16] In contrast, Gunal et al[11] found consistently less motion in the dominant shoulders of the 1000 right-handed Turkish military recruits they studied.

Variations in population size and composition, study design, and measuring techniques undoubtedly contribute to the confusion regarding the influence of age, sex, and dominance on shoulder ROM. We recognized the need to examine a large number of subjects over a broad age range to determine whether these variables influence shoulder ROM.

In the evaluation of a large study population, the

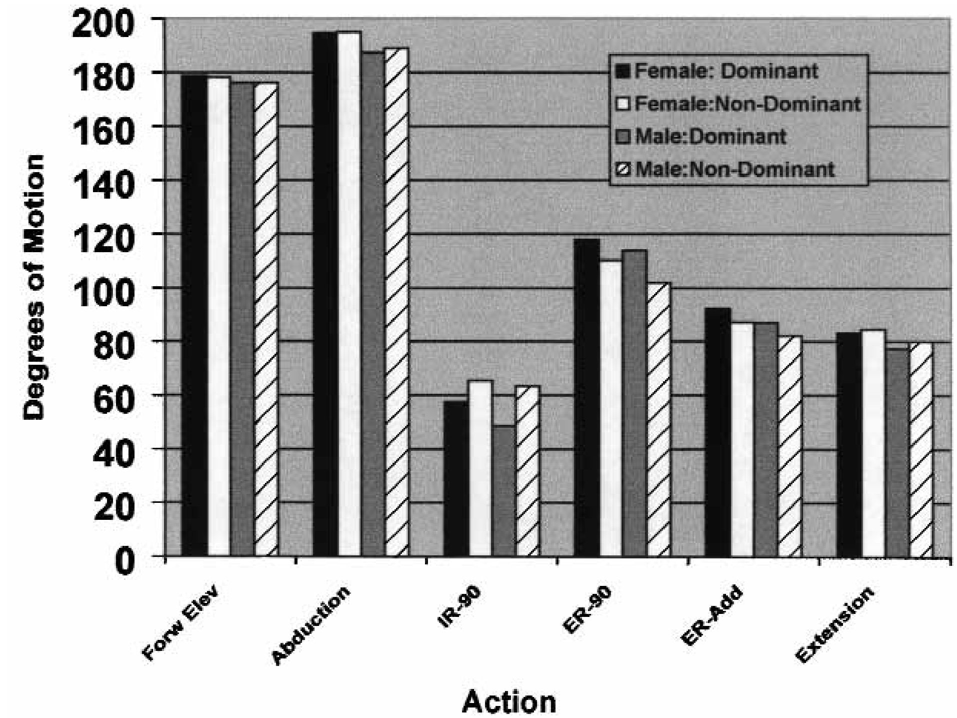

Figure 3 Mean passive motion. *Forw Elev,* Forward elevation; *IR,* internal rotation; *ER,* external rotation; *Add,* adduction.

issue of statistical versus clinical significance becomes important. Several methods for measuring shoulder ROM are available. Equipment such as an electromagnetic movement sensor and the Cybex II isokinetic dynamometer (Cybex International, Medway, Mass) has been used to evaluate shoulder ROM.[4,12] However, the measurements derived do not necessarily correlate with those obtained with different measuring techniques. In this study a manual goniometer was chosen to measure ROM because of the ease with which this device can be obtained and applied clinically. The use of a clinical goniometer to measure upper extremity ROM has been demonstrated to be reliable, particularly when the same observer is responsible for repeated measurements.[5,14,17]

In this study population, amplitudes of shoulder ROM decreased with age for all measured motions, except internal rotation. Although an increase in internal rotation with age was surprising, this finding has been reported previously.[16] In our study population the largest age-related differences in this motion were observed when comparing the 0- to 10-year-old age group with the older age groups as a whole. Although continued increases in internal rotation with age occurred, the magnitude of change was relatively small after the age of 11 years.

The remaining motions evaluated in this study showed a decrease with aging, though the manner in which ROM declined varied in magnitude. As Figure 1 illustrates, the amount of change per year was larger for abduction and external rotation with the arm abducted than for extension and external rotation with the arm adducted. Special mention should be made with regard to the influence of age on forward elevation. Because several individuals in the first 4 decades were able to achieve 180°, the clinical maximum, of this motion, a linear decline in forward elevation was not seen. However, a decline of approximately 10° was seen over the last 3 decades in our study population. Thus, although one can expect a decline in shoulder abduction, external rotation, and extension over a period of several years even in a young, healthy individual, a loss of forward elevation in patients under the age of 40 years should not be attributed merely to aging.

In this specific population of healthy individuals, we would not expect the magnitude of change in shoulder motion with aging to affect functional status adversely. However, it is possible that these age-related changes are large enough to affect the determination of shoulder impairment, particularly in older patients.

Our results regarding sex and shoulder ROM confirmed our clinical impression that female subjects have a greater magnitude of motion than male subjects. The motions with the largest differences were abduction, internal rotation, external rotation with the arm abducted, and external rotation with the arm adducted, as shown in Table I and Figures 2 and 3.

Although differences in ROM based on sex revealed a consistent pattern in this study population, our results that compared the amplitudes of motion between dominant and nondominant shoulders varied with the motion being tested. There were no statistically significant differences for forward elevation or abduction. In contrast, dominant arms displayed significantly more external rotation, regardless of whether the arm was abducted or adducted during measurement. The converse was true for internal rotation and extension. However, the magnitude of difference between shoulders for extension was relatively small (Table I, Figures 2 and 3) and thus may be difficult to detect clinically.

The lack of consistent findings regarding shoulder dominance and ROM in the past has led some to suggest that an uninjured limb can be used as a control when one is evaluating contralateral shoulder impairment.[6] Our results indicate that the differences between dominant and nondominant shoulder ROM for internal and external rotation are of sufficient magnitude that such comparisons may be misleading.

Several studies have examined shoulder ROM in athletic populations such as professional baseball players,[3] intercollegiate athletes,[4] and competitive tennis players.[7,8,10] Among the findings reported in these select populations are an increase in shoulder external rotation in the dominant extremity[3,4,7,8] and a decrease in shoulder internal rotation in the dominant extremity.[3,7,8,10] In our population even the young, prepubescent age group (0-10 years) demonstrated statistically significant differences between shoulder internal and external rotation. This makes it difficult to attribute these dominance-related differences solely to repetitive microtrauma sustained from athletic participation.

To our knowledge, this study represents the largest cohort of North American individuals in whom shoulder ROM was measured. The standards for normal shoulder ROM that currently exist[2] are based on an investigation of 109 male subjects under the age of 55 years in which only minimal differences between dominant and nondominant shoulders were found.[6] Our results suggest that guidelines for shoulder ROM should include male and female subjects of varying ages. The influence of arm dominance should also be considered, particularly when one is evaluating shoulder rotation.

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