Decreased Shoulder Range of Motion on Paretic Side After Stroke

The purposes of this investigation of patients with stroke were to 1) determine and compare shoulder lateral rotation range of motion (SLRROM) measured at the threshold of pain on the paretic and nonparetic sides; 2) establish the intrarater and interrater reliability of the measurements; and 3) determine the relationship between SLRROM measurements and the independent variables of age, sex, and time since onset of stroke. Subjects were 25 rehabilitation inpatients. The two investigators each measured the patients' SLRROM twice on both the paretic and nonparetic sides using a gravity goniometer. An analysis of variance (ANOVA) demonstrated that SLRROM was significantly less on the paretic side than on the nonparetic side ($F = 28.98$, $p < .001$). The ANOVA demonstrated no difference in the two raters' measurements of SLRROM. The intraclass correlation coefficients (ICC[3,1]) and interrater reliability coefficients were all good to high (.874–.989). The SLRROM on the paretic side correlated significantly with time since onset of stroke ($r = -.538$, $p < .01$). As a consequence of this study, we concluded that 1) patients with stroke tend to lose SLRROM on the paretic side, 2) SLRROM tends to decrease with time, and 3) measurements of SLRROM obtained with a gravity goniometer are reliable and sensitive. [Andrews AW, Bohannon RW: Decreased shoulder range of motion on paretic side after stroke. Phys Ther 69:768–772, 1989]

Key Words: Cerebrovascular disorders; Pain; Paresis; Upper extremity, shoulder.

The joints most often demonstrating decreased range of motion following stroke are the shoulder and the ankle. Clinicians working with patients with stroke may be concerned particularly with shoulder joint ROM because of the demonstrated relationship between limited ROM and pain in the paretic shoulder. Contributing to clinicians' concern is a knowledge that shoulder ROM restrictions worsen as time since stroke increases and a belief that the development of movement restriction at the shoulder is "a failure of management or failure to apply treatment at the appropriate time."[p192]

The clinician wishing to measure shoulder ROM in the stroke patient has numerous factors to consider. These factors include choices between motions, instruments, techniques, and interpretations of the measurements obtained. Although such factors have not been addressed in studies specific to stroke patients, results from other types of patients do provide some direction for clinicians concerned about measuring shoulder ROM in patients with stroke.

Granting that the range of many motions can be measured at the shoulder, lateral rotation may be the most appropriate single motion to measure in patients with painful stiff shoulders. Lateral rotation, which is a component of the "capsular pattern," is the most limited motion in painful stiff shoulders.

Two instruments, gravity and universal (standard) goniometers, have been used to measure shoulder ROM. Clarke et al used a gravity goniometer to measure passive shoulder ROM. They reported an average difference of less than 7% between two observers' measurements. Riddle et al used two different sizes of universal goni-
ometers to measure passive shoulder ROM. Among their subjects were patients with neurological disorders whose shoulder lateral rotation range of motion (SLRROM) was measured. The intratester reliability for the SLRROM measurements was .98 for both goniometers. The intertester reliability of the SLRROM measurements was .85 for the large goniometer and .88 for the small goniometer.

None of the studies we reviewed described the technique for establishing the end point for the shoulder ROM measurement. Nevertheless, we propose three possible criteria that might be used: 1) maximum possible ROM, 2) ROM until passive resistance is first felt, and 3) ROM to the point of pain. Because patients with stroke often demonstrate shoulder pain, the last measurement criterion might be particularly appropriate for them.

Among the factors that can be important in interpreting ROM measurements are "normal" ROM values, measurements of the contralateral side, and the influence of such variables as age and sex. In this introduction, these factors will be reviewed primarily as they relate to one motion—shoulder lateral rotation. Clarke et al reported mean measurements of SLRROM, depending on age, of 54.0 to 64.4 degrees for women and 47.4 to 66.8 degrees for men. Measurements reported by Murray et al were quite different, perhaps in part because they were of active motion. They reported mean SLRROMs of 94 and 101 degrees for young men and women, respectively, and of 82 and 94 degrees for older men and women, respectively. Clarke et al reported that shoulder ROM was related closely between sides ($r = .8, p < .001$) and that no difference existed based on dominance. Murray et al, however, reported that SLRROM on the dominant side was an average of 5 degrees greater than on the non-dominant side ($p < .01$). Both groups of investigators reported an influence of age on ROM. Clarke et al reported correlations of $-0.5$ to $-0.6$ between ROM and age in both sexes. Murray et al reported that young men had significantly greater SLRROM than older men. Sex was also shown to be a factor in SLRROM by the same two groups of investigators. Clarke and colleagues reported that "on the average, male subjects tended to have about 92 percent of the range of movement of their female counterparts." Murray and co-workers found that among older subjects, women had significantly greater SLRROM than men.

Despite these findings, SLRROM measurements obtained using specific instruments and techniques have not been reported for the paretic and nonparetic sides of stroke patients. It was the primary purpose of this investigation to determine and compare between sides SLRROM measured at the threshold of pain with a gravity goniometer. Additional purposes were to determine the intrarater and interrater reliability of the measurements and the relationship of age, sex, and time since onset of stroke with the measurements. Our expectations were 1) that SLRROM would be significantly less on the paretic side than on the nonparetic side, 2) that SLRROM measurements would be reliable, and 3) that time since onset of stroke would be correlated significantly with SLRROM but that age and sex would not be correlated significantly with SLRROM.

**Method**

**Subjects**

The initial convenience sample for this study consisted of 28 consecutively admitted patients who 1) were admitted to rehabilitation for their first stroke, 2) could follow instructions, 3) provided informed consent, and 4) had an appreciation of the position of their paretic upper limb in space. Criterion four was considered met when patients could find directly their paretic thumb with the nonparetic hand while their eyes were covered. Three of the patients, on interview, were found to have pre-morbid problems affecting their shoulders and were excluded from the study. The remaining 25 subjects were 12 men and 13 women. Twelve subjects were paretic on the left side, and 13 subjects were paretic on the right side. Their mean age was 61.4 ± 11.4 years (range = 33–84 years). The mean time since onset of stroke was 74 ± 103 days (range = 11–511 days).

**Instrumentation**

Shoulder lateral rotation range of motion was measured using an MIE fluid-filled gravity goniometer* affixed to a clear 30-cm ruler. The goniometer was marked in 1-degree increments.

**Procedure**

This investigation, which was a component of a larger study, involved eight repeated measures of SLRROM. Before SLRROM was measured, all subjects were told that they were to inform the tester when they first felt pain in their shoulders during the testing. They were told to disregard any pulling sensation or sensation of tightness and to inform the tester only when they first experienced pain. Two measurements were performed by each of two investigators (AWA and RWB) on both the paretic and nonparetic sides. The order in which the measurements were performed by the two investigators and on the two sides varied. The senior investigator (RWB) tested 14 subjects first. The paretic side was tested first in 16 subjects. During all measurements, the subjects were positioned supine on a padded mat table with their shoulders abducted 45 degrees, their elbows held at 90 degrees, and their forearms pronated. Measurements of SLRROM were begun from a position of neutral shoulder rotation. From that position, the testers slowly rotated the shoulders laterally to the threshold of pain (ie, until the subjects expressed

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that they first felt pain in the shoulder). The tester then positioned the goniometer and the ruler on a line from the olecranon to the lateral styloid process and measured the subject's SLRROM (Figure). Each investigator was "blind" to the other's measurements but not to his own. Repeated measurements by the same investigator were separated by about 30 seconds. Measurements by the two investigators were separated by one-to-five-minute intervals.

**Data Analysis**

Descriptive statistics were calculated for each investigator's measurements of SLRROM. From the senior investigator's measurements, tallies were performed of the number of subjects whose nonparetic shoulders had more SLRROM than their paretic shoulders, regardless of the amount, at least 10 degrees more SLRROM, and at least 20 degrees more SLRROM. Using the mean of each investigator's two measurements, a 2×2 analysis of variance (ANOVA) for repeated measures was performed to compare SLRROM measurements at the threshold of pain between sides and raters. One-way ANOVAs were performed and intraclass correlation coefficients (ICC[3,1]) were calculated to establish the reliability within and between raters' measurements on both sides. The mean of each rater's two measurements was used for determining intrarater reliability. The Pearson product-moment correlation (r) was used to determine the relationship between the senior investigator's measurements of SLRROM on the two sides and the three independent variables (age, sex, and time since onset of stroke).

**Results**

Table 1 presents a summary of the two raters' measurements of SLRROM. Twenty of the 25 subjects had greater SLRROM on the nonparetic side than on the paretic side. The SLRROM of the nonparetic side was greater than on the paretic side by 10 or more degrees in 19 subjects and by 20 or more degrees in 14 subjects. The ANOVA demonstrated that the SLRROM was significantly greater on the nonparetic side than on the paretic side (F = 28.98, p < .001) (Tab. 2). All SLRROM measurements, both within and between raters, were quite comparable (Tab. 1). The differences between raters, however, are larger than those within raters. The ANOVA did not demonstrate the difference between raters to be significant (F = 0.13, p = .722) (Tab. 2). All ICCs were consistent with good to high reliability. The intrarater ICCs were .944 and .989 for the nonparetic and paretic sides, respectively, for rater AWA and .976 and .989 for the nonparetic and paretic sides, respectively, for rater RWB. The interrater ICCs were .874 on the nonparetic side and .961 on the paretic side. Table 3 shows the correlations between SLRROM and the three independent variables (time since onset of stroke, age, sex). The only significant correlation was between the SLRROM on the paretic side and time since onset of stroke (p < .01).

**Discussion**

In this study, the shoulder motion most often restricted in patients with stiff painful shoulders—SLRROM—was measured. On the nonparetic side, the passive measurements of SLRROM at the threshold of pain were greater than the passive measurements reported by Clarke et al but roughly comparable to the active measurements reported by Murray et al. The measurements on the paretic side, on the contrary, were within the range reported by Clarke et al but considerably less than the values reported by Murray et al. In keeping with our expectations and consistent with Fugl-Meyer et al, the measurements were reduced on the paretic side as compared with the nonparetic side. This finding is particularly noteworthy because the measurements...
Table 1. Summary of Two Raters' Measurements of Shoulder Lateral Rotation Range of Motion (SLRROM) (in Degrees) on Paretic and Nonparetic Sides of Patients with Stroke (N = 25)

<table>
<thead>
<tr>
<th>Side</th>
<th>Rater</th>
<th>Trial</th>
<th>SLRROM</th>
<th>Difference in SLRROM</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Intrarater</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(\bar{X} )</td>
<td></td>
</tr>
<tr>
<td>Paretic</td>
<td>AWA</td>
<td>1</td>
<td>64.8</td>
<td>3.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>64.2</td>
<td>6.7</td>
</tr>
<tr>
<td></td>
<td>RWB</td>
<td>1</td>
<td>64.8</td>
<td>3.3</td>
</tr>
<tr>
<td>Nonparetic</td>
<td>AWA</td>
<td>1</td>
<td>91.3</td>
<td>4.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>91.1</td>
<td>6.2</td>
</tr>
<tr>
<td></td>
<td>RWB</td>
<td>1</td>
<td>91.5</td>
<td>1.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>92.4</td>
<td></td>
</tr>
</tbody>
</table>

*Calculated from the absolute difference between each rater's two trials for each subject.

*Calculated from the absolute difference between the mean of the two raters' two trials for each subject.

were taken soon after the subjects were admitted to the rehabilitation center. Whether the limitations represent "a failure of management or failure to apply treatment at the appropriate time," (p192) however, remains to be determined.

Using a gravity goniometer and using the threshold of pain as an end point of measurement, reliability between and within raters was found to be good to high and comparable to that reported by Riddle et al, who used universal goniometers. Thus our expectation regarding reliability was fulfilled. Because pain and ROM limitations are both frequent consequences following stroke, a measurement that incorporates both (ie, SLRROM measured at the threshold of pain) may be quite useful to the clinician. By limiting the ROM measurement to the threshold of pain (which occurs prior to or at the point of capsular restriction), the patient is spared unnecessary discomfort. By identifying the threshold of pain with a ROM measurement, a precise indication of ROM-limiting pain is identified. Such a measure may be highly sensitive for identifying the response of the patients to regimens directed at preventing or treating shoulder pain. Although ease of application was not studied in this project, both testers considered measurement of SLRROM with the gravity goniometer to be easier than with the universal goniometer.

Table 2. Analysis-of-Variance (ANOVA) Summary Comparing Shoulder Lateral Rotation Range of Motion Measurements* Obtained by Two Raters from Paretic and Nonparetic Sides of Patients with Stroke (N = 25)

<table>
<thead>
<tr>
<th>Source</th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side (S)</td>
<td>1</td>
<td>18279.04</td>
<td>18279.04</td>
<td>28.98</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Error</td>
<td>24</td>
<td>15139.34</td>
<td>630.81</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rater (R)</td>
<td>1</td>
<td>5.76</td>
<td>5.76</td>
<td>0.13</td>
<td>.722</td>
</tr>
<tr>
<td>Error</td>
<td>24</td>
<td>1066.12</td>
<td>44.42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S × R</td>
<td>1</td>
<td>1.96</td>
<td>1.96</td>
<td>0.06</td>
<td>.811</td>
</tr>
<tr>
<td>Error</td>
<td>24</td>
<td>802.92</td>
<td>33.46</td>
<td></td>
<td></td>
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</table>

*The mean of each rater's two measurements was used in the ANOVA.

We did not expect age or sex to affect measurements of SLRROM, despite the findings of others. Our expectations were based on the mean and standard deviation of the subjects' ages, our use of the threshold of pain as an end point of measurement, and our belief that the stroke itself has results of far greater influence on SLRROM than age or sex. These expectations were fulfilled. Because previous studies have shown a relationship between time since onset of stroke and either SLRROM or shoulder pain measured during such motion, we expected the signifi-
cant correlation that was found between SLRROM measured at the threshold of pain and time since onset of stroke. This relationship may or may not be consistent with a failure to act to prevent losses in ROM at the shoulder or a failure of applied actions to have their desired result. The results of different methods of treatment for preventing and correcting losses in SLRROM measured at the threshold of pain merit investigation. The relationship between such losses and function should also be studied.

Conclusions

Patients with stroke measured soon after admission to the rehabilitation center demonstrated SLRROM measurements that were significantly less on the paretic side than on the non-paretic side. The measurements were reliable within and between investigators. The SLRROM measurements on the paretic side were correlated negatively and significantly with time since onset of stroke. As a consequence of this study, we conclude that 1) patients with stroke tend to lose SLRROM on the paretic side, 2) SLRROM decreases as time passes following stroke, and 3) measurements of SLROM obtained with the gravity goniometer are reliable and sensitive. Such measurements, therefore, may merit broader clinical application.

References