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Rehabilitation of a glenohumeral instability utilizing the body blade

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Traditional rehabilitation for shoulder dislocation has a success rate of only 20%. The body blade has been hypothesized to strengthen the muscles stabilizing the shoulder girdle by training the contractile tissues directly and also indirectly affecting the joint and surrounding noncontractile tissues when responding to rapid positional changes and mechanical energy. Shoulder dislocation negatively affects both the active (musculature) and passive (joint and ligaments) stabilizers of the glenohumeral joint. Therefore, the purpose of this case report was to evaluate the efficacy of therapeutic exercise using the body blade in the conservative management of an individual with glenohumeral instability. The patient, an 18-year-old male, dislocated his left shoulder after a wave crashed on top of him. Intervention included therapeutic exercise using the body blade. Measures were taken at examination, re-evaluation (6th visit), and discharge (11th visit). According to the 11-point numeric pain rating scale, worst pain was reduced from 4 to 0. Glenohumeral ROM measures at discharge were all within normal range except external rotation (deficit of 10 degrees), compared to the initial ROM deficits of 10–35% of noninvolved values. Post intervention strength, as assessed by handheld dynamometry, revealed deficits only in scapular retraction compared to the uninvolved side (21% compared to an initial deficit of 39%). Other muscle groups showing deficits from 20% to 40% at initial examination exceeded the comparative strength of the other limb at discharge. The SPADI and WOSI scores were reduced from 13 to 0 and 482 to 46, from initial examination to discharge, respectively. Furthermore 6 months post episode of care the patient reported no recurrent dislocation of the involved shoulder. The success rate of an exercise program with individuals who have dislocated their glenohumeral joint is poor. After 11 visits of physical therapy using the body blade the patient improved in ROM, strength, and function.

Introduction

Hawkins, Bell, Hawkins, and Koppert, 1986, indicated there is a 1–2% overall incidence regarding glenohumeral dislocations, typically occurring in either the second or sixth decade of life. Ninety-five percent of first-time dislocations occur from trauma (Hayes et al, 2002). In 98% of traumatic glenohumeral dislocations, the humeral head translates anteriorly, classifying the trauma as an anterior glenohumeral dislocation. Gross (1988) indicated that 70% of glenohumeral dislocations will reoccur within 2 years of initial injury. More specifically, individuals 20 years old or younger have a recurrence rate of 83–90% (Walton et al, 2002). Furthermore, in a randomized controlled trial assessing the effectiveness of immobilization, it was reported

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that in addition to subjects who experienced recurrence of dislocation (55%), an additional 15% of patients 22 years of age or younger reported subjective instability, but no recurrence of dislocation when surveyed 2 years after initial injury (Hovelius et al, 1983).

Dynamic structures directly and indirectly generate joint kinetics and kinematics. The deltoid, long head of the biceps brachii, rotator cuff, and muscles that control the movement and position of the scapula are the dynamic tissues directly and indirectly responsible for glenohumeral stability (Aronen, 1986; Speer, 1995). The rotator cuff through a co-contraction of muscles directly stabilizing the joint reduces translation such that a "50 percent reduction of rotator cuff forces increased anterior displacement by 46 percent" (Wuelker, Korell, and Thven, 1998). In 64% of glenohumeral instability cases, scapular instability was observed, indicating the pivotal role these dynamic structures play indirectly (Kibler and Perry, 1998; Warner, Micheli, and Arslenian, 1992). To reproduce accurate kinematics it is essential that the body maintain a balance between the scapular stabilizers, the rotator cuff, and the non-contractile tissues.

Rehabilitation attempts to address the etiological factors leading to recurrence by enhancing the force production of contractile tissues, therefore improving the biomechanics responsible for glenohumeral stabilization. Rehabilitation primarily has focused on flexibility, range of motion, and progression of strengthening with modes of resistance such as free weights or theraband (Burkhead and Rockwood, 1992; Hayes et al, 2002). Traditional rehabilitation of initial immobilization and then physical therapy has a success rate of 20% for patients with glenohumeral dislocations (Davy and Drew, 2002). The focus of most rehabilitation processes on isolated rotator cuff musculature rather than scapular stabilizers may be responsible for the poor rate of success. Ultimately, these muscle groups must work in a coordinated effort resulting in co-contraction about the joint and if possible be trained during functional types of activities. Finally, and we do not know if this is possible, the passive stabilizers (joint capsule and ligaments) may respond to stimulation that occurs during training if the stimulation involves joint and ligament receptors. Stimulation of capsule and ligament may in effect cause some level of repair to damaged structures, similar to repair from mechanical effects from ultrasound (Dyson, 1987; Enwemeka, 1990).

A unique rehabilitation tool, the body blade requires the patient to generate oscillatory movements of the upper extremity. The body blade has been hypothesized to strengthen the muscles stabilizing the shoulder girdle by training the contractile tissues directly, and also indirectly affecting the joint and surrounding non-contractile tissues when responding to rapid positional changes (Austin, 2001). In a descriptive study, the patient using the body blade produced concentric and eccentric muscle contractions in a rapid manner, generating co-contraction of muscle groups and ultimately strengthening of the muscle groups (Austin, 2001). To produce the rhythmic oscillation of the body blade, gross muscle strength and coordination are required; this takes training and repeated practice (Schulte and Warner, 2001). Tyler and Hutton (1986) stated "Intuitively it makes sense that muscle conditioning/training enhances joint position and central/peripheral control associated with reciprocal co-activation exercises". Davies and Dickoff-Hoffman (1993) after analyzing EMG activity of co-contractions of the biceps brachii and triceps in nine healthy subjects, concluded that co-activation firing protects joints from compressive and distractive forces.

Traditional rehabilitation of previously dislocated and unstable shoulders has generally had a poor success rate in reducing further dislocations (Hovelius, 1987). There appears to be a theoretical framework that enhancing muscle co-activation may protect the joint and that noncontractile tissue responds favorably to repeated mechanical stimulation (Austin, 2001; Schulte and Warner, 2001). Therefore, the purpose of this case report was to evaluate the efficacy of therapeutic exercise using the body blade in the conservative management of an individual with glenohumeral instability.

Case description

Patient

The patient was an 18-year-old right hand dominant male who was referred to physical therapy with a medical diagnosis of left shoulder dislocation. The mechanism of injury involved a large forceful wave that crashed on top of the patient, consequently dislocating his left glenohumeral joint, which was positioned in abduction and external rotation. In 98% of traumatic glenohumeral dislocations, the humeral head translates anteriorly, classifying the trauma as an anterior glenohumeral dislocation (Hayes et al, 2002). This trauma occurred 3 weeks prior to the initiation of physical therapy and resulted in pain, impaired range of motion, and reduced strength, thus causing upper extremity dysfunction. Although the relocation was immediately self-induced, the patient did seek medical attention where x-rays revealed no evidence of a fracture. It is unusual for a glenohumeral dislocation to not require manual relocation, but in instances where the individual may have increased laxity of their joints as with some athletes this can occur. No other imaging was administered. The patient's physician immobilized his left upper extremity in a sling for 3 days and forwarded the patient to physical therapy with a diagnosis of traumatic shoulder dislocation.

The patient indicated throughout his high school career he competitively swam butterfly and was continuing with intramural water sports in college. Although this patient had no previous shoulder problems from swimming, his rehabilitation was designed to foster stability in various positions to replicate the biomechanics of swimming butterfly, the most painful stroke as reported by McMaster, Troup, and Arredondo, 1989. Other activities of interest to the patient included mountain bike riding and kayaking. The patient's greatest concerns with activities of daily living and recreation were his inability to use his involved upper extremity to sleep prone, reach into his back pocket, and swim due to the apprehension of instability and pain.

Examination

The patient's medical history revealed no systemic comorbidities. In high school he experienced tendonitis after he injured his left shoulder during a sledding accident. According to the patient the glenohumeral joint was not displaced, therefore neither medical attention nor physical therapy was required. The patient reported that the pain and tendonitis subsided on their own over a 2-month period.

The patient presented with impairments of pain, limited range of motion in shoulder flexion, shoulder abduction, shoulder internal and external rotation, and strength deficits in shoulder flexion, shoulder internal rotation, scapular retraction.

Several outcome measures were used to evaluate specific impairments, functional limitations, and disabilities related to the patient. These included the apprehension test, relocation test, the numeric pain rating scale, goniometry, handheld dynamometry, shoulder pain and disability index (SPADI), the Western Ontario shoulder instability index (WOSI), and the short form 36 (SF-36). Each outcome measure was chosen because of its adequate psychometric characteristics and ability to measure each of the components of the Nagi Model. Concomitant use of the SPADI and WOSI captures the patient's specific limitations regarding the glenohumeral joint, and a global health assessment is determined by use of the SF-36.

The following special tests were negative on examination: empty can; Neer's; and modified O'Brien's for detecting rotator cuff abnormality, weakness in the supraspinatus tendon secondary to a tear, or pain associated with impingement (Magee, 2002). The apprehension test for anterior shoulder dislocation and relocation for anterior shoulder dislocation were positive upon examination (Table 1). Lo et al, 2004, in a randomized control trial analyzed the apprehension test and the relocation test with 46 subjects of

Table 1. Special tests for examination of glenohumeral joint stability.

Special test	Examination	Re-evaluation	Discharge
Apprehension	Positive	Negative	Negative
Relocation	Positive	Negative	Negative
Neer's	Negative	*	*
Empty can	Negative	*	*
Modified O'Brien's	Negative	*	*

*Was not tested at that time.

various shoulder diagnosis. They determined a sensitivity of 52.8% and 45.8% and a specificity of 98.9% and 54.7% for apprehension test and relocation test, respectively. The apprehension test and the relocation test have been described as demonstrating instability in the glenohumeral joint having a positive predictive value of 97.7% and 43.9%, as well as a negative predictive value of 72.8% and 56.7%, respectively.

Numeric pain rating scale is an 11-point scale ranging from 0 to 10, which the patient is asked to rate their pain where 0 is no pain and 10 is the worst pain experienced. The numeric pain rating scale highly correlates (0.79–0.95), with the visual analog scale, which many consider the gold standard for rating pain (Berthier et al, 1998; DeLoach, Higgins, Caplin, and Stiff, 1998). The numeric pain rating scale has a test retest reliability of 0.67–0.96 (Stratford and Spadoni, 2001). The minimal detectable change for the measure is three points on the scale (Stratford and Spadoni, 2001). The patient rated his pain a 4 out of 10 at its worst and reported his pain awoke him during sleep approximately four or five times a week. The patient denied any neurological symptoms and any point tenderness.

Goniometric measures were taken bilaterally for comparison. Goniometric measures are valid and reliable, particularly the intrarater reliability in the shoulder has a measure of 0.90 (Boone et al, 1978; Gajdosik and Bohannon, 1987). Active range of motion was assessed because the literature reports passive range of motion is more difficult to reliably measure than active range of motion (Gajdosik and Bohannon, 1987). With passive range of motion stretching of soft tissue is incorporated into the measurement taken, which is dependent on the force applied to the limb. The force applied into the limb is hard to control and inevitably decreases reliability (Gajdosik and Bohannon, 1987). Boone et al, 1978 suggested that joint range of motion should exceed 5° to be classified as an improvement. The patient presented with a 49° deficit with glenohumeral flexion, a 51° deficit with abduction, a 6° deficit with internal rotation, and a 20° deficit with external rotation, all measured on the left glenohumeral joint (Table 2), compared to the noninvolved side.

The handheld dynamometer was used to assess strength bilaterally for a means of comparison. It has been previously demonstrated that handheld dynamometry has a high reliability both on a day-to-day basis, 0.75–0.94, and by trial basis, 0.89–0.97 (Balogun et al, 1998). Handheld dynamometry also has high interrater reliability of 0.83–0.96 when examined between trials. Handheld dynamometry was used because it is a more sensitive measure of strength than manual muscle testing (Balogun et al, 1998). The method used for the measures of shoulder, elbow, and scapular actions were from Bohannon (1997). This involved an isometric hold against the hand held dynamometer with the dynamometer force perpendicular to the force applied by the patient. Three repetitions were taken with the highest value of the three recorded. The first measure was always taken on the noninvolved side followed by the involved side and then repeated for the three repetitions (six total). One minute of rest was provided between maximum efforts. The patient had a strength measure for shoulder flexion of 21 pounds of force on the left versus 31 pounds on the right; with shoulder internal rotation the patient exhibited 16 pounds on the left versus 22 pounds on the right. In regards to scapular retraction 17 pounds of force were measured

Table 2. Goniometric measures of the glenohumeral joint (measured in degrees).

	Examination	Re-evaluation	Discharge
Involved/noninvolved/ normative value (Boone et al, 1978)			
Shoulder flexion	131/180/167	172/*/167	180/*/167
Shoulder internal rotation	59/65/69	72/*/69	63/*/69
Shoulder external rotation	55/75/104	85/*/104	94/*/104
Shoulder abduction	129/180/184	180/*/184	184/*/184

*Measurement was not taken at that time.

Table 3. Handheld dynamometry measures of Strength (measured in pounds of force).

Motion	Examination	Re-evaluation	Discharge	Non-involved
Shoulder flexion	21	26	42*	31
Shoulder abduction	23	28	28	21
Shoulder external rot	14	22	28	14
Shoulder internal rot	16	24	26*	22
Horizontal adduction	13	24	27	14
Elbow flexion	13	26	33*	17
Elbow extensioin	25	23	23	27
Scapular retraction	17	17	22*	28
Scapular depression	12	19	23*	15

*Significant improvement from examination to discharge according to clinical practice guidelines developed by the Philadelphia Panel (Brosseau et al, 2001).

on the left and 28 pounds of force on the right (Table 3).

The SPADI is a self-administered subjective questionnaire that is categorized into two domains: 1) pain and 2) disability. SPADI scores range from 0 to 100 where lower scores indicate a more desirable health status. The disability component of this outcome measure has moderately strong construct validity with the function subscale of the UCLA shoulder of 0.64, and simple shoulder test of 0.80 (Roddey et al, 2000). Roach, Budiman-Mak, Songsiridej, and Lertratanakul (1991) declared the SPADI had a test–retest reliability of 0.65 and was highly correlated with active range of motion, 0.54–0.80. The minimally clinically important difference for the SPADI is 10 points (McClure and Michener, 2003). The numeric version of the SPADI was used in this case versus the original visual analog scale version of the SPADI. When the original version was compared to the numeric version, there was an intra-class correlation coefficient of 0.86 (McClure and Michener, 2003). Thus, the numeric scale scores are on

Table 4. Score for the shoulder pain and disability index (SPADI).

	Initial visit	Re-eval	Discharge
Pain Scale: How severe is your pain:			
1. At it's worst	3	1	0
2. When lying on the involved side	2	0	0
3. Reaching for something on a high self	2	0	0
4. Touching the back of your neck	3	0	0
5. Pushing with the involved arm	0	0	0
Disability Scale: how much difficult do you have:			
1. Washing your hair	0	0	0
2. Washing your back	3	1	0
3. Putting on an undershirtor pullover sweater	0	0	0
4. Putting on a shirt that buttons down the front	0	0	0
5. Putting on your pants	0	0	0
6. Placing an object on a high shelf	1	0	0
7. Carrying a heavy object of 10 lbs.	0	0	0
8. Removing something from your back pocket	1	0	0
Combined Average Score:	13	2	0

Table 5. Score for the Western Ontario Shoulder Instability Index (WOSI).

Scores summary	Initial visit	Re-eval	Discharge
Physical Symptoms			
Average per question	24.7	7.7	1.2
Sports/Recreation/Work			
Average per question	14.0	5.8	2.5
Lifestyle			
Average per question	33.3	4.5	2.0
Emotions			
Average per question	15.3	7.0	5.6
Total Score:	482	129	46

average 2.5 points greater than the original version of the SPADI. The patient scored a 13 upon examination (Table 4).

The WOSI is a self-administered scale designed to evaluate shoulder instability. The WOSI is comprised of 21 items presented as a visual analog scale, which are categorized into five domains: 1) physical symptoms, 2) sports and recreation, 3) work, 4) lifestyle, and 5) emotions. WOSI total scores range from 0 to 2100 such that lower scores are indicative of better health. Research indicates the WOSI has a high construct validity of 0.70–0.76 with the Disability of the Arm Shoulder and Hand test (DASH) (Kirkley, Griffin, McLintock, Ng, 1998). A study also revealed that the WOSI has high reliability when the test was administered after 2 weeks, 0.95, and 3 months, 0.91. The WOSI also demonstrates high responsiveness with a 0.93 standardized response mean (Kirkley, Griffin, McLintock, Ng, 1998). The patient's WOSI score was a 482 upon initial examination (Tables 5 and 6).

The SF-36 is a global self-report measure, which assesses eight specific health concepts: 1) physical functioning, 2) role limitations, 3) social functioning, 4) bodily pain, 5) general mental health, 6) role limitations, 7) vitality, and 8) general health perceptions. Health concept scores can vary from 0 to 100 where higher numbers indicate a more desirable health. Typically, scores are separated into physical component and a mental component summary. The SF-36 has been extensively researched and has a high reliability of 0.94–0.96 (Ware and Sherbourne, 1992) and correlates with the SPADI ($r = 0.67$) (Beaton and Richards, 1996). The patient had a score of 51.1 on the physical component and a 63.0 on the mental component of the SF-36 upon initial examination.

Evaluation and diagnosis

Based on our history and examination, we diagnosed the patient with an anterior and inferior glenohumeral dislocation. Impairments included:

- Pain during shoulder flexion
- Decreased range of motion in his left shoulder for abduction, flexion, internal and external rotation
- Decreased strength in his left upper extremity as well as scapular muscles

At the disability level, we noted minimal to moderate pain while he was:

- Lying on the involved shoulder
- Reaching to place an object on a high shelf
- Washing his back
- Touching the back of his neck
- Sleeping prone
- Reaching to his back pocket

At the handicap level, we found an inability to swim. We classified the patient in the *Guide to Physical Therapist Practice* (2001) practice pattern 4D: impaired joint mobility, motor function, muscle performance, and range of motion associated with connective tissue dysfunction. The medical diagnosis was a left glenohumeral dislocation.

Prognosis

The *Guide to Physical Therapy Practice* (2001) indicates that the expected range of number of

Table 6. Western Ontario Shoulder Instability Index (WOSI)[26] instrument and patient responses on items of difficulty.

PHYSICAL SYMPTOMS

1) How much pain do you experience in your shoulder with overhead activities?
2) How much aching or throbbing do you experience with your shoulder?
3) How much weakness or lack of strength do you experience in your shoulder?
4) How much fatigue or lack of stamina do you experience in your shoulder?
5) How much clicking, cracking or snapping do you experience in your shoulder?
6) How much stiffness do you experience in your shoulder?
7) How much discomfort do you experience in your neck muscles as a result of your shoulder?
8) How much feeling of instability or looseness do you experience in your shoulder?
9) How much do you compensate for your shoulder with other muscles?
10) How much loss of range of motion do you have in your shoulder?

SPORTS/RECREATION/WORK

11) **How much has your shoulder limited the amount you can participate in sports or recreational activities?**
    (Scores: examination = 14, re-evaluation = 5, discharge = 5, 6 months post PT regime = 0)
12) How much has your shoulder affected your ability to perform the specific skills required for your sports and work? (If your shoulder affects both sports and work, consider the area that is most affected.)
13) How much do you feel the need to protect your arm during activities?
14) How much difficulty do you experience lifting heavy objects below shoulder level?

LIFESTYLE

15) How much fear do you have of falling on your shoulder?
16) How much difficult do you experience maintaining your desired level of fitness?
17) How much difficulty do you have "roughhousing or horsing around" with family or friends?
18) How much difficulty do you have sleeping because of your shoulder?

EMOTIONS

19) **How conscious are you of your shoulder?**
    (Scores: examination = 38, re-evaluation = 16, discharge = 13, 6 months post PT regime = 10)
20) How concerned are you about your shoulder becoming worse?
21) How much frustration do you feel because of your shoulder?

Bolded Items scoring ≥ 5 at discharge.

visits per episode of care is 3–36 for practice pattern 4D. This broad range established for a heterogeneous patient population provides little prognostic guidance. Relevant for the prognosis of the patient described in this case report is the expected natural history, and the outcomes with PT intervention using the body blade. A superior outcome with the treatment plan described over natural history may provide guarded indication of the effectiveness of therapeutic exercise using the body blade.

We searched the Medline, CINAHL, and Rehabilitation and Physical Medicine databases from 1975 to June 2006 by using the terms treatment AND glenohumeral dislocation OR glenohumeral instability OR glenohumeral subluxation. With regard to the natural history of shoulder dislocation, Hovelius et al, 1996 compared strict immobilization or sling use for 3–6 weeks for patients 12–22 years of age. Eighty-four shoulders were followed over a 10-year period. Twenty-eight shoulders had no additional dislocations (26%), and this was evenly distributed between the strict mobilization and the sling groups. Thirty-two of the 46 shoulders that were immobilized had at least one recurrence (70%), compared to 24 of 38 shoulders for the sling group (63%). There was no significant difference between treatment groups, so in effect it can be expected that approximately 67% can expect recurrent dislocations with this type of intervention, or in essence lack of intervention from a therapeutic exercise standpoint in early rehabilitation. No other outcomes except further dislocation were followed. Arciero, Wheeler, Ryan, McBride (1994) had similar findings, with 80% of his patients developing recurrent instability following a month of immobilization and then rehabilitation consisting of strengthening and range of motion exercises. Kiviluoto, Pasila, Jaroma, Sundhom (1980) had different findings in that immobilization for a week in a sling had poorer outcomes of recurrent dislocation than immobilization for 3 weeks. In summary, Kiviluoto, Pasila, Jaroma, Sundhom (1980) suggested that immobilization for 3 weeks can help reduce redislocation, whereas Arciero, Wheeler, Ryan, McBride (1994) and Hovelius et al, (1996) did not find strict immobilization for 3–4 weeks to have a positive impact on stopping recurrence of dislocation, and that even when coupled with rehabilitation patients of Arciero et al, still had a high recurrence rate.

These studies would seem to indicate that the prognosis for glenohumeral dislocation for young individuals both with regard to natural history (i.e., without intervention) and with PT consisting of exercises is not very good. With immobilization or immobilization and PT, only one in four patients had a successful outcome of no further dislocation. We have to conclude that there is a lack of published research indicating the optimal number of treatments per episode of care for patients with glenohumeral dislocation.

Previous case studies with patients having shoulder instability or rotator cuff tears suggest 18–22 visits over 6–7 weeks; however, the patients in these cases were significantly older (>70 years old and less active) (Echeverry and Hasson, 2004; Piccoli and Hasson, 2004). Therefore, we believed the patient would require 8–12 visits over a 4–6 week period.

Intervention

Each session began with the patient warming up on the SCI FIT, PRO II arm ergometer (Scientific Solutions, Tulsa, OK). The warm-up included the patient alternating between the forward mode and the reverse mode each minute for 5 minutes at a moderate intensity, level 5 of 20, and revolutions per minute as tolerable. This exercise was performed to warm up the shoulder girdle and upper torso for strength and endurance training. At the conclusion of each treatment session ice was used as a prophylactic toward pain, soreness, or joint irritation that any exercises might cause.

The progression of the body blade (Body-Blade, Inc., West Chester, PA) exercises was developed to gradually challenge the patient from both a muscle force generation and joint stability standpoint (Table 7). To begin, the patient used the body blade with bilateral upper extremities in one position to facilitate small oscillatory motion of shoulder flexion/extension ension and shoulder internal/external rotation.

Exercises challenging the muscles that control scapular protraction were administered based on an anatomical study by Weiser, et al, 1999, who examined glenohumeral translation at various angles of scapular protraction with five cadavers. Weiser, et al, 1999, concluded "repetitive or chronic protraction of the scapula may result in excessive strain and, ultimately, insufficiency in the anterior band of the inferior glenohumeral ligament" which has a role in the stability of the joint. Figure 1 exhibits the exercise where the patient held the body blade bilaterally along the vertical axis and oscillated the blade in a medial/lateral direction while actively rotating the torso to facilitate a resultant scapular protraction and retraction. This exercise was designed to challenge these scapulothoracic muscles to enhance stability. This exercise enhances stability because the position of the scapula is actively controlled by scapulothoracic muscles, and not static ligamentous structures as in Weiser's cadavers. Another exercise that the patient completed to enhance scapular control was scapular protraction. This exercise entailed holding the body blade along the x-axis and oscillating the tool in an anterior/posterior direction while protracting the scapula as demonstrated in Figure 2.

Once the patient could perform all bilateral exercises and exercises targeting scapular control without pain and with a controlled smooth motion, then unilateral (involved) upper extremity exercises were incorporated. The patient completed the following exercises: elbow flexion/extension to target the long head of the

Table 7. Progression using the body blade.

Session	Axis	Oscillation	Upper extremity	Movement (shoulder unless noted)	ROM	Position	Repetition	Sets
1	X	Superior/inferior	Left	Flexion/extension	Neutral	Standing bilateral	10	1
	X	Superior/inferior	Left	Elbow flexion/extension	Neutral	Standing bilaterally	10	1
	Z	Medial/lateral	Left	Abduction/adduction	Neutral	Standing bilaterally	10	1
	Y	Medial/lateral	Left	Internal/external rotation	Neutral	Standing bilaterally	10	1
2	X	Anterior/posterior	Bilateral	Scapular protraction	100%	Standing bilaterally	10	1
	Y	Medial/lateral	Bilateral	Trunk rotation	100%	Standing bilaterally	10	2
	X	Superior/inferior	Bilateral	Flexion/extension	25%	Standing bilaterally	10	2
	Y	Medial/lateral	Bilateral	Internal/external rotation	25%	Standing bilaterally	10	2
	Z	Medial/lateral	Left	Abduction/Adduction	25%	Standing bilaterally	10	2
3	X	Superior/inferior	Bilateral	Flexion/extension	50%	Standing bilaterally	10	2
	Y	Medial/lateral	Bilateral	Internal/external rotation	50%	Standing bilaterally	10	2
	Z	Medial/lateral	Left	Abduction/Adduction	50%	Standing bilaterally	10	2
	Y	Medial/lateral	Bilateral	Trunk rotation	100%	Standing bilaterally	10	2
4	Y	Medial/lateral	Bilateral	Trunk rotation	100%	Standing bilaterally	10	2
	X	Superior/inferior	Left	Elbow flexion/extension	100%	Standing bilaterally	10	2
	X	Anterior/posterior	Bilateral	Scapular protraction	100%	Standing bilaterally	10	2
	X	Anterior/posterior	Bilateral	Trunk extension	100%	Prone on physioball and bilateral feet on floor	10	2
	Y	Medial/lateral	Bilateral	Internal/external rotation	50%	Standing bilaterally	10	
	X	Superior/inferior	Bilateral	Flexion/extension	50%	Standing bilaterally	10	2
	X	Medial/lateral	Left	Abduction/adduction	30%	Standing bilaterally	10	2
5	X	Superior/inferior	Bilateral	Flexion/extension	100%	Standing on RLE	5	2
	X	Superior/inferior	Bilateral	Flexion/extension	100%	Standing on LLE	5	1
	Y	Medial/lateral	Bilateral	Internal/external rotation	100%	Standing on RLE	5	1
	Y	Medial/lateral	Bilateral	Internal/external rotation	100%	Standing on LLE	5	1
	Z	Medial/lateral	Left	Abduction/adduction	100%	Standing on LLE	5	1
	Z	Medial/lateral	Left	Abduction/adduction	100%	Standing on RLE	5	1
	X	Superior/inferior	Bilateral	Flexion/extension UE With Trunk extension	100%	Prone on physioball	5	1
		Superior/inferior	Left	Diagonal 1 flexion/extension UE With Trunk extension	100%	Standing bilaterally	10	1
6	X	Superior/inferior	Bilateral	Flexion/extension	100%	Standing on RLE	10	2
	X	Superior/inferior	Bilateral	Flexion/extension	100%	Standing on LLE	10	2

(*Continued*)

Session	Axis	Oscillation	Upper extremity	Movement (shoulder unless noted)	ROM	Position	Repetition	Sets
	Y	Medial/lateral	Bilateral	Internal/external rotation	100%	Standing on RLE	10	2
	Y	Medial/lateral	Bilateral	Internal/external rotation	100%	Standing on LLE	10	2
	Z	Medial/lateral	Left	Abduction/adduction	100%	Standing on RLE	10	2
	Z	Medial/lateral	Left	Abduction/adduction	100%	Standing on LLE	10	2
	X	Superior/inferior	Bilateral	Flexion/extension With Trunk extension	100%	Prone on physioball	10	2
7	X	Superior/inferior	Left	Flexion/extension	60%	Standing bilaterally	10	2
	Z	Medial/lateral	Left	Abduction/adduction	60%	Standing bilaterally	10	2
	Y	Medial/lateral	Left	Internal/external rotation	60%	Standing bilaterally	10	2
	X	Superior/inferior	Bilateral	Flexion/extension With Trunk extension	100%	Prone on physioball with bilateral feet on a 6” stool	10	1
8	X	Superior/inferior	Left	Flexion/extension	100%	Standing bilaterally	10	2
	Z	Medial/lateral	Left	Abduction/adduction	100%	Standing bilaterally	10	2
	Y	Medial/lateral	Left	Internal/external rotation With Trunk rotation	100%	Standing bilaterally	10	2
		Superior/inferior	Left	Diagonal 1 flexion/extension UE With Trunk flexion/ extension	100%	Standing bilaterally	10	1
		Superior/inferior	Left	Diagonal 1 flexion/extension UE With Trunk extension	100%	Prone on physioball with bilateral feet on floor	10	1
		Superior/inferior	Left	Diagonal 1 flexion/extension UE	100%	Standing on LLE	10	2

Superior/inferior	Left	Diagonal 1 flexion/extension UE	100%	Standing on RLE	10	2
Superior/inferior	Left	Diagonal 1 flexion/extension UE With Trunk flexion/extension	100%	Standing bilaterally	10	2
Ball bouncing against a wall	Left	Internal/external rotation With UE positioned in abduction 90 degrees and external rotation 90 degrees	30 degrees	Standing bilaterally	until fatigue	0
Ball bouncing against a wall	Left	Internal/external rotation With UE positioned in abduction 90 degrees and external rotation 90 degrees With Trunk rotation of 180 degrees as it relates to the wall	30 degrees	Standing bilaterally	Until fatigue	0
Plyometric with a trampoline	Left	Internal/external rotation With UE positioned in abduction 90 degrees and external rotation 90 degrees		Standing with RLE anterior to LLE	20	3

Figure 1. The model is holding the body blade bilaterally along the y-axis and oscillates the blade in a medial/lateral direction while actively rotating the torso to facilitate a resultant scapular protraction and retraction.

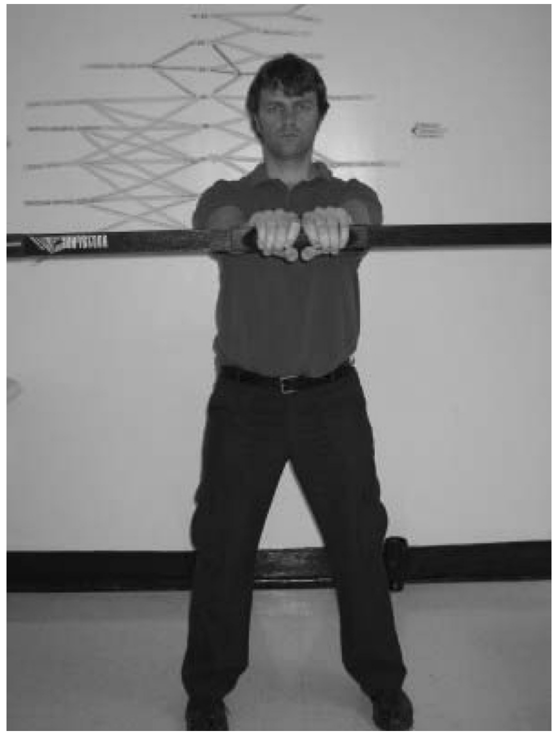

Figure 2. The model is holding the body blade along the x-axis oscillating the tool in an anterior/posterior direction while protracting the scapula.

biceps brachii, a dynamic stabilizer of the glenohumeral joint; shoulder abduction/adduction; shoulder flexion/extension; and shoulder internal/external rotation. Initially, the patient completed each exercise through a partial range of motion. The patient was then gradually progressed to full range of motion when the patient exhibited a smooth trajectory of motion while oscillating the body blade without subsequent pain.

When the patient was able to complete full-range unilateral exercises with the involved extremity by oscillating the body blade through a smooth trajectory of motion without subsequent pain, the patient was challenged to complete diagonal patterns of exercise. These diagonal pattern exercises were based on proprioceptive neuromuscular facilitation (PNF) patterns (Figure 3). The diagonal pattern was progressed to incorporate flexion/extension of the torso. Next, these diagonal pattern exercises were then progressed by manipulating the patient's distal support because functionally not all tasks allow both lower extremities to be in contact with the ground. The patient completed the diagonal pattern, incorporating flexion/extension of torso while standing on one lower extremity.

Because the primary concern is reoccurrence of glenohumeral dislocation, it is essential that an individual be rehabilitated to gain stability in the likeliest position of possible glenohumeral dislocation. The most unstable phase of the butterfly stroke is the recovery phase, where the limb is out of water, because the upper extremity is positioned in shoulder abduction and external rotation with elbow flexion then extension (Richardson, 1986). During the recovery phase the rotator cuff limits translation of the humeral head during abduction of the glenohumeral

Figure 3. The model is holding the body blade along the y-axis and is performing diagonal patterns while oscillating the tool in medial/lateral direction while rotating and incorporating flexion/extension of the torso.

joint. The ultimate goal was to rehabilitate the patient so he could perform motions with the body blade to simulate the threatening positions during the recovery phase of the butterfly stroke. Therefore, once the patient demonstrated smooth and coordinated motions with the diagonal patterns while continuously oscillating the body blade, the patient was progressed to exercises to simulate these threatening positions. Figure 4 shows how the patient completed threatening exercises prone with trunk extension bilaterally then unilaterally as in Figure 5.

Outcomes

As indicated previously, several outcome measures were used including the numeric pain rating scale, goniometric measures, handheld dynamometry, SPADI, WOSI, and SF-36, which were all administered upon examination, re-evaluation, which occurred 36 or six visits after the initial examination, and at discharge, 50 days or 11 visits after the initial examination.

According to the patient his pain was rated a 4 out of 10 at its worst upon initial examination. When it was assessed upon re-evaluation, the patient reported 0 out of 10. The patient was able to continue to function without pain when assessed at discharge. This change of four points on the numeric rating scale is clinically significant as discussed previously.

Figure 4. The model performs motions with the body blade to simulate the threatening positions during the recovery phase of the butterfly stroke.

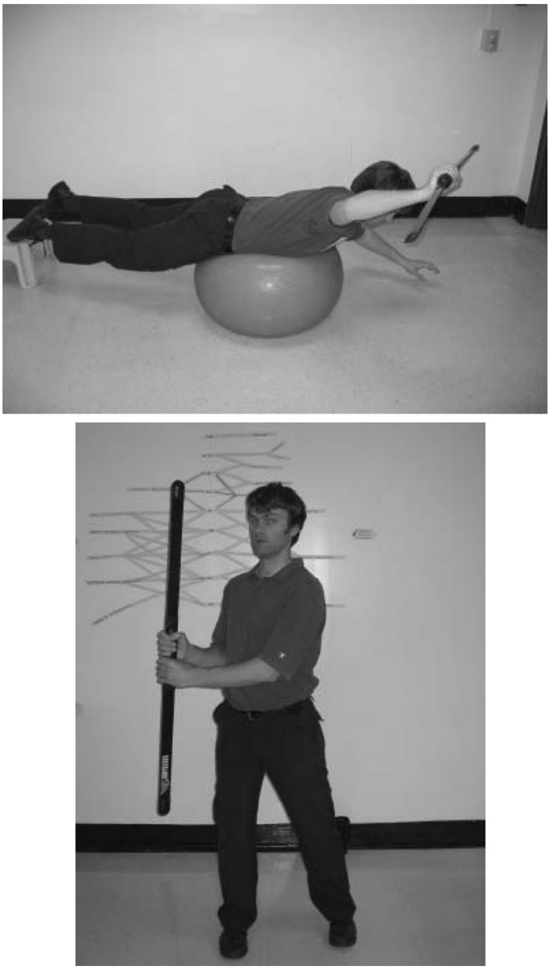

Figure 5. The same position as in Figure 4, but with the unilateral involved arm.

Goniometric measures of active range of motion indicated deficits with glenohumeral flexion, abduction, and internal and external rotation upon examination (Table 2). Upon re-evaluation and at discharge it became apparent that glenohumeral flexion, abduction, internal and external rotation improved to be within normal limits as compared to the uninvolved side.

Bilateral handheld dynamometry demonstrated an increase for shoulder flexion, and internal rotation, scapular depression, and elbow flexion, but no change for scapular retraction (Table 3). The strength in the involved limb was now greater than the patient's initial measurements of the noninvolved upper extremity with the exception of scapular retraction. Upon re-evaluation the patient no longer exhibited positive symptoms associated with apprehension and relocation tests. These findings did not change upon discharge (Table 1).

Scores of the SPADI at re-evaluation revealed a decrease of 11 points, which indicates a meaningful clinical change. This decrease is indicative of an improvement in health. The patient continued to improve since at discharge the patient scored a 0 on the SPADI (Table 4).

During re-evaluation a WOSI score of 129 was calculated compared to the initial examination, with an inclination of improvement of the functional capacity of the involved upper extremity. Upon discharge, the patient scored a 46, indicating further improvement (Tables 5 and 6). There are no data on the WOSI regarding meaningful clinical change, yet in our opinion the large change in score would suggest patient improvement.

The patient's mental component summary of the SF-36 did not significantly change from examination to re-evaluation and again to discharge, 63.0, 59.9, and 58.8, respectively. A change in the physical component summary occurred from examination to re-evaluation. Upon discharge the patient showed a 13.6% change compared to the initial examination. This global measure was not able to detect the significant physical changes or mental changes the patient encountered because of its lack of specificity to shoulder impairments.

The patient was contacted, by way of e-mail, upon 6 months following the completion of this physical therapy regimen and indicated that he had not dislocated his involved upper extremity. The patient also reported a 0 on the WOSI question "How much has your shoulder limited the amount you can participate in sports or recreational activities?" and a score of 10 on the WOSI question "How conscious are you of your shoulder." Both of these WOSI items were deficits at discharge and continued to improve even after intervention was discontinued.

Discussion

Glenohumeral dislocation can lead to instability. Instability causes pain and dysfunction of the joint but can also damage surrounding tissue. Impingement and rotator cuff tears are often associated with anterior shoulder instability (Hawkins, Bell, and Koppert, 1986; Jobe, Moynes, Brewster, 1987; Neviaser, Neviaser, and Neviaser, 1993). Rowe and Zarins, 1981, observed a Bankart lesion in 85% of traumatic instability cases, which required surgery. Hill-Sachs lesions have been observed in 80% of traumatic instability cases (Walton et al, 2002).

As discussed previously a high percentage of young individuals experience recurrent dislocation, therefore increasing their risk for instability and further glenohumeral damage. Consequently, it is vital for individuals to regain strength and range of motion to improve the biomechanics of glenohumeral and scapulothoracic motion to prevent further structural and tissue damage.

The literature discusses both surgical and conservative (nonsurgical) interventions as appropriate treatment options for anterior glenohumeral instability. Deitch et al, (2003) in a study of 32 patients with traumatic anterior shoulder dislocation reported "no significant difference in the functional outcome of patients who had undergone surgical stabilization and those treated non-operatively." The literature analyzing conservative treatment of exercise routines indicates generally a poor prognosis. Yoneda, Welsh, and MacIntosh (1982) reported a recurrence rate of glenohumeral dislocation of 17.3% after a 13-year follow-up of a post immobilization exercise routine. Burkhead and Rockwood (1992) conducted a strengthening program targeting the rotator cuff, deltoid, and scapular stabilizers following recurrent anterior, posterior, or multidirectional traumatic or atraumatic subluxation of the glenohumeral joint. Unfortunately, only 16% of the traumatic subluxation population had good to excellent results 46 months following the exercise regime. Burkhead and Rockwood (1992) stated patients chose physical therapy interventions versus surgical stabilization even after being informed there is a fairly low success rate as determined by previous investigations. However, Aronen and Regan (1984) had much higher success rates with a program that began with isometrics and then progressed to isotonic and isokinetic exercises. The sample was small and involved 20 midshipmen from the U.S. Naval Academy. Their recurrence rate of anterior shoulder dislocations was 25% over a 3.5-year period, thus a 75% success rate. They stated that "adherence to a specific, aggressive postdislocation rehabilitation program, plus rigid restrictions to activities . . . can substantially improve the likelihood of a full return to activity without recurrent shoulder dislocation." Most investigators suggest at the best a guarded outcome using traditional strengthening programs that target impairments. Aronen's subjects underwent rehabilitation in a fashion that encouraged involvement in both athletic and functional activities that were necessary in the context of training to become a military personnel.

The body blade is a rhythmic oscillatory device that was used in this case as a tool to enhance strength in functional positions and motions. Initially, this patient's deficits were pain particularly when reaching high, touching the back of one's neck, and washing one's back, all of which are rotational motions, as captured by the SPADI. Initially, the WOSI captured the patient's deficits, to include physical symptoms such as pain with overhead activities, weakness, clicking, stiffness, and a feeling of instability or looseness as well as a change in lifestyle due to difficulty sleeping and a fear of falling on the involved shoulder. The body blade exercise regimen was designed to strengthen both dynamic and static structures to improve stability of the glenohumeral joint, consequently diminishing the physical symptoms of instability, pain with activity, and weakness therefore enhancing one's lifestyle. Upon discharge there was no pain or difficulty as assessed by the SPADI during ADL's; a 95% change with the physical symptoms on the WOSI; and a 94% change on the lifestyle component of the WOSI. The exercises using the body blade to simulate unstable functional positions (e.g., the position during the butterfly stroke) suggests the dynamic and static stabilizing structures improved in strength and possibly better control of muscle co-activation particularly since the patient had a 82% change with the sports/recreation/work component of the WOSI.

This case, with a 90% WOSI improvement; no deficits on the SPADI upon discharge; and no report of a recurrence of dislocation 6 months following injury, suggests use of the body blade to functionally strengthen the involved upper extremity and upper torso was beneficial. Furthermore, these findings suggest a functional strengthening program using the body blade has a positive outcome over traditional rehabilitation programs reported within the literature.

While it has been demonstrated that this individual gained functional capacity after a rehabilitation regimen with the body blade, there are several limitations to this case. The major limitations to this study are its inability to address the emotional component or consciousness of the injury, lack of appropriate proprioception measures, and experimental design.

The literature indicates proprioceptive feedback is required to operate oscillatory devices to improve the ability to replicate joint position (Schulte and Warner, 2001). A measure of the patient's ability to evaluate joint position should have been administered since enhancement of proprioception is essential in this patient population because reproduction of joint position is significantly reduced in patients with shoulder instability than in unimpaired individuals (Hayes et al, 2002). Furthermore, there is a significantly greater threshold of detection of passive shoulder motion in individuals with shoulder instability versus individuals with normal shoulders (Warner, Micheli, and Arslenian, 1992). Oscillatory training devices may have an effect on proprioception enhancement by improving neuromuscular control and motor learning (Schulte and Warner, 2001).

Without an experimental design having an adequate population an inference that training with the body blade directly enhances the functional capacity of individuals with glenohumeral dislocations cannot be made. It is therefore recommended that future randomized control trials with use of the body blade are established since there is a strong theoretical basis and an excellent case outcome for promoting the body blade in rehabilitation of shoulder dislocations and shoulder instability.

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