Shoulder Dysfunction Assessment: Self-report and Impaired Scapular Movements

Background and Purpose. Shoulder dysfunction is common in various patient populations. This investigation was performed to assess shoulder dysfunction with self-report and performance-based functional measures. Subjects. Fifty men (25 with shoulder dysfunction and 25 without shoulder dysfunction) participated in this study. Methods. Self-report functional disabilities were assessed with the Flexilevel Scale of Shoulder Function (FLEX-SF), and electromagnetic tracking sensors were used to monitor 3-dimensional scapular movements during 4 functional tasks. Results. Relative to the control group, the group with shoulder dysfunction showed significant alterations in scapular movements (averages of 6.9° less posterior tipping, 5.7° less upward rotation, and 2.3 cm more elevation). Scapular kinematics correlated significantly \((r)\) with the Self-report FLEX-SF measure during functional tasks (posterior tipping \(= .454\) to \(.712\), upward rotation \(= .296\) and \(.317\), and elevation \(= -.310\)). Discussion and Conclusion. Functional disabilities were identified with self-report and performance-based functional measures. The inadequate scapular posterior tipping and scapular upward rotation as well as the excessive elevation may have implications in planning intervention strategies for people with shoulder dysfunction. [Lin J, Hanten WP, Olson SL, et al. Shoulder dysfunction assessment: self-report and impaired scapular movements. Phys Ther. 2006;86:1065–1074.]

Key Words: Activities of daily living, Biomechanics, Rehabilitation, Scapula, Shoulder-related dysfunction.

Jiu-jenq Lin, William P Hanten, Sharon L Olson, Toni S Roddey, David A Soto-quivano, Hyun K Lim, Arthur M Sherwood
The prevalences of shoulder dysfunction in various patient populations have been reported to be 34% of people 65 and older,1 64% of patients with stroke,2 and 78% of patients with spinal cord injury.3 Additionally, some occupational activities, such as polishing, sanding, and grinding, and certain recreational activities, such as overhead sports and wheelchair athletics, have been found to result in or to increase shoulder dysfunction.1–6 Shoulder dysfunction can affect an individual’s ability to function independently, consequently decreasing quality of life.7–10

The effects and prevalence of shoulder dysfunction have fostered the development of functional activity assessments for use in both research and clinical practice.11 Functional activity measures generally fall into 2 broad categories: self-report measures and performance-based measures.12 Self-report measures assess the effects of disorders in terms of patients’ functional limitations and disabilities and reflect the quality of life of patients. Assessment with a motion analysis system of functional tasks performed by patients can provide quantitative information and identify specific impaired movements.

In upper-quarter functional activities, scapular motion plays an important role in determining overall shoulder mobility. Scapular motion is a 3-dimensional movement that involves a combination of translation and rotation, which together act to allow efficient humeral motion. This motion is accomplished by the precise positioning of the glenoid on the spherical articular surface of the humeral head and by the maintenance of the optimum length-tension muscle relationships of the shoulder joint.13,14

Despite the critical role of the scapula in shoulder mobility, the characteristics of scapular movement impairments during functional tasks or the relationships between scapular movement impairments and functional disabilities in patients with shoulder dysfunction have not been adequately researched. Compared with people who are healthy, people with shoulder impingement syndrome showed decreased upward rotation (4.1°), decreased posterior tipping (average = 7°), and excessive scapular elevation during simple arm elevations.15–18 A protracted position of the scapula is considered to be a possible factor in shoulder subluxation.19 These studies focused primarily on abnormal scapular kinematics to explain shoulder pathologies such as impingement, rotator cuff injury, and frozen shoulder, but no studies have evaluated scapular movement impairments during functional tasks or the relationships between abnormal scapular movements and functional disabilities.
An investigation of the relationships between impaired scapular movements and functional disabilities would help clinicians target only those scapular movement impairments that are related to functional disabilities. The purposes of this study were to quantify and compare the 3-dimensional scapular movements of subjects with and subjects without shoulder dysfunction and to examine the relationships among scapular movements and self-report assessment scores for the affected shoulders in subjects with shoulder dysfunction. We hypothesized that subjects with shoulder dysfunction would exhibit less posterior tipping, less upward rotation, and more protraction of the scapula than would subjects without shoulder dysfunction during functional tasks. We also hypothesized that the abnormal scapular movements detected during functional tasks would reflect, among other factors, alterations in a subject’s assessment of his or her ability to perform various activities of daily living.

Method

Subjects
All subjects were adults who were at least 18 years of age. Subjects without shoulder dysfunction were defined as those not having experienced pain or limited range-of-motion (ROM) symptoms of the shoulder within the preceding 6 months. Subjects with shoulder dysfunction had right shoulder pain and limited ROM that were present at the time of the test and that had existed for at least 4 weeks, the ability to independently raise the affected arm overhead, and the consent of their physicians to participate in the study. Subjects with shoulder dysfunction were initially diagnosed by a physician and later were excluded after an examination by a physical therapist if they had cervical symptoms during a cervical screening examination (active and resisted ROM), numbness or tingling in the upper extremity, a history of onset of symptoms because of a traumatic injury, or a history of surgery on the shoulder.

Fifty subjects (25 subjects with shoulder dysfunction and 25 pair-matched subjects without shoulder dysfunction) met the inclusion and exclusion criteria of the investigation. One of the 25 subjects with shoulder dysfunction did not complete the study procedure because of pain and discomfort during the tasks. The demographic characteristics for all subjects are shown in Table 1. The mean age of the subjects was 54.5 years (SD=13.9).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Subjects With Shoulder Dysfunction a (n=24)</th>
<th>Subjects Without Shoulder Dysfunction b (n=25)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X</td>
<td>SD</td>
</tr>
<tr>
<td>Age (y)</td>
<td>57.5</td>
<td>13.8</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>95.2</td>
<td>18.8</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>178.3</td>
<td>6.3</td>
</tr>
<tr>
<td>FLEX-SF score</td>
<td>30.5 (32.2)</td>
<td>6.1 (5.5)</td>
</tr>
<tr>
<td>Scapular upward rotation (°)</td>
<td>6.2</td>
<td>6.0</td>
</tr>
<tr>
<td>Scapular protraction (°)</td>
<td>64.1</td>
<td>5.3</td>
</tr>
<tr>
<td>Scapular anterior tipping (°)</td>
<td>10.9</td>
<td>8.4</td>
</tr>
<tr>
<td>Duration (mo)</td>
<td>22.3</td>
<td>9.2</td>
</tr>
<tr>
<td>Flexion (°)</td>
<td>136</td>
<td>12</td>
</tr>
<tr>
<td>Abduction (°)</td>
<td>110</td>
<td>20</td>
</tr>
<tr>
<td>Internal rotation (°)</td>
<td>51</td>
<td>18</td>
</tr>
<tr>
<td>External rotation (°)</td>
<td>45</td>
<td>25</td>
</tr>
<tr>
<td>Pain</td>
<td>1.3</td>
<td>2.0</td>
</tr>
</tbody>
</table>

a Subjects were diagnosed as having rotator cuff injury (n=12), impingement (n=6), or adhesive capsulitis (n=6).
b P values are presented for comparisons between the 2 groups.
c FLEX-SF=Flexilevel Scale of Shoulder Function. FLEX-SF was assessed twice (before and after performing functional tasks). FLEX-SF scores obtained after performing functional tasks are shown in parentheses.
d Duration of symptom (pain or limited range or motion).
e At end range of shoulder motion.
f Pain intensity at the time of testing as determined with a visual analog scale (0–10).
Table 2. Description of the 4 Functional Tasks$^a$

<table>
<thead>
<tr>
<th>Task</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A: overhead height (hard task)</td>
<td>While sitting on a wooden chair (height=450 mm), the subjects used their right arms to lift and place an object (a bottle filled with 0.45 L of water) on the near edge of a height-adjustable desk at a constant distance (300 mm) from the wooden chair and at the height of the top of the subject's head.</td>
</tr>
<tr>
<td>B: shoulder height (routine task)</td>
<td>While sitting on a wooden chair, the subjects used their right arms to lift and place an object on the near edge of a height-adjustable desk at shoulder height.</td>
</tr>
<tr>
<td>C: sliding a box (medium task)</td>
<td>While sitting on a wooden chair, the subjects used their right arms to slide a box (weight=4.5 kg) across a table at desk height (760 mm) by pushing it away from them.</td>
</tr>
<tr>
<td>D: reaching for a saltshaker (easy task)</td>
<td>While sitting on a wooden chair, the subjects reached to the middle of a desk (height=760 mm) with their right arms to get a saltshaker (weight=0.3 kg) and bring it to the near edge of the desk.</td>
</tr>
</tbody>
</table>

$^a$The object or saltshaker in tasks A, B, and D was placed at the near edge of the desk in the sagittal plane of the acromial process of the scapula. The distance for the subjects to push the box and to reach for the saltshaker in tasks C and D was 1.2 times the arm length of each subject in the sagittal plane and was measured from the acromial process of the scapula. The arm length was measured from the acromial process of the scapula to the end of the middle finger while the subjects sat with their arms extended at their sides.

$(t_{(147)}=14.6, \ P<.0005)$. All subjects were men and were tested on their dominant arms. Each subject signed an informed consent form approved by the institutional review board of the Michael E DeBakey Veterans Affairs Medical Center.

FASTRAK Motion Analysis System

The FASTRAK motion analysis system* was used to detect shoulder complex movements. This system includes sensors, a transmitter, motion capture units, a personal computer, and 6-D research software.† Within a 76-cm source-to-sensor separation, the root-mean-square system accuracies are 0.15 degree for orientation and 0.3 to 0.8 mm for position.15,20 We also calibrated and verified the measurement accuracies before carrying out the main test by using a calibration table for the absolute distance and angles between markers.

Self-report FLEX-SF Measure

The selection of the FLEX-SF to assess shoulder function and disability in this study was based on its complete assessment of shoulder function and appropriate psychometric properties for reliability, validity, and responsiveness to clinical change.21 In this scale, respondents answer a single question that grossly classifies their level of function as low, medium, or high. Then they respond only to the items that target their level of function.

Functional Tasks

The 4 functional tasks (Tab. 2) included arm-raisings tasks (tasks A and B) and arm forward-reaching tasks (tasks C and D). These tasks were chosen from the 33 functional tasks used for the FLEX-SF questionnaire.21 In this scale, the 33 functional tasks may be categorized into 5 groups (easy tasks, moderate and easy tasks, moderate tasks, moderate and hard tasks, and hard tasks). The functional tasks in each group are similar in difficulty. In the interest of devising an efficient measure, we selected these 4 representative functional tasks because they were thought to have a similar moment arm and a similar center of mass of the shoulder joint but different levels of difficulty. Task B represents the single-question routine task, and tasks A, C, and D represent hard, moderate, and easy levels of function, respectively.

Procedure

After signing the informed consent form, the subjects were examined by a physical therapist to establish the clinical conditions of their shoulders, including ROM, current pain assessed with a visual analog scale, and the FLEX-SF questionnaire. The FASTRAK sensors then were attached to the bony landmarks with adhesive tape as described in previous reports.15,16,22,23 These 3 surface sensors were placed on the sternum and the flat superior bony surface of the scapular acromial process, and the points were secured with Velcro straps‡ to the distal humerus between the lateral and the medial epicondyles. A fourth sensor attached to a stylus was used to digitize palpated anatomic coordinates (bony landmarks: sternal notch, xiphoïd process, seventh cervical vertebra, eighth thoracic vertebra, acromioclavicular joint, root of the spine of the scapula, inferior angle of the scapula, lateral epicondyle, and medial epicondyle; the glenohumeral joint rotation center was operationalized from the anterior humeral joint and the posterior humeral joint). The thorax, scapula, and humerus were palpated and tracked (30-Hz sampling rate) while subjects sat with their arms relaxed at their sides. Kinematic data were collected for 5 seconds in this resting seated position.

$^a$Polhemus Inc, 49 Hercules Dr, PO Box 560, Colchester, VT 05446.
$^b$Skill Technologies Inc, 1292 E Maryland Ave, Suite 1G, Phoenix, AZ 85014.
$^c$Velcro USA Inc, 496 Brown Ave, Manchester, NH 03103.
Subjects then were asked to perform 4 functional tasks (Tab. 2). For the functional tasks, each subject was informed that during the investigation, it was important that the functional tasks be performed naturally, without trunk leaning or rotation compensation, and that they pretend that nobody was observing them. Additionally, specific postural instructions that were developed during pilot testing and standardized for all subjects were given to each subject. These postural instructions focused mainly on the maintenance of an erect sitting posture during the tasks. The order of functional tasks was randomized.

Once the subjects were familiar with the functional tasks, they were instructed to perform each activity a total of 3 consecutive times at their self-selected speed (about 2–3 seconds). The kinematic data from 3 trials for each task were collected. The subjects were given approximately 2 to 3 minutes of rest between practice and test conditions.

Sensors were not removed and replaced between trials. The mean of the 3 trials was calculated. These data were used to differentiate subjects with shoulder dysfunction and subjects without shoulder dysfunction and to test the relationships between impaired scapular movements and self-reported functional disabilities. Because differences between subjects’ perceptions of function and their actual function might be expected, the self-report FLEX-SF questionnaire was used again after the functional tasks.

**Data Reduction**

The absolute axes defined by the sensors of the FASTRAK device were converted to anatomically defined axes derived from digitized bony landmarks. Raw kinematic data were low-pass filtered at a 6-Hz cutoff frequency and converted into anatomically defined rotations. Standard matrix transformation methods were used to determine the orientation of the scapula relative...
to the thorax. This orientation was described by use of a Euler angle sequence of rotation about $Z_s$ (protraction/retraction), rotation about $Y_s$ (downward/upward rotation), and rotation about $X_s$ (posterior/anterior tipping) (Fig. 1). Scapular elevation was defined as the vertical displacement of the scapular sensor during functional activities.

Reliability of Data for Scapular Kinematics During Functional Activities
Reliability data for scapular kinematics during functional tasks were reported previously. Intraclass correlation coefficients ($\text{ICC}[2,k]$) for the mean of 3 trials for the dependent kinematic variables in each task ranged from .91 to .99. The similarity index ranged from .78 to .97, indicating that movement patterns were similar among trials during the 4 functional tasks.

Data Analysis
To determine whether a significant scapular kinematic difference existed between the 2 groups, 2-factor analysis-of-variance (ANOVA) mixed models with factors of group (subjects with shoulder dysfunction or subjects without shoulder dysfunction) and task (4 functional tasks) were calculated for each of the 4 peak kinematic variables. Bonferroni follow-up analyses were used to adjust for multiple pair-wise comparisons when appropriate. The relationships between the scores on the FLEX-SF (after the functional task test session) and impaired scapular kinematics (peak scapular posterior tipping, peak scapular upward rotation, peak scapular protraction, and peak scapular elevation) were assessed with Pearson product moment correlation coefficients ($r$). Additionally, ICC(2,1) for self-report scores obtained before and after the functional task test session were calculated to determine the reliability for the self-report measures.

Results
Representative kinematic data from a subject during the overhead height task (task A) are shown in Figure 2. Although there was substantial variability among tasks and subjects, the major components of the 4 functional tasks were scapular posterior tipping, scapular upward rotation, scapular protraction, and scapular elevation.
found in only 6 subjects with shoulder dysfunction when they raised their right arms to place an object at a height just overhead (task A). Data for 6 subjects (task A) were dropped from both the ANOVA and correlation analyses. Thus, these data were excluded from the correlation calculations to minimize skin motion artifacts in our results; therefore, data from 18 subjects with shoulder dysfunction and 24 subjects with shoulder dysfunction were used to conduct the statistical ANOVA and correlation analyses for task A and for tasks B, C, and D, respectively.

The 2-way (2 × 4, group × task) ANOVA for repeated measures on the task factor were calculated for the measured scapular kinematic variables. There was a significant main effect of group, and there was an interaction effect for peak scapular posterior tipping (group effect: $df=1.41; P<.0005$; and group × task interaction effect: $df=3.123; P<.0005; n=43$) (Fig. 3). Interaction was related to differences between tasks when averaged across groups. Averaged across the 4 functional tasks, scapular posterior tipping was lower in subjects with shoulder dysfunction ($6.9°, P<.0005$) than in comparison subjects. For peak scapular upward rotation, the groups responded differently across the tasks (group × task interaction effect: $df=3.123; P=.011; n=43$) (Fig. 3). Subsequently, the effects of group were investigated for each task. In task B, scapular upward rotation was lower in subjects with shoulder dysfunction ($5.7°, P=.006$) than in comparison subjects. In tasks A, C, and D, scapular upward rotation did not differ between the groups. For peak scapular elevation, the groups also responded differently across the tasks (group × task interaction effect: $df=3.123; P<.0005; n=43$) (Fig. 3). In task A, scapular elevation was higher in subjects with shoulder dysfunction (1.8 cm, $P<.0005$) than in comparison subjects. In tasks B, C, and D, scapular elevation did not differ between the groups. There was no main effect of group, and there was no interaction effect for peak scapular protraction.

Correlations Between Scapular Kinematics and FLEX-SF Scores

Significant Pearson correlation coefficients ($r$, from $-0.076$ to $0.712$, highlight the fact that scapular kinematics (tipping, upward rotation, and elevation) are related to a subject’s self-reported shoulder functional activities (Tab. 3). Among the significant correlations, scapular kinematics and external rotation were strongly correlated ($r=.712$).
Correlations Between Scapular Kinematics and Functional Disability Scores Among the 4 Functional Tasks

<table>
<thead>
<tr>
<th>Correlation With:</th>
<th>Scapular Tipping</th>
<th>Scapular Upward Rotation</th>
<th>Scapular Protraction</th>
<th>Scapular Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (n=18)</td>
<td>.712*</td>
<td>.172</td>
<td>.042</td>
<td>-.310*</td>
</tr>
<tr>
<td>B (n=24)</td>
<td>.535*</td>
<td>-.159</td>
<td>.202</td>
<td>-.217</td>
</tr>
<tr>
<td>C (n=24)</td>
<td>.493*</td>
<td>.296</td>
<td>-.176</td>
<td>-.089</td>
</tr>
<tr>
<td>D (n=24)</td>
<td>.454*</td>
<td>.317*</td>
<td>-.185</td>
<td>-.076</td>
</tr>
</tbody>
</table>

*Tasks A to D were as follows: task A—the subjects used their right arms to place an object at a height just overhead; task B—the subjects used their right arms to place an object at shoulder height; task C—the subjects used their right arms to slide a box across a table; and task D—the subjects reached to get a saltshaker.

Reliability of Self-report Scores

The ICC (.86) for self-report measures indicated good agreement before and after the functional task test session.

Discussion

In this study, shoulder-related dysfunction was assessed with 2 types of functional outcome measures: self-report and performance-based measures. Our primary interest was to identify important impaired scapular movements related to self-report measures of functional disabilities. We believe that the variables identified in this study, such as scapular tipping, scapular upward rotation, and scapular elevation, may help clinicians to plan intervention strategies for efficiently improving a patient’s condition. However, the fact that the study design does not lend itself to a determination of whether the observed kinematic differences were a cause of pathology or simply a compensation for some other impairment should be noted.

In agreement with the results of previous studies, the present study demonstrated weak-to-moderate significant relationships between shoulder movement impairments and self-reported functional disabilities in subjects with shoulder dysfunction. Bekkering and coworkers25 investigated the relationships between joint impairments and upper- and lower-limb functions in 21 children with systemic juvenile idiopathic arthritis. The correlation between functional disability (Juvenile Arthritis Functional Assessment Scale) and loss of joint motion (Joint Alignment and Motion Scale) was good (r = .77). They also indicated that the loss of shoulder joint motion appeared to be the most important factor in predicting a limitation in arm function. Specific to the shoulder joint, Bostrom26 showed a weak-to-moderate relationship between shoulder movement impairments and functional status questionnaires in patients with arthritis and shoulder problems. Our findings are especially noteworthy because scapular movements during functional tasks were evaluated, whereas previous research studies25,26 investigated primarily humeral elevation. Our results suggest that scapular kinematics, in addition to humeral kinematics, also are important in reflecting functional disabilities in people with shoulder dysfunction.

Both self-report and performance-based measures are valuable for assessing shoulder-related dysfunction. Self-report measures offer an efficient and cost-effective method of comprehensively assessing functional disabilities. However, differences between patients’ perceptions of function and their actual function have been mentioned in criticisms of their applicability.11,27 In our study, there was a significant difference in FLEX-SF scores before and after performance of the tasks (Tab. 1). It was interesting to discover that subjects with shoulder dysfunction rated their abilities with lower FLEX-SF scores after performing the tasks. However, the clinical importance of the difference between the 2 FLEX-SF scores should be investigated further. Alternatively, performance-based measures can capture the degree of dysfunction specific to the desired task.

Alterations of scapular kinematics are believed to exist in patients with shoulder pathologies such as impingement and frozen shoulder syndromes.15–17,28–31 Our results for subjects with nonspecific shoulder dysfunction support this premise. Our data also suggest that scapular kinematics are correlated significantly with a subject’s self-reported disabilities, particularly scapular tipping. Without posterior tipping of the scapula, which elevates the anterior acromion to provide adequate clearance for the rotator cuff tendons, subjects with shoulder dysfunction were unable to perform the tasks. We also found more elevation of the scapula (average = 1.9 cm) in subjects with shoulder dysfunction than in subjects without shoulder dysfunction during task A. The elevation of the scapula during task A also was correlated significantly with FLEX-SF scores. The negative correlation coeffi-
cient indicates that a subject with more severe shoulder disabilities (low FLEX-SF scores) had more scapular elevation movements. Most likely, the increased elevation of the scapula in the present study was a compensatory pattern that might be secondary to restricted glenohumeral motion in subjects with shoulder dysfunction.

A possible explanation for the lack of a significant group difference in scapular protraction is the subject variability of performance. On the basis of their study investigating subacromial space by magnetic resonance imaging during protraction and retraction, Solem-Bertoft et al. hypothesized that decreased subacromial space during protraction occurred in subjects with shoulder dysfunction during humeral elevation and resulted in an incapability of the greater tuberosity of the humerus to pass freely under the acromion. Our data did not support our hypothesis that there would be more scapular protraction during functional activities in subjects with shoulder dysfunction. The means for scapular protraction showed similar angles between the 2 groups across the 4 functional tasks. Because of the substantial protraction angle variation in the relatively small sample, the lack of statistical significance may be attributable to a type II error (not enough power). We considered a 3-degree difference between groups to be clinically meaningful. When the smallest standard deviation (5.3) among the functional activities was used, the power to detect a 3-degree difference between groups (α=.05) in scapular protraction angle was calculated to be .45. A sample size of 45 subjects per group would have been required to achieve a power level of .80. Despite the potential type II error, more scapular protraction was observed when subjects placed an object at a height just overhead (task A) than during the other activities. Thus, placing an object at a height just overhead with increased scapular protraction may be considered a risk activity in contributing to a shoulder disorder.

We used a skin-based approach that involved digitized bony landmarks and magnetic tracking sensors for measuring shoulder kinematics during functional activities. For definition of the longitudinal axis of the humerus, the glenohumeral joint rotation center was estimated from 2 digitized points (anterior glenohumeral joint and posterior glenohumeral joint). However, these 2 points lacked discrete landmarks for palpation, a factor that may have affected the accuracy of the data. To improve accuracy, we defined and observed the 2 points on the humerus that moved the least with respect to the scapula when the humerus was moved into several midrange glenohumeral positions. Although the definitions of the axes were standardized and based on previous studies, there may have been errors in digitizing the bony landmarks. However, for a given subject, the definitions of the axes were identical among trials and tasks. The skin motion artifact, which is associated with musculature and subcutaneous fat between skin and bone, is another limitation of the skin-based approach. Karduna et al. indicated that data collected with the acromion method would be acceptable if humeral elevation stayed below 120 degrees. In the present study, 6 subjects without shoulder dysfunction raised their arms above 120 degrees during task A. Subsequently, these data were excluded from our data analysis to validate our findings. In addition, our ICCs suggest good consistency, and our data regarding the amount and general pattern of shoulder kinematics are similar to those of other studies; these facts help validate our method. However, it should be noted that limiting the movements to 120 degrees because of the methodology may have prevented us from capturing all of the dysfunction, particularly in task A.

Several factors regarding the subject sample should be considered. The population of interest consisted of subjects with shoulder dysfunction (mean duration of symptoms, greater than 3 months). As these subjects continued to use their affected shoulders during daily activities despite intermittent periods of pain, they may have developed compensation strategies that may not be apparent in a population of subjects with more acute symptoms. Furthermore, the mean FLEX-SF score for the subjects with shoulder dysfunction was 50.5. Subjects with more severe impairments may be expected to show different alterations in kinematics. Because the population from which our sample was obtained was from a Veterans Affairs medical center (estimated to be 85%–90% men), all of the subjects participating in the present study were men. Although there are no data identifying sex differences for the dependent variables, the generalizability of the study results to women is uncertain. Additionally, the subjects with shoulder dysfunction in the present study were mainly older people with sedentary lifestyles; the mechanisms of shoulder disorders may differ in young people involved in athletic activities. The 4 functional tasks used in the present study may not represent functional activities as a whole in subjects with shoulder dysfunction. Many people have difficulty reaching behind the back during activities and, as a result, will compensate for lack of glenohumeral ROM by inducing more motion at the scapula to achieve the same end reach position. Other functional tasks may need to be tested in future studies.

**Conclusion**

Functional disabilities were identified by self-report and performance-based measures. Specifically, functional disabilities were characterized by less posterior tipping, less upward rotation, and more elevation of the scapula in subjects with shoulder dysfunction. Scapular posterior tipping was associated significantly with FLEX-SF scores throughout the 4 functional tasks used in the present...
study. Additionally, less upward rotation and excessive scapular elevation during the selected activities also were correlated significantly with self-reported functional disabilities. Consequently, scapular posterior tipping, scapular upward rotation, and scapular elevation may have implications in planning intervention strategies for patients with shoulder dysfunction.

References