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## Some Factors Predict Successful Short-Term Outcomes in Individuals With Shoulder Pain Receiving Cervicothoracic Manipulation: A Single-Arm Trial

Paul E. Mintken, Joshua A. Cleland, Kristin J. Carpenter, Melanie L. Bieniek, Mike Keirns, Julie M. Whitman

**Background.** It has been reported that manipulative therapy directed at the cervical and thoracic spine may improve outcomes in patients with shoulder pain. To date, limited data are available to help physical therapists determine which patients with shoulder pain may experience changes in pain and disability following the application of these interventions.

**Objective.** The purpose of this study was to identify prognostic factors from the history and physical examination in individuals with shoulder pain who are likely to experience rapid improvement in pain and disability following cervical and thoracic spine manipulation.

**Design.** This was a prospective single-arm trial.

**Setting.** This study was conducted in outpatient physical therapy clinics.

**Participants.** The participants were individuals who were seen by physical therapists for a primary complaint of shoulder pain.

**Intervention and Measurements.** Participants underwent a standardized examination and then a series of thrust and nonthrust manipulations directed toward the cervicothoracic spine. Individuals were classified as having achieved a successful outcome at the second and third sessions based on their perceived recovery. Potential prognostic variables were entered into a stepwise logistic regression model to determine the most accurate set of variables for prediction of treatment success.

**Results.** Data for 80 individuals were included in the data analysis, of which 49 had a successful outcome. Five prognostic variables were retained in the final regression model. If 3 of the 5 variables were present, the chance of achieving a successful outcome improved from 61% to 89% (positive likelihood ratio=5.3).

**Limitations.** A prospective single-arm trial lacking a control group does not allow for inferences to be made regarding cause and effect. The statistical procedures used may result in “overfitting” of the model, which can result in low precision of the prediction accuracy, and the bivariate analysis may have resulted in the rejection of some important variables.

**Conclusions.** The identified prognostic variables will allow clinicians to make an *a priori* identification of individuals with shoulder pain who are likely to experience short-term improvement with cervical and thoracic spine manipulation. Future studies are necessary to validate these findings.



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Shoulder pain can present a diagnostic challenge. One study on nonspecific shoulder pain showed rotator cuff tendinopathy in 85% of patients, but 77% were diagnosed with more than one shoulder problem.<sup>1</sup> The most common causes of shoulder pain, namely rotator cuff pathology and adhesive capsulitis, may present similar findings but have a different set of outcomes and responses to specific treatments.<sup>2</sup> Although specific diagnoses can be made in some patients with shoulder pain,<sup>3</sup> de Winter et al<sup>4</sup> reported only moderate agreement on the classification of shoulder disorders and concluded that differentiation among shoulder disorders is complicated. Dinant et al<sup>5</sup> argued that we need a shift from diagnostic to prognostic research, as health care providers frequently see patients with conditions such as shoulder pain and low back pain that are difficult to accurately diagnose.

The prevalence of shoulder symptoms has been reported to range from 20% to 33%,<sup>6</sup> and the incidence of shoulder complaints in the general population is increasing.<sup>7</sup> Furthermore, several authors have reported low rates of perceived recovery for individuals with a new episode of shoulder pain.<sup>8-11</sup> The prognosis generally is poor, with re-

covery rates of only 49% to 59% at the time of an 18-month follow-up.<sup>9,11</sup> Additionally, Rekola et al<sup>12</sup> reported that 25% of individuals with shoulder or neck pain experienced at least one episode of recurrence within 12 months, suggesting that shoulder pain can be recurrent and frequently progresses to the chronic stage. This is important, as the direct costs for the treatment of people with shoulder dysfunction in the United States in 2000 totaled \$7 billion.<sup>13</sup> Furthermore, Kuijpers et al<sup>14</sup> reported that patients with persistent shoulder pain generated 74% of the total costs.

*Regional interdependence* is defined as “the concept that seemingly unrelated impairments in a remote anatomical region may contribute to, or be associated with, the patient’s primary complaint.”<sup>15(p658)</sup> This concept of examining and treating impairments away from the primary source of pain is gaining popularity in orthopedic manual therapy.<sup>15</sup> Patients with primary reports of shoulder pain often have impairments of the shoulder girdle, including the cervicothoracic spine and the adjacent ribs, and these impairments can negatively affect patient outcomes.<sup>16-21</sup> For example, Sobel et al<sup>19</sup> found that more than 40% of patients with shoulder complaints had impairments of the cervicothoracic spine and the adjacent ribs. They concluded that impairments in the cervicothoracic spine and adjoining ribs represent an integral part of the intrinsic causes of shoulder complaints. Additionally, Norlander and colleagues<sup>16-18</sup> investigated the correlation between mobility in the cervicothoracic junction in patients with musculoskeletal neck and shoulder pain and found a significant association between decreased mobility in the thoracic spine and the presence of patient-reported complaints associated with neck and shoulder pain. Impairments of the

cervicothoracic spine and adjacent ribs have been shown to predict a poor outcome and triple the risk for developing shoulder disorders.<sup>16-19,22</sup> Finally, Crosbie et al<sup>23</sup> demonstrated in 32 women who were healthy that thoracic motion was present in both bilateral and unilateral shoulder elevation, and they concluded that a key link exists between the thoracic spine and arm elevation.

Current evidence suggests that inclusion of manipulative interventions (both thrust and nonthrust techniques) indeed may be helpful in the treatment of individuals with shoulder pain.<sup>22,24-27</sup> Some studies have included cervicothoracic manipulative interventions in addition to other interventions in the management of shoulder pain.<sup>24-26</sup> To date, 2 studies have investigated the effectiveness of treatment directed solely at the cervicothoracic spine and ribs in individuals with shoulder pain.<sup>22,24</sup> Boyles et al<sup>24</sup> found that individuals with impingement syndrome who received thoracic spine thrust manipulation demonstrated significant improvements in pain and disability 48 hours after treatment. Bergman et al<sup>22</sup> randomly assigned individuals with a primary report of shoulder pain to receive either usual medical care (UMC) for their shoulder symptoms from their primary care physicians or usual care plus manipulative therapy (UMC+MT) directed at the cervicothoracic spine and rib cage. Although there were no between-group differences identified at the 6-week follow-up, the UMC+MT group demonstrated significantly higher rates of “full recovery,” as well as more improvement in the severity of main complaints and disability at 12, 26, and 52 weeks.<sup>22</sup> These findings suggest that a subgroup of individuals with shoulder pain may exist who will respond dramatically to these interventions.



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- **eTable 1:** Categorical Variables From the Baseline Clinical Examination
- **eTable 2:** Continuous Variables From the Baseline Clinical Examination
- **Audio Abstracts Podcast**

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Recently, there have been multiple studies identifying prognostic variables to guide physical therapy interventions.<sup>28-30</sup> It would be useful for physical therapists to have guidance in selecting which patients with shoulder pain may experience improved outcomes following manipulative interventions targeted at the cervicothoracic spine. Thus, the purpose of this project was to identify prognostic factors for individuals with shoulder pain likely to experience improvements in pain and disability following the application of cervicothoracic spine thrust and nonthrust manipulation.

### Materials and Method

We conducted a prospective single-arm trial of consecutive individuals with a primary complaint of shoulder pain who were seen for physical therapy at 1 of 7 outpatient physical therapy clinics (Wardenburg Health Center, University of Colorado Boulder, Boulder, Colorado; the faculty practice at the University of Colorado Denver, Aurora, Colorado; Physiotherapy Associates, Greenwood Village, Colorado; Rehabilitation Services of Concord Hospital, Concord, New Hampshire; Groves Physical Therapy, St Paul, Minnesota; Newton Wellesley Hospital, Newton, Massachusetts; and Southwest Physical Therapy, Yuma, Arizona). Inclusion criteria required participants to be between the ages of 18 and 65 years, with a primary report of shoulder pain and a baseline Shoulder Pain and Disability Index (SPADI) score of 20% or greater. The SPADI is a self-administered questionnaire consisting of pain and disability subscales, where the means of the 2 subscales are combined to produce a total score ranging from 0 (best) to 100 (worst).<sup>31</sup> The SPADI has excellent reliability, validity, and responsiveness.<sup>31,32</sup> Exclusion criteria included any medical “red flags” suggestive of a nonmusculoskeletal etiology of symptoms, acute frac-

tures in the shoulder region, acute severe trauma in the cervical or thoracic region in the previous 6 weeks, a diagnosis of cervical spinal stenosis or bilateral upper-extremity symptoms, osteoporosis, prior surgery to the cervical or thoracic region, evidence of central nervous system involvement, insufficient English-language skills to complete the questionnaires, or signs consistent with nerve root compression (defined as impairment in at least 2 of the following: myotomal strength, sensation, or reflexes). “Red flags” were ruled out by a combination of a medical screening questionnaire, a neurological examination, and a patient history.<sup>33</sup> All participants reviewed and signed a consent form approved by one of the following institutional review boards: the University of Colorado at Boulder, Boulder, Colorado; the University of Colorado Denver, Denver, Colorado; Regis University, Denver, Colorado; Newton-Wellesley Hospital, Newton, Massachusetts; or Concord Hospital, Concord, New Hampshire.

### Physical Therapists

Nine physical therapists participated in the examination and treatment of participants in this study. All therapists underwent a standardized training regimen, which included studying a manual of standard procedures with the operational definitions for each examination and treatment procedure used in this study. All participating therapists then underwent a 1-hour training session in which they practiced all study procedures to ensure they were performed in a standardized fashion. Participating therapists had a mean of 11.6 years (SD=10.2, range=0-29) of clinical experience. Five of the 9 therapists were board certified in orthopedics and had received fellowship training in manual therapy.

### Examination Procedures

Participants provided demographic information and completed a variety of standardized self-report measures,<sup>34</sup> followed by a standardized history and physical examination at baseline. Self-report measures included a body diagram to assess the distribution of symptoms,<sup>35</sup> a numeric pain rating scale (NPRS),<sup>36</sup> the SPADI,<sup>31</sup> the Modified Fear-Avoidance Beliefs Questionnaire (FABQ),<sup>37</sup> and the Tampa Scale for Kinesiophobia (TSK).

The body diagram was used to record the location and nature of a patient's shoulder symptoms.<sup>38</sup> The body diagram has been shown to be a reliable tool to localize a patient's symptoms.<sup>39</sup> The 11-point NPRS (range=0-10) was used to measure pain intensity. The scale is anchored on the left with the phrase “no pain” and on the right with the phrase “worst imaginable pain.” The NPRS was used to rate the participants' current level of pain and their worst and least amount of pain in the previous 24 hours. The average of the 3 ratings was used to represent each participant's level of pain. Numeric pain scales have been shown to be reliable and valid.<sup>36,40,41</sup>

The FABQ is a 16-item questionnaire that was designed to quantify fear and avoidance beliefs in individuals with low back pain (LBP).<sup>37</sup> The FABQ has 2 subscales: a 7-item scale to measure fear-avoidance beliefs about work and a 4-item scale to measure fear-avoidance beliefs about physical activity. Higher scores represent an increase in fear-avoidance beliefs. We modified the FABQ by changing the word “back” to “shoulder” on the questionnaire. We used the 11-item TSK that assesses fear of movement or of injury or reinjury.<sup>42</sup> Individuals rate each item on a 4-point Likert scale, with scoring alternatives ranging from “strongly disagree” to “strongly agree.” Test-

retest reliability is high.<sup>42</sup> The SPADI is a 13-item questionnaire consisting of a pain domain with 5 questions and a disability domain with 8 questions. Each section is scored from 0% to 100%, with higher scores indicating higher levels of pain and disability. Beaton and Richards<sup>43</sup> reported that the individual-level reliability of measurements obtained with the SPADI had an intraclass correlation coefficient of .91. The minimal clinically important difference (MCID) is 10 points.

The historical examination included questions about age, sex, employment status, past medical history, expectations for treatment, mode of onset, location and nature of the patient's symptoms, number of days since onset, aggravating and relieving factors, number of previous episodes of shoulder pain, and treatment for previous episodes. The physical examination began with a neurological screen,<sup>44</sup> followed by an assessment of posture as described previously.<sup>28,45</sup> Griegel-Morris et al<sup>46</sup> examined the reliability of postural assessment using a plumb line and reported a high degree of reliability ( $\kappa = .83$ ).

The therapist then measured pain-free active shoulder flexion<sup>47</sup> and administered a battery of 3 functional tests described by Yang and Lin<sup>48</sup>: hand to neck, hand to scapula and hand to opposite shoulder movements. A soft tape measure was used to measure the resting position of the scapula from the midpoint of the sternal notch (SN) to the medial aspect of the coracoid process (CP) and the horizontal distance from the posterolateral angle of the acromion (PLA) to the thoracic spine (TS).<sup>49</sup> The Scapula Index was calculated using the equation:  $[(SN \text{ to } CP/PLA \text{ to } TS) \times 100]$ .<sup>49</sup> The lateral slide test was used to evaluate 3 different positions of the scapula as described by

Kibler.<sup>50</sup> Scapular dyskinesis was assessed as described by Kibler et al.<sup>51</sup>

The therapist then performed a battery of special pathoanatomic tests for the shoulder. These tests were selected based on their psychometric properties, including high sensitivity or specificity, identified during our literature review. As included participants had a primary complaint of shoulder pain, we wanted the tests to cover the spectrum of potential pathoanatomic conditions involving the shoulder. The tests included the load and shift test and the sulcus sign,<sup>52</sup> the apprehension/relocation test,<sup>52</sup> the Paxinos test and acromioclavicular joint palpation,<sup>53</sup> the active compression test,<sup>54</sup> the anterior slide test,<sup>55</sup> the Hawkins-Kennedy impingement test,<sup>56-58</sup> the Neer impingement test,<sup>56-58</sup> the empty can and full can test,<sup>59</sup> the drop sign,<sup>60</sup> and the Speed test.<sup>61</sup>

Next, cervical range of motion (ROM) and symptom response were assessed using an inclinometer for flexion, extension, and side bending and a long-arm goniometer for rotation.<sup>62-64</sup> These measurements have been shown to have moderate intertester reliability.<sup>62,63,65</sup> Active rotation of the thoracic spine was assessed visually, and any symptom provocation was recorded.<sup>65</sup> We acknowledge that thoracic spine ROM is very difficult to measure accurately. The following tests were used to screen for cervical radiculopathy<sup>66</sup>: the Spurling test, the Upper Limb Tension Test, the distraction test, and cervical rotation active ROM. First rib mobility testing was performed in a sitting position<sup>67</sup>; the therapist palpated the first rib and assessed symmetry during quiet breathing and passive downward springing. The cervical rotation lateral flexion test also was performed in a sitting position.<sup>68</sup>

Passive ROM of the shoulder was measured as described by Norkin and White.<sup>69</sup> Cross-chest adduction was measured in a supine position with the shoulder flexed to 90 degrees with 0 degrees of adduction to assess for posterior shoulder tightness.<sup>70</sup> Passive accessory joint mobility as described by Maitland<sup>71</sup> was assessed at the following joints: glenohumeral (anterior, posterior, and inferior glides, as well as distraction), acromioclavicular, and sternoclavicular. Based on comparison with the opposite shoulder, each motion was judged to be hypomobile, normal, or hypermobile.

Finally, the therapist assessed the length<sup>72</sup> and strength (force-generating capacity)<sup>45</sup> of the muscles of the upper quarter and endurance of the deep neck flexor muscles.<sup>73</sup> Spring testing of the cervical and thoracic spine (C2-T9) and ribs (1-9)<sup>74</sup> and segmental mobility of the cervical spine<sup>72</sup> were assessed for mobility and symptom response.

Of the 80 participants who were enrolled in the study, 18 underwent a second examination by an additional therapist who was blind to the findings of the first clinician. The 18 participants who underwent a second evaluation were selected based on the availability of a second clinician to perform the examination. The reliability analysis was performed to evaluate the intertester reliability of data obtained for the identified potential prognostic variables.

## Treatment

As treatment outcome served as the reference criterion,<sup>75</sup> all participants received the same standardized treatment regardless of the results of the clinical examination. Treating clinicians were not permitted to adjust the intervention based on individual clinical decision-making processes.<sup>34</sup> During each session, the participants received 1 nonthrust mobilization



technique directed at the lower cervical spine and 5 different thrust manipulation techniques directed at the thoracic spine. We used a large number of techniques targeting the cervical and thoracic regions, as it has been reported that patients with shoulder pain may have impairments from the cervicothoracic junction to the lower thoracic spine.<sup>16-20,22,23,46,49</sup> We wanted to be sure that we addressed any impairments that might be present in this region in order to maximize our chances for success. All techniques took less than 10 to 15 minutes to perform and are described below using the standardized terminology proposed by Mintken et al<sup>76</sup>:

- A high-velocity, mid-range distraction force to the midthoracic spine on the lower thoracic spine in a sitting position (Appendix 1).
- A low-velocity, end-range, left and right lateral translational force to the lower cervical spine on the upper thoracic spine in a supine position in "neutral" and slight cervical flexion (Appendix 1).
- A high-velocity, end-range, anterior-posterior force through the elbows to the cervicothoracic junction on the upper thoracic spine in a supine position (Appendix 1).
- A high-velocity, end-range, anterior-posterior force through the elbows to the upper thoracic spine on the midthoracic spine in a supine position in cervicothoracic flexion (Appendix 1).
- A high-velocity, end-range, anterior-posterior force through the elbows to the middle thoracic spine on the lower thoracic spine in a supine position in cervicothoracic flexion (Appendix 1).
- A high-velocity, mid-range, posterior-to-anterior force to the midthoracic spine on the upper thoracic spine in a prone position (Appendix 1).

Each nonthrust manipulation was performed for 30 seconds at each

cervical level (C5-7) in neutral and slight cervical flexion (for a total of 6 bouts of oscillations to the left and 6 bouts of oscillations to the right). In order to maximize each patient's opportunity for improvement, each individual received each thrust technique twice, for a total of 10 thrust manipulations per treatment session.

Following the manual therapy interventions, all participants were instructed in 2 general spinal mobility exercises. The first was a general cervical mobility exercise called the "3-finger ROM exercise" (Appendix 2).<sup>77</sup> The second was a general thoracic mobility exercise performed in a supine position (Appendix 2).<sup>72</sup> Individuals performed both exercises for 10 repetitions, 3 to 4 times per day, while participating in the study. Participants also received instruction to maintain their usual activity level within the limits of pain. The first treatment session always was performed on the day of the initial examination, and the participant was scheduled for a follow-up visit within 2 to 4 days.

The 15-point Global Rating of Change (GROC) described by Jaeschke et al<sup>78</sup> was used as the reference criterion for establishing a successful outcome. This decision was based on the fact that the GROC is considered to be a valid reference standard for identifying clinically important change.<sup>78</sup> The scale ranges from -7 ("a very great deal worse") to 0 ("about the same") to +7 ("a very great deal better"). Intermittent descriptors of worsening or improving are assigned values from -6 to +6, respectively. Scores of +4 and +5 are reported to indicate moderate changes in patient status, and scores of +6 and +7 indicate large changes in patient status.<sup>78</sup> Individuals who rated their perceived recovery on the GROC as "a very great deal better," "a great deal better," "quite a bit better," or "moderately

better" (ie, a score of +4 or greater) at follow-up were categorized as having a successful outcome. We set +4 as the threshold for success because this score represents clinically meaningful improvements and, due to the short duration of this study, it would be likely that the clinical outcome would be attributable to the intervention rather than the passage of time.<sup>78</sup> We chose not to use the SPADI, as it may not adequately capture low levels of disability.<sup>79</sup>

At the beginning of the second session, the participants completed the GROC and the other outcome measures. If their score on the GROC did not exceed the +4 cutoff at the second session, they received the same intervention program again and were scheduled for a follow-up within 2 to 4 days. Participants again completed the GROC along with the other outcome measures. If they scored +4 or better on the GROC, they were categorized as having a successful outcome; if they scored below +4, they were categorized as not having a successful outcome. At this point, their participation in the study was complete, and the therapist could administer further treatment as needed.

### Data Analysis

We used SPSS version 16.0\* to analyze the data. Individuals were dichotomized as having or not having a successful outcome based on the treatment response, as indicated on the GROC (-7 to +3=nonsuccessful outcome, +4 to +7=successful outcome). The mean NPRS and SPADI change scores (and 95% confidence intervals [CIs]) were calculated for the success and nonsuccess groups and were analyzed using an independent *t* test to determine whether any differences existed between groups. Individual variables

\* SPSS Inc, 233 S Wacker Dr, Chicago, IL 60606.

from self-report measures, the history, and the physical examination were tested for univariate relationship with the GROC reference criterion using independent-samples *t* tests for continuous variables and chi-square tests for categorical variables. Variables with a significance level of  $P < .10$  were retained as potential prognostic variables.<sup>80</sup> A liberal significance level was selected to increase the likelihood that no potential prognostic variables would be overlooked. For continuous variables with a significant univariate relationship, sensitivity and specificity values were calculated for all possible cutoff points and then plotted as a receiver operator characteristic (ROC) curve.<sup>81</sup> The point on the curve nearest the upper left-hand corner represented the value with the best diagnostic accuracy, and this point was selected as the cutoff defining a positive test.<sup>81</sup>

Sensitivity, specificity, and positive and negative likelihood ratios (+LR and -LR) were calculated for potential prognostic variables. Potential prognostic variables were entered into a stepwise logistic regression model to determine the most accurate set of variables for prediction of treatment success. A significance level of  $P < .10$  was set to increase the likelihood that no potential prognostic variables would be overlooked.<sup>80</sup> The Hosmer-Lemeshow goodness-of-fit statistic was used to assess if the model fit the data.<sup>82</sup> Variables retained in the regression model were factors that might predict which individuals with shoulder pain are likely to benefit rapidly and dramatically from manual therapy interventions directed at the cervicothoracic spine.

Cohen kappa ( $\kappa$ )<sup>83</sup> was used to calculate the interrater reliability of categorical data for identified prognostic variables from the patient history and clinical examination. Intraclass

correlation coefficients (2,1) and the 95% CIs were calculated to determine the interrater reliability for continuous variables identified as potential prognostic variables.<sup>84</sup>

### Role of the Funding Source

This study was supported by a grant from the American Academy of Orthopaedic Manual Physical Therapists.

### Results

Between October 2006 and December 2008, 131 individuals with a primary report of shoulder pain who were seen for physical therapy were screened for eligibility criteria. Eighty individuals (61%) satisfied the criteria for the study and agreed to participate. The total number of participants screened and reasons for ineligibility are shown in Figure 1. Patient demographics and initial baseline scores for self-report measures are shown in Table 1. Clinical examination variables for the entire sample and both the success and nonsuccess groups, as well as the reliability values, are shown in eTable 1 (available at [ptjournal.apta.org](http://ptjournal.apta.org)) for categorical variables and eTable 2 (available at [ptjournal.apta.org](http://ptjournal.apta.org)) for continuous variables. Of the 80 individuals who enrolled in the study, a total of 49 (61%) experienced a successful outcome. Thirty-one individuals (63% of those who experienced a successful outcome) experienced a successful outcome at the time of the second visit. The remaining 18 individuals reported a successful outcome at the third visit (following 2 treatment sessions). No adverse events were reported during the study.

Data for individual therapists were analyzed separately, and there was no heterogeneity among therapists' average outcomes. Specifically, the percentage of successful patients per therapist was analyzed using chi-square tests, and the results were not

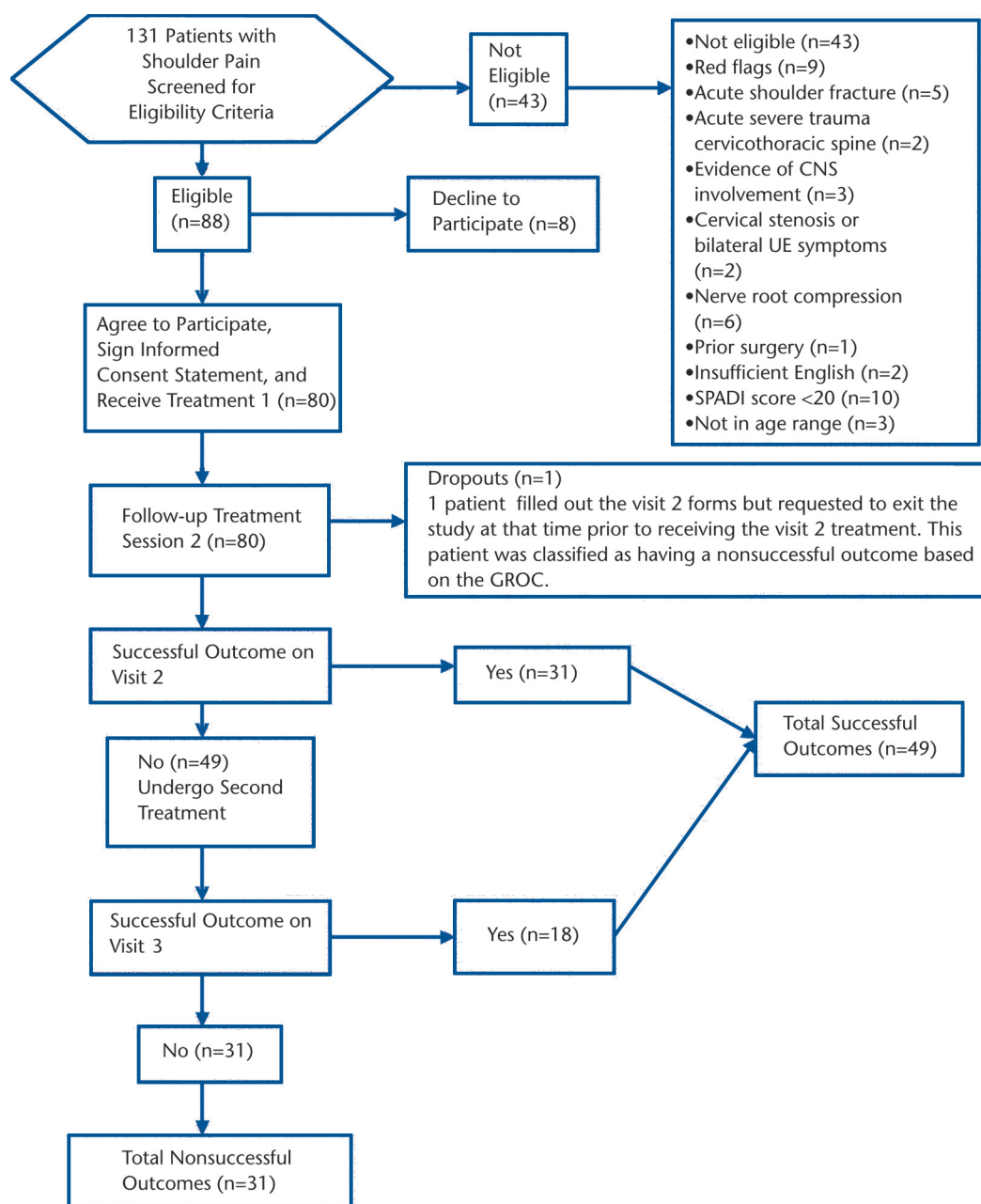
significant ( $P = .425$ ). Additionally, changes on the SPADI and the NPRS were analyzed using an analysis of variance (ANOVA), and there was no significant difference among therapists for these outcomes ( $P = .44$  and  $.113$ , respectively).

Baseline scores, final scores, and change scores with 95% CIs for all outcomes scales for the success and nonsuccess groups are reported in Tables 2 and 3. Differences in change scores for the SPADI for the success group were significantly better than for the nonsuccess group ( $P < .001$ ), with a mean difference between groups of 12.9 (95% CI = 7.3, 18.5). The mean SPADI score for the success group decreased by more than 50% (from 38.1 to 18.4), whereas the mean SPADI score for the nonsuccess group decreased by 18% (from 37.9 to 30.4) (Fig. 2A). Additionally, analysis of NPRS change scores revealed the success group experienced significantly greater improvements compared with the nonsuccess group, with a mean difference between-group change of 1.7 (95% CI = 1.1, 2.3) (Fig. 2B). The success group exceeded the MCID for both the SPADI<sup>79</sup> and the NPRS<sup>85</sup> (19.7 and 2.2, respectively).

The participants' ability to flex the shoulder without pain also improved significantly in both groups ( $P < .001$ ). Differences in change scores for pain-free shoulder flexion were significantly better for the success group than for the nonsuccess group, both immediately after treatment ( $P = .017$ ) and at the final visit ( $P < .001$ ), with mean differences between groups of 7.5 degrees (95% CI = 1.4°, 13.7°) and 13.8 degrees (95% CI = 6.2°, 21.4°), respectively (Tab. 3, Fig. 3).

The 14 potential prognostic variables (Tab. 4) that exhibited a significance level of less than .10 were

## Prognosis in Individuals With Shoulder Pain Receiving Cervicothoracic Manipulation



**Figure 1.**

Flow diagram showing participant recruitment and retention. CNS=central nervous system, UE=upper extremity, SPADI=Shoulder Pain and Disability Index, GROC=Global Rating of Change.

entered into the logistic regression. The cutoff values determined by the ROC curve analysis were 90 days since the onset of symptoms and pain-free shoulder flexion of  $<127$  degrees. We dichotomized duration of symptoms to greater or less than 90 days. Accuracy statistics for all 14

variables (and 95% CIs) are shown in Table 4. The +LRs ranged from 1.1 to 3.0. Of the 14 variables that were entered into the regression model, 5 were retained as the most parsimonious group of prognostic variables for identifying individuals with shoulder pain likely to benefit rap-

idly and dramatically from manual therapy interventions targeting the cervicothoracic region (Nagelkerke  $R^2=.56$ ). The Hosmer-Lemeshow goodness-of-fit statistic indicated the model fit the data ( $P=.90$ ).

**Table 1.**Demographics, Baseline Self-Report Variables, and Baseline Characteristics of Participants<sup>a</sup>

Variable	Success Group (n=49)	Nonsuccess Group (n=31)	P
Age (y)	40.4 (13.5)	42.5 (12.8)	.51 <sup>b</sup>
Sex: female, n (%)	29 (59%)	19 (61%)	.52 <sup>c</sup>
Duration of symptoms (d), mean (SD), median	482.39 (1,635.5), 99	555.84 (1,289.5), 225	.15 <sup>d</sup>
NPRS score	4.0 (1.7)	4.3 (1.8)	.42 <sup>b</sup>
SPADI score (0–100)	38.1 (13.9)	37.9 (13.1)	.93 <sup>b</sup>
FABQ-PA score (0–24)	13.1 (4.8)	12.7 (6.4)	.80 <sup>b</sup>
FABQ-W score (0–42)	10.7 (8.8)	8.9 (10.3)	.41 <sup>b</sup>
TSK score (0–55)	22.7 (4.4)	21.9 (6.0)	.53 <sup>b</sup>
BMI (kg/m <sup>2</sup> )	24.5 (4.2)	26.4 (5.9)	.11 <sup>b</sup>
Prior history of shoulder pain, n (%)	24 (49%)	18 (58%)	.50 <sup>c</sup>
Traumatic injury, n (%)	13 (27%)	11 (35%)	.45 <sup>c</sup>
Symptoms distal to the shoulder	11	17	.004 <sup>c</sup>
Taking medications, n (%)	30 (61%)	25 (81%)	.07 <sup>c</sup>

<sup>a</sup> Data are mean (SD) unless otherwise indicated. NPRS=numeric pain rating scale, SPADI=Shoulder Pain and Disability Index, FABQ-PA=Fear-Avoidance Beliefs Questionnaire–physical activity subscale, FABQ-W=Fear-Avoidance Beliefs Questionnaire–work subscale, TSK=Tampa Scale of Kinesiophobia, BMI=body mass index.

<sup>b</sup> Independent-samples *t* test.

<sup>c</sup> Chi-square test.

<sup>d</sup> Mann-Whitney *U* test.

The pretest probability for the likelihood of success with manual therapy and general mobility exercises for this study was 61% (49 out of 80 participants). If the patient exhibited 4 or 5 out of the 5 variables, the diagnostic accuracy was maximized (+LR was infinity), with a posttest probability of success at 100% (Tab. 5). The accuracy of predicting success when 3 out of 5 variables were present (+LR=5.3, 95% CI=1.7, 16.0) was 89%. The accuracy decreased to 78% if only 2 out of

5 variables were present. Reliability data for all variables are presented in eTables 1 and 2 (available at [ptjournal.apta.org](http://ptjournal.apta.org)).

## Discussion

We have identified several prognostic factors that can potentially identify, *a priori*, individuals with shoulder pain who are likely to experience a rapid and dramatic response to manual therapy and ROM directed to the cervicothoracic spine. This information may be use-

ful for guiding clinical decision making for individual patients. The results of our study suggest that 61% of individuals with shoulder pain are likely to experience a successful outcome with this intervention program. If 3 out of 5 variables were present (+LR=5.3, 95% CI=1.7, 16.0), the likelihood of success increased to 89%. All individuals who met 4 or 5 of the variables had a positive outcome (+LR=∞, posttest probability=100%). According to the criteria described by Landis and

**Table 2.**

Baseline, Final, and Change Scores for Outcome Measures

Outcome Measure	Baseline Mean (SD)	Final Mean (SD)	Within-Group Change Score (95% CI) <sup>a</sup>	Between-Group Change Scores (95% CI)
Shoulder Pain and Disability Index (0–100)				12.9 (7.3, 18.5) <i>P</i> <.001
Success group	38.1 (13.9)	18.4 (12.0)	19.7 (15.5, 20.0)	
Nonsuccess group	37.9 (13.1)	30.4 (13.7)	6.9 (4.6, 9.1)	
Numeric pain rating scale (0–10)				1.7 (1.1, 2.3) <i>P</i> <.001
Success group	4.0 (1.7)	1.8 (1.1)	2.2 (1.9, 2.6)	
Nonsuccess group	4.3 (1.8)	3.9 (1.5)	0.50 (–0.08, 0.90)	

<sup>a</sup> CI=confidence interval.



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**Table 3.**

Baseline, Immediate Posttreatment, and Final Session Degrees of Pain-Free Shoulder Flexion

Variable	Baseline Mean (SD)	Final Mean (SD)	Within-Group Change Scores (95% CI) <sup>a</sup>	Between-Group Change Scores (95% CI)
Pain-free shoulder flexion, pretreatment to immediate posttreatment				7.5 (1.4, 13.7) <i>P</i> =.017
Success group	118.6 (31.0)	142.0 (29.8)	23.1 (19.1, 27.2)	
Nonsuccess group	134.7 (24.4)	150.1 (20.6)	15.6 (11.1, 20.1)	
Pain-free shoulder flexion, pretreatment to final visit				13.8 (6.2, 21.4) <i>P</i> <.001
Success group	118.6 (31.0)	149.3 (25.1)	30.4 (25.1, 35.7)	
Nonsuccess group	134.7 (24.4)	151.1 (19.1)	16.6 (11.9, 21.3)	

<sup>a</sup> CI=confidence interval.

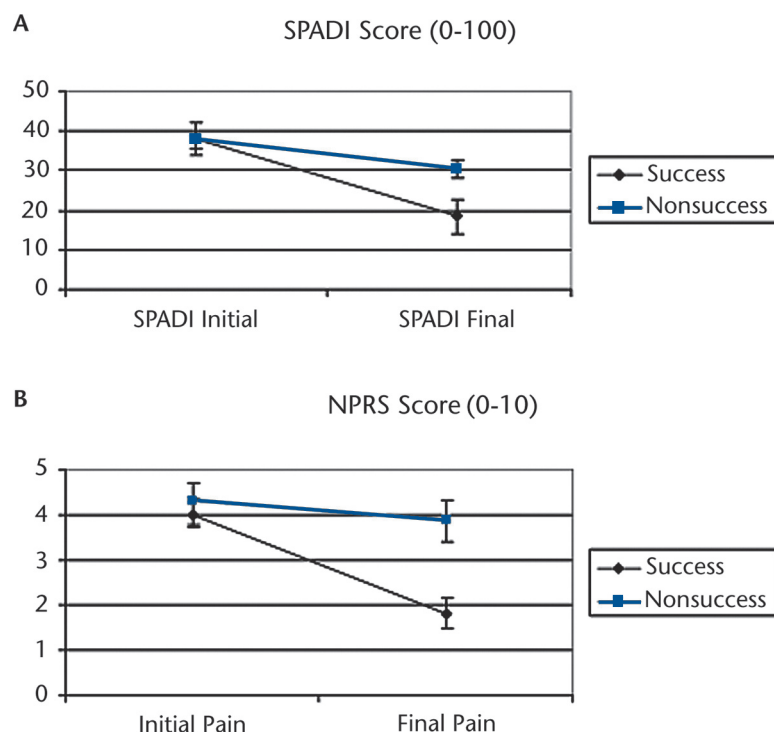
Koch,<sup>86</sup> all prognostic variables exhibited moderate to substantial reliability. We consider these reliability coefficients acceptable to guide clinical decision making in the treatment of individuals with shoulder pain.

The 5 prognostic variables that were retained in the regression model

were: pain-free shoulder flexion of <127 degrees, shoulder internal rotation of <53 degrees, a negative Neer test, not taking medications of any kind for shoulder pain, and duration of symptoms of <90 days. Two variables from the patient history provided an indication that this subgroup is more likely to experi-

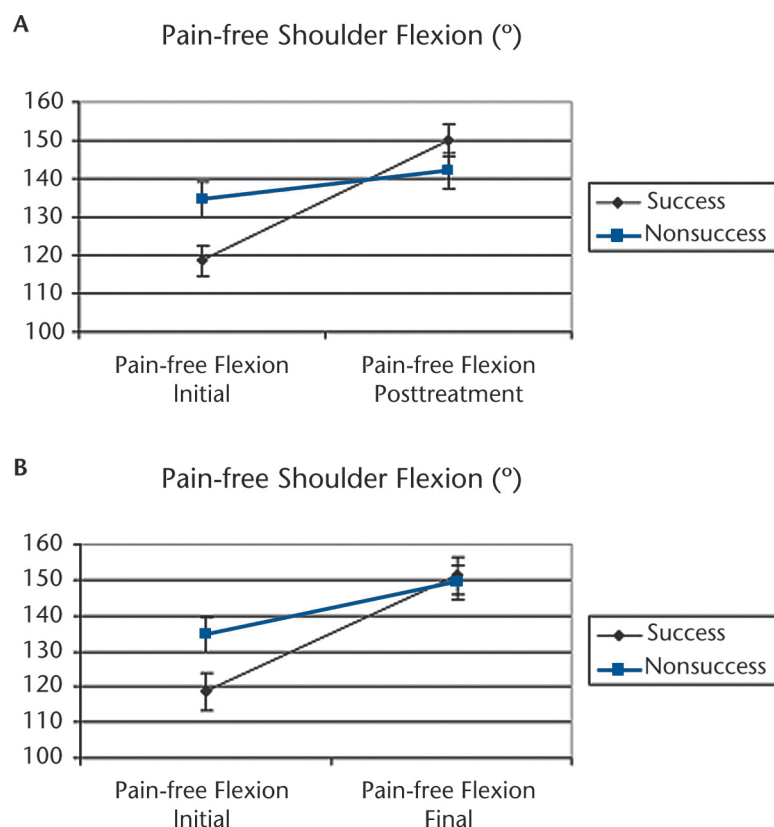
ence improvement if they are not taking medications and have a shorter duration of symptoms. Brox and Brevik<sup>87</sup> reported that not taking medications was a prognostic factor for success in individuals with rotator cuff tendinosis. A longer duration of symptoms frequently has been shown to be associated with a poorer prognosis.<sup>88-90</sup> Two studies have shown that a duration of symptoms of >3 months predict persistent shoulder symptoms and increased sick leave.<sup>88-90</sup> Although a duration of symptoms of ≤90 days was one of the strongest predictors of successful outcome, we used a high threshold for defining success on the GROC<sup>78</sup> to attempt to distinguish between patients who improved significantly with manipulation and those who were improving over time due to natural history of the disorder. Finally, the magnitude of the difference in change scores for both the SPADI and the NPRS substantiates that an important clinical change occurred in the success group.

Two of the prognostic variables included limitations in shoulder motion: pain-free shoulder flexion of <127 degrees and shoulder internal rotation of <53 degrees. These limitations in shoulder motion could be linked to restricted spine and rib



**Figure 2.**

(A) Line graph for Shoulder Pain and Disability Index (SPADI) scores of intervention time (*P*<.001 for both groups). (B) Line graph for numeric pain rating scale (NPRS) scores of intervention time (*P*<.001 for success group).



**Figure 3.**

(A) Line graph for changes in pain-free shoulder flexion immediately posttreatment ( $P < .001$  for both groups). (B) Line graph for changes in pain-free shoulder flexion from initial visit to final visit ( $P < .001$  for both groups).

cage ROM. Decreased thoracic spine ROM has been associated with a functional restriction of arm movement.<sup>91,92</sup> Crosbie et al<sup>23</sup> found that there is significant movement in the thoracic spine with unilateral and bilateral arm elevation. Sobel et al<sup>26</sup> reported that impaired cervicothoracic mobility may be an intrinsic cause of shoulder pain. Painful shoulder elevation may be caused by restricted cervicothoracic spine motion.<sup>16-18,46</sup> Interestingly, both groups in our study improved significantly ( $P < .001$ ) in the degree of pain-free shoulder flexion following the manipulative interventions. Additionally, it is possible that the changes we observed were due to a neurophysiological effect of manipulation that may be unrelated to any biomechanical effects or changes. There is a significant body of litera-

ture demonstrating that spinal manipulation affects the flow of sensory information to the central nervous system, evokes paraspinal muscle reflexes, alters motoneuron excitability, and increases pain tolerance or its threshold.<sup>93-96</sup>

We were surprised that a negative Neer test was predictive of success. The trials by Boyles et al<sup>24</sup> and Bang and Deyle<sup>27</sup> required that subjects have either a positive Neer test or a positive Hawkin-Kennedy test. However, it has been reported that many individuals with shoulder pain have no significant impairments in the glenohumeral structures.<sup>20,25</sup> Sobel et al<sup>20</sup> and Winters et al<sup>25</sup> reported that up to a third of subjects with shoulder pain had no identifiable shoulder "synovial impairments" beyond impaired cervicothoracic mobility.

Winters et al<sup>25</sup> found that subjects with purely shoulder girdle disorders (pain or limited motion in the cervical spine, the thoracic spine, or the adjoining ribs) had better outcomes when randomized to receive manipulation (including manipulation of the cervical spine, upper thoracic spine, upper ribs, acromioclavicular joint, and glenohumeral joint) versus conventional physical therapy. As the Neer test has been shown to be sensitive and not specific,<sup>56,58</sup> perhaps it serves as a good test to rule out structures that are mechanically painful around the glenohumeral joint and may cue the clinician to focus on the cervicothoracic spine and ribs.

This study successfully developed a set of prognostic factors that may help identify individuals with shoulder pain who are likely to experience meaningful changes in pain, disability, and ROM following cervicothoracic manipulation and general mobility exercises. We believe that these results are generalizable to individuals with a primary report of shoulder pain seeking physical therapy care, as data were collected by 9 physical therapists at 7 outpatient clinics across the country. There were no differences in outcomes among clinicians with varying levels of experience; therefore, it is unlikely that any potential clustering effect based on an individual therapist would have biased the results. It should be noted that this is only the first step in the process of identifying prognostic variables.<sup>97</sup> Future studies will be necessary to validate the predictive value of the prognostic factors in a randomized controlled trial with a comparison group and a longer-term follow-up. Ultimately, if these variables do turn out to be useful guides to clinical decision making, an impact analysis should be performed to determine the effects on economic factors, clinical practice patterns, and patient outcomes.

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**Table 4.**

Accuracy Statistics with 95% Confidence Intervals (CIs) for Individual Predictor Variables<sup>a</sup>

Variable	Sensitivity (95% CI)	Specificity (95% CI)	Positive Likelihood Ratio (95% CI)	Posttest Probability (%)
Symptoms <90 d	.47 (.33, .62)	.84 (.66, .94)	2.9 (1.2, 6.6)	81.9
Pain-free shoulder flexion <127°	.59 (.44, .73)	.74 (.55, .87)	2.3 (1.2, 4.4)	78.3
Shoulder internal rotation <53° at 90° of abduction	.78 (.63, .88)	.53 (.35, .71)	1.7 (1.1, 2.5)	72.7
Scapula Index greater than 66.5	.57 (.42, .71)	.67 (.47, .82)	1.7 (0.98, 3.0)	72.7
Pain with cervical range of motion	.55 (.40, .69)	.67 (.47, .82)	1.7 (0.99, 2.9)	72.7
Hypomobility of either first rib	.94 (.82, .98)	.23 (.10, .43)	1.2 (0.99, 1.5)	65.2
Weak middle trapezius muscle	.65 (.49, .77)	.6 (.41, .77)	1.6 (0.99, 2.6)	71.5
No deltoid muscle weakness	.77 (.62, .87)	.52 (.31, .71)	1.1 (1.1, 2.4)	63.2
No symptoms distal to shoulder	.77 (.62, .87)	.57 (.38, .74)	1.8 (1.1, 2.8)	71.8
Scapular symptoms	.71 (.57, .83)	.65 (.45, .80)	2.0 (1.2, 3.3)	75.8
Painful arc with flexion	.29 (.17, .43)	.90 (.73, .97)	3.0 (0.92, 9.4)	82.4
Negative active compression test	.73 (.59, .85)	.47 (.29, .65)	1.3 (0.95, 2.0)	67
Negative Neer test	.50 (.35, .65)	.73 (.54, .87)	1.9 (0.97, 3.6)	74.8
Not taking medications	.38 (.24, .53)	.83 (.65, .94)	2.3 (0.93, 5.4)	78.3

<sup>a</sup> Pretest probability of success=61%.

There are limitations to the current study that should be recognized. First, a prospective single-arm design lacking a comparison group does not allow for inferences to be made regarding cause and effect. Weeks<sup>98</sup> stated that single-arm studies are the most vulnerable to a regression effect, as the absence of a control

group makes it impossible to determine the amount of change due to regression. The *regression effect* is defined as a statistical phenomenon in which a finding that may seem significant on first analysis will tend to be closer to the mean of a group on a subsequent measurement.<sup>98</sup> It is possible that the statistical proce-

dures used may have resulted in overfitting of the model, which may have resulted in low precision of the prediction accuracy.<sup>99</sup> Therefore, the values for sensitivity, specificity, and LR presented here may be higher than they actually were. Furthermore, it is possible that the prognostic variables were not reliably se-

**Table 5.**

Clinical Prediction Rule Criteria Identified in the Logistic Regression Analysis and Their Accuracy Statistics

Clinical Prediction Rule Criteria Identified in Logistic Regression Analysis						
Pain-free shoulder flexion <127°						
Shoulder internal rotation <53° at 90° of abduction						
Negative Neer test						
Not taking medications for their shoulder pain						
Symptoms less than 90 d						
No. of Predictor Variables Present	Sensitivity	Specificity	Positive Likelihood Ratio	Probability of Success (%) <sup>a</sup>	Patients Who Satisfied:	
					Success	Nonsuccess
Met all 5	.04 (.01, .15)	1.0 (.86, 1.0)	∞	100	2	0
Met at least 4	.27 (.15, .41)	1.0 (.86, 1.0)	∞	100	13	0
Met at least 3	.51 (.37, .65)	.90 (.73, .97)	5.3 (1.7, 16.0)	89	25	3
Met at least 2	.90 (.77, .96)	.61 (.42, .78)	2.3 (1.5, 3.6)	78	44	12
Met at least 1	1.0 (.90, 1.0)	.19 (.08, .38)	1.0 (1.2, 1.5)	61	49	25

<sup>a</sup> The probability of success is calculated using the positive likelihood ratios and assumes a pretest probability of 61%.

lected and that they may represent spurious findings rather than true prognostic variables. It also is possible that the initial screening process using bivariate analysis may have caused the rejection of some variables that actually have prediction accuracy.<sup>100</sup> However, as is the case with all statistical modeling, the results presented here will require validation to protect against potential problems and limitations. Such validation could include performing the study on an independent sample of patients.<sup>99</sup>

It is possible that one or more of the prognostic variables simply identify individuals who have a favorable natural history rather than a response to the manual therapy and general mobility exercises. Although this may be the case, our sample included participants with relatively longstanding symptoms (65% had symptoms for greater than 90 days). We chose not to limit the duration of symptoms, as research indicates that 50% of individuals with a new onset of shoulder pain will continue to have symptoms at 6 months, and 40% still have symptoms at 1 year.<sup>11,89</sup> In this study, the median duration of symptoms was 99 days for the success group and 225 days in the nonsuccess group. The individuals in our study with acute symptoms seemed to respond more favorably than those with chronic symptoms. The proportion of individuals with a duration of symptoms of >90 days was the same for both the success group (n=26, 32.5%) and the nonsuccess group (n=26, 32.5%). The proportion of individuals with a duration of symptoms of <90 days was significantly different ( $P=.005$ ) between the success group (n=23, 29%) and the nonsuccess group (n=5, 6%).

It also is possible that we did not capture every possible variable that could be a potential predictor during

the examination. We did not standardize the number of treatments, which could have affected the results. It is possible that the small sample size and the number of variables entered into the logistic regression may have resulted in overfitting of the model, which may have led to spurious findings.<sup>99</sup> However, in order to not introduce bias into the analysis, we included all potential predictor variables, and any variable that identified as a predictor should be re-examined in future studies.<sup>99</sup> As we collected only data for short-term outcomes on these individuals, we do not know whether the individuals who were classified as having a successful outcome were still doing well at a longer-term follow-up. Finally, although there is a percentage of individuals with shoulder pain for whom a specific diagnosis can be made, we chose to not separate out any specific diagnoses, which potentially confounded our results.

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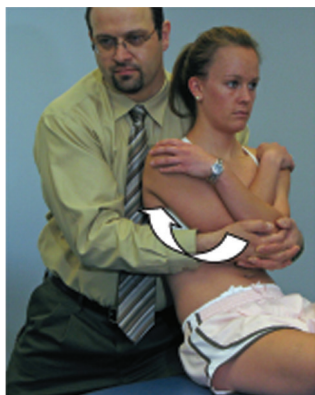
## Prognosis in Individuals With Shoulder Pain Receiving Cervicothoracic Manipulation

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### Appendix 1.

#### Manual Therapy Interventions

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Seated thoracic spine thrust manipulation. The therapist uses his sternum as a fulcrum on the individual's middle thoracic spine and applies a high-velocity distraction thrust in an upward direction.



The treating therapist cradles the individual's head and neck and performs a lateral translation (Maitland grades III and IV) to the right and left in neutral and flexion, 3 bouts of 30 seconds from C5 to C7.



Supine cervicothoracic thrust manipulation technique. The therapist uses his body to push down through the individual's elbows to perform a high-velocity, low-amplitude thrust directed toward moving C7 on T1.

*(Continued)*

### Appendix 1. Continued

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Supine upper thoracic spine thrust manipulation technique. The therapist uses his body to push down through the individual's arms to perform a high-velocity, low-amplitude thrust directed in the direction of the arrow toward T1 through T4.



Supine middle thoracic spine thrust manipulation technique. The therapist uses his body to push down through the individual's arms to perform a high-velocity, low-amplitude thrust directed in the direction of the arrow toward T5 through T8.



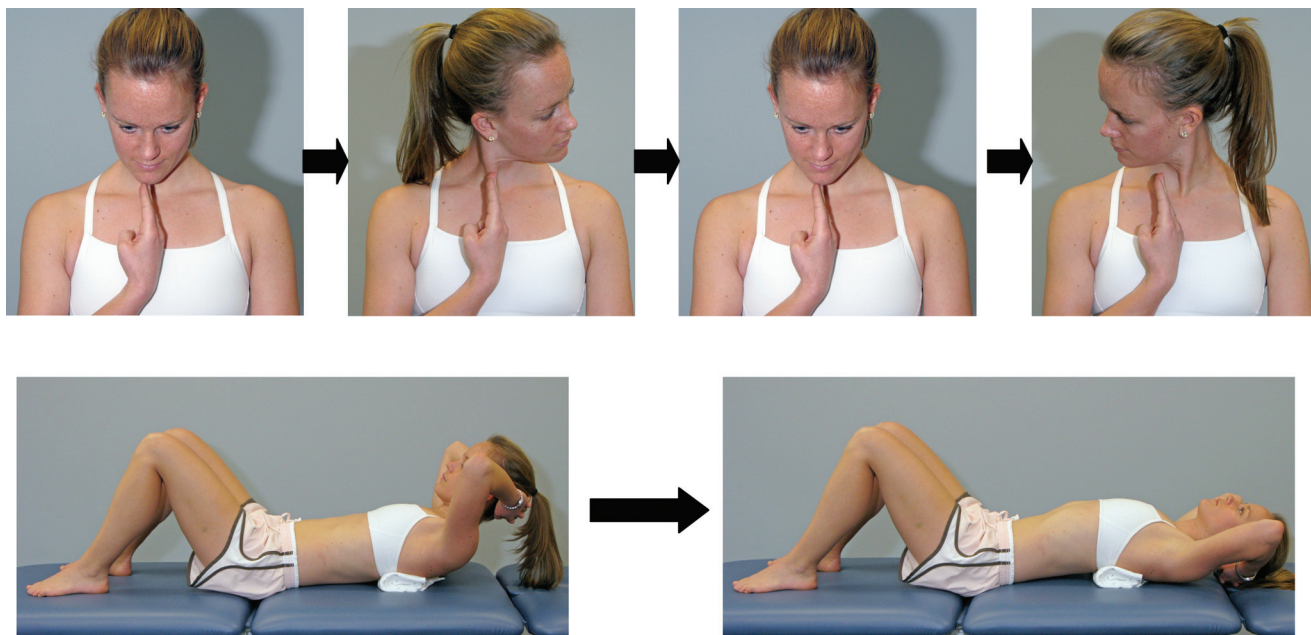
Prone middle to lower thoracic spine thrust manipulation technique. The therapist achieves a "skin lock" with the pisiforms of each hand over the transverse processes of the target vertebra pushing caudal with one hand and cephalad with the other. The therapist then uses his body to push down through his arms to perform a high-velocity, low-amplitude posterior to anterior thrust.



**Appendix 2.**

General Spinal Mobility Exercises

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Active-range-of-motion (AROM) exercises performed by participants in the study: 3-finger cervical AROM and supine thoracic extension over a towel.