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Case Report

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The Effect of Electrical Stimulation Cueing in a Competitive Powerlifter with Shoulder Pain and Scapular Dyskinesis: A Case Study

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Abstract

Background: Shoulder conditions are a common musculoskeletal complaint. The presence of scapular dyskinesis has been shown to result in 43% increase in shoulder pain in athletes. It is known that peripheral ES changes muscle behavior. There are no studies that examine exercise with triggered ES to the lower trapezius, to address shoulder pain and scapular dyskinesis.

Methods: The purpose of this case study was to demonstrate that specific parameters with triggered ES, combined with 3 exercises, would result in meaningful improvement in shoulder function and pain in a 22-year-old powerlifter with chronic shoulder pain and scapular dyskinesis. The patient received 6 treatments of trigger switch cued ES and exercise plus four manual therapy sessions. A biphasic-pulsatile current was used. The frequency and pulse-width were 25 pps and 250 usec, respectively. The intensity was comfortable and produced scapular retraction.

Results: Improvements were noted in all outcomes. Numeric Pain Rating Scale was decreased to 1/10. Left shoulder passive range of motion was returned to 100%. The Quick Dash Disability score improved from 38.6% to 2.27%. The Quick Dash Work Module score improved from 6.6 to 0, the Quick Dash Sport Module score improved from 37.5 to 0. The Patient Specific Functional Scale score improved from 3.7 to 8.3. Thoracic spine to scapula distance differences occurred at the following shoulder abduction angles: -0.7 cm at 0, -0.1 cm at 45, +0.4 cm at 90, and -0.5 cm at 120.

Conclusion: Trigger switch ES and 3 exercises, plus traditional manual therapy, resulted in improvement in all self-report outcome measures and a change in thoracic spine to scapula distance in a patient with shoulder pain and scapular dyskinesis who had failed to improve by traditional physical therapy.

Keywords

Electrical stimulation cueing; Powerlifter; Shoulder pain; Scapular dyskinesis

Background and Purpose

Shoulder conditions are a common musculoskeletal complaint [1]. The presence of scapular dyskinesis has been shown to result in 43% increase in shoulder pain in athletes [2]. There is a body of evidence that shows an association between scapular dysfunction, and shoulder pain [3-8], across a variety of shoulder pathologies [9,10], and specifically associated in the overhead athlete [11].

Scapular dyskinesis is defined as altered scapular motion and position [12]. This term can refer to the scapular position at rest, such as winging of the medial scapular border [9], or a lack of smooth coordinated movement during upper extremity elevation [13]. The Scapular Dyskinesis Test [14] (SDT) is a clinically relevant, quick visual exam to detect scapular dyskinesis at rest or during active upper extremity elevation. The motion is characterized as dyskinesis as "yes" (presence of deviation or dysrhythmia/asymmetry) or "no" (no dyskinesis) by visual inspection of winging (medial border prominence), and/or lack of smooth coordinated movement. A lack of smooth coordinated movement can include early scapular elevation or shrugging while raising the arm into forward flexion, and/or rapid downward scapular rotation during arm lowering from full flexion) [14,15].

When scapular dyskinesis occurs, the goal of treatment is to reestablish normal muscle recruitment, and timing of muscle firing, about the scapula, in order to restore normal timing of muscle recruitment that control the scapula. to restore normal activity or timing of muscle recruitment that control the scapula. Restoration of normal recruitment and timing of muscle firing allows for optimal shoulder girdle mechanics [12,13], and ideally the improvement of pain and function. One type of scapular dyskinesis is observable shoulder shrugging during arm elevation. Excessive shoulder shrugging is indicative of a lack of coordination between the upper, middle and lower trapezius muscles [16], and can be called scapular dyskinesis. In the case of trapezius muscle imbalance caused scapular dyskinesis, exercises that promote a high lower trapezius (LT) to low upper trapezius (UT) muscle activation ratio are preferable because those exercises promote selective activation of the LT muscles with minimal activation of overactive UT muscles [15].

Electrical stimulation is one intervention to restore normal recruitment timing of muscles, in this case the LT. Electrical stimulation results in consistently positive outcomes for various orthopedic and neurologic patient populations, [15-19] and peripheral ES changes muscle behavior [19-22]. Although research outlines positive therapeutic outcomes associated with ES, [16,23-27] ES to restore hypoactive LT muscle in the case of a patient with chronic shoulder pain and scapular dyskinesis, is unknown to these authors. The addition of ES to voluntary muscle contraction has positive outcomes in the normalization of muscle control [22,28].

The purpose of this case report is to present a novel treatment intervention for an individual with scapular dyskinesis and chronic shoulder pain resulting in an inability to participate in powerlifting. The exact dosing and application of the ES is novel. This case study used ES delivered via trigger switch added to exercise (ESTherex), in order to promote neuroplastic changes created by both central nervous system (CNS) and peripheral nervous system (PNS) mechanisms [18-19,29].

Case Study

The subject was a 22-year-old male power lifter with a complaint of progressive shoulder pain that started at the age of fourteen. The subject had a history of martial arts participation since the age of

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seven which included body weight resisted shoulder strengthening exercises such as push-ups, pull ups, and triceps dips. The subject reported progressive shoulder pain after the initiation of progressive resistive upper extremity strengthening with free weights which he defined as "powerlifting". The subject defined powerlifting as, "moderate to heavy free weight training." The subject reported an inability to compete as a power lifter at the time of the intervention because of shoulder pain severe enough to prohibit him from lifting a light weight such as for example, his young nephew, in order to swing him around. The subject reported an inability to progress his free weight-training program. The subject also reported shoulder pain, "when lifting anything heavy". The subject sought care in order to avoid exploratory shoulder surgery. The subject's chief complaint was pain in the left lateral upper arm (P1) and left lateral elbow (P2), in addition to numbness and "weakness" in the left 4th and 5th digits.

Unsuccessful treatment interventions included physical therapy twice for two months duration each, consultation with an orthopedist, multiple cortisone injections, and multiple diagnostic examinations (MRI, x-ray and nerve conduction velocity test). Diagnostic findings were negative. The subject's goal was to continue powerlifting and resolve the pain.

Examination

A physical therapy evaluation was completed; findings are summarized in Table 1. The patient had a positive Scapular Dyskinesis

Table 1: Physical therapy examination findings.

Cervical Spine AROM	**Initial Evaluation 3/13/17**		**Discharge 4/17/17**
Flex	100% (chin-chest)		100% (chin-chest)
Ext	35°		50° (100%)
L SB	10° "choke" ant right neck, "like a waterfall"		20° (100%)
R SB	20°		20° (100%)
R rot	90°		90° (100%)
L rot	90°		90° (100%)
Shoulder/Elbow Passive Range of Motion (PROM)	**Left**	**Right**	**Left**
Flex	160°	170°	170°
Ext	20°	45°	45°
Abd	155° (10° from coronal neutral)	175°	175°
Horizontal adduction	Elbow to ipsilateral nostril	100% (elbow to contralateral nostril)	100% (left elbow to contralateral nostril)
ER @ 90	80°	80°	80°
ER @ 0	40°	45°	75°
IR @ 90	85°	90°	90°
Elbow flexion	WNL	WNL	WNL
Elbow extension	WNL	WNL	WNL
Supination	45°	WNL	90°
Pronation	WNL	WNL	WNL
Shoulder AROM			
Lift-off (back)	~50% (2 fingers)	100% (~4 fingers)	100% (~4 fingers)4 fingers
Hand Behind Head (2nd finger)	T3	T3	T3
Hand Behind Back (2nd finger)	T7	T7	T3
Myotome Screening	**Left**	**Right**	**Discharge-Left**
C4	5	5	5
C5 (abduction)	4-	5	5
C5 (biceps)	4-	5	5
C6	4+	5	5
C7	4+	5	5
C8	5	5	5
T1	4+	5	5
Manual Muscle Testing[33]	**Left**	**Right**	**Discharge-Left**
Lower Trapezius[33]	2+	4	4
Rhomboids	5	5	5
Extension	4	4	5
Neuro	**Exam**		**Discharge-Left**
Reflexes	0 @ biceps, tricipes, brachioradialis	0 @ biceps, tricipes, brachioradialis	NT
Sensation (light touch)	Intact C5-T1 dermotomes	Intact C5-T1 dermotomes	NT
Upper limb tension test (median nerve bias)	Positive	Negative	Negative
Hoffman's	Negative	Negative	Negative
Special Test	Left	Right	
Neer	(-)	(-)	(-)
Hawkins Kennedy	(-)	(-)	(-)
Lift Off Test	(-)	(-)	(-)

Test (SDT) [14]. The neurologic screen did not indicate peripheral nerve pathology however indicated generalized difference in left upper extremity myotome assessment and positive upper limb tension all of which were resolved during the course of the treatment. The patient also had positive scapular abduction syndrome [30] with excessive humeral internal rotation.

Intervention

Measurement procedures

Thoracic spinous process to inferior scapular angle distance (TSS) was measured at 0, 45, 90, and 120 degrees of shoulder abduction. Measurements were taken at treatment one of the six ESTherex intervention treatments. Measurements were also taken at the end of the ESTherex protocol during visit number six of six, and 2 weeks after ESTherex had been completed (Table 2).

Exercise: Protocol and subject education

Three exercises were selected based on electromyographic findings reported by Cools et al. of exercises that promote low upper trapezius to high lower trapezius (UT/LT) muscle activation patterns (Figure 1). The subject received ES to the lower trapezius using a remote trigger switch that was coordinated with the initiation of active muscle contraction by the subject [31]. The frequency and pulse width were 25 pps and 250 usec respectively. The intensity was high enough to produce visible scapular adduction and depression, but comfortable to the subject. Each exercise was performed 3 sets of 15 repetitions with complete rest for 1-minute between exercise sets.

The subject received 6 ESTherex treatments over a 3-week period. During the 3-week ESTherex period, the subject was advised to perform the same three exercises without ES as a Home Exercise Program (HEP) on two additional non electrical stimulation days. The subject was further advised to continue the home exercise program after the end of the ESTherex protocol; until the 2 weeks follow up post measurement 2 (PM2) had been completed. Home exercise compliance was monitored with a home exercise program journal. The subject was 100% compliant with HEP recommendations.

The subject also received a physical therapy evaluation and 4 manual treatment interventions lasting 30-45 minutes in duration, see Table 3 treatment schedule. Manual physical therapy interventions where consistent with contemporary care for the subject's impairments. It was assumed that manual treatments were similar to those tried previously in physical therapy but that had been

Table 2: Thoracic Spine to Scapula (TSS) distance in centimeters.

PROM Shoulder	TSS Baseline	TSS Post Measurement (PM1) (6th visit)	Difference (Baseline to PM1)	TSS Post Measurement 2 (PM2)	Difference (Baseline to PM2)
0	8.8	9.5	-0.7	10.3 cm	0.8 cm (PM1); 1.5 cm (baseline)
45	8.3	8.2	0.1	10.5 cm	2.3 cm (PM1); 2.2 cm (baseline)
90	9.5	9.9	-0.4	11 cm	1.1 cm (PM1); 1.5 cm (baseline)
120	13	12.5	0.5	11.5 cm	-1.0 cm(pm1); -1.5 cm

Figure 1: A) Side lying shoulder external rotation with electrical stimulation to the lower trapezius. B) Side lying shoulder flexion 90° to 120° with electrical stimulation to the lower trapezius. C) Prone horizontal abduction with electrical stimulation to the lower trapezius.

Table 3: Schedule ESTherex/Manual Treatment and Assessment.

3-13-17 Week 1	**Initial Evaluation**	**Initial Evaluation**
3-16-17	ESTherex 1/6	Self-Reported Outcomes TSS (Baseline)
3-20-17 **Week 2**	Manual Treatment Day (MTD) 1	
3-21-17	ESTherex 2/6	
3-23-17	ESTherex 3/6	
3-27-17 **Week 3**	MTD 2	
3-28-17	ESTherex 4/6	
3-30-18	ESTherex 5/6	
4-3-17 **Week 4**	MTD 3	
4-4-17	ESTherex 6/6	**PM1**
4-10-17 **Week 5**	No treatment	No treatment
4-17-17 **Week 6**	MTD 4	DC Examination
4-18-17	No treatment	**PM2**

Table 4: Self-Reported Functional Outcome Scores-Baseline, Final, Post measurement 1 (PM1), Post measurement 2 (PM2), baseline to PM1 difference, and baseline to PM2 difference.

Self-Reported Outcomes	Initial 3-16-17	Final PM 1 4-4-17	Difference Baseline to PM1 4/4/17	PM2 4-18-14	Difference Baseline to PM2 4-18-17
Quick Dash Disability/Symptom	38.6	2.27	36.33	2.27	36.33
Work module	6.3	0	6.3	0	6.3
Sport module	37.5	0	37.5	0	37.5
Numeric Pain Rating Scale	9	3	6	1	8
Patient Specific Functional Scale: Average	3.7	8.3	4.63	9	4.63
Patient Specific Functional Scale: Power lifting	4	8	4	9	4
Patient Specific Functional Scale: Sleeping on back	4	9	5	9	5
Patient Specific Functional Scale: Left side flexibility	3	8	5	9	5

unsuccessful. Interventions included: subscapularis mobilization, posterior glenohumeral joint mobilization, upward scapular rotation mobilization, myofascial release of the ventral upper arm, mobilization of the proximal radius, and home exercise program instruction of levator scapulae, teres minor and internal rotation sleeper stretches.

Discussion

The subject reported the following pain free functional improvements at the end of the treatment protocol: able to lift heavy weights, able to return to power lifting (heavy free weights), and able to participate in a Tough Mudder obstacle race. Left lateral shoulder pain decreased to 1/10 (Table 4). The subject's complaint of N/T was resolved. Left shoulder PROM was returned to full and pain free (Table 1). Minimally clinically importance difference cut-off scores were met for all self-report outcome measures at post measurement one (PM1) and continued at post measurement two (PM2). The Quick Dash Disability score improved from 38.6% disability to 2.27% disability with a 36.33% improvement. Both the Quick Dash Work and Sport subscale score improved to 0% disability (from 6.3% and 37.5% respectively). The Numeric Pain Rating Scale (NPRS) score improved from 9/10 to 1/10 by PM2. The Patient Specific Functional Scale (PSFS) average improved from 3.7 to 8.3 with improvement in individual scores as follows: 4 to 8 for powerlifting, 4 to 9 for sleeping supine, and 3 to 8 for left side lying flexibility.

The thoracic spine to scapula (TSS) distance changed at all abduction angles by PM2. Of note is the TSS distance change at 45 degrees abduction at PM1 which was negligible but was markedly increased at the 2 weeks follow up after ESTherex treatments had been completed. The most notable change in TSS distance occurred at 0 degrees abduction (rest) at both PM1 and PM2 with TSS difference of 0.7 cm. and 0.8 cm respectively. Interestingly however, by PM2, all TSS measurements changed to within 1.2 cm at all abduction angles in spite of baseline TSS measurements ranging from 8.8 to 13 cm from the spine (Table 2).

Left shoulder PROM improved to equal the non-involved side (right) at the end of the treatment protocol. The subject's complaint of pain improved from 9/10 to 3/10 at PM1 and 1/10 at PM2 (Table 4), and continued to improve after the cessation of treatment to pain free (0/10) as per patient report. All self-reported functional outcome scale scores met and exceeded clinically important differences (Table 4).

Thoracic spine to scapula distance changed at all abduction angles by PM2 with a trend of TSS distances increasing (or decreasing) toward a median range TSS distance of 10.5 to 11 cm. The greatest TSS distance change occurred at 45 degrees with the TSS at baseline of 8.3 cm, increasing to TSS of 10.5 cm by PM2. The changes in all TSS distances may suggest less aberrant baseline position of the scapula resulting in an improvement in PROM, self-report outcomes, pain and function.

At all angles except one (120 degrees) there was an increase in TSS distance from baseline to PM1/PM2. However, at PM1 and PM2 there was a decrease in TSS distance. This is important because the lower trapezius recruitment is greatest at angles higher than 90 degrees and maximal recruitment occurs at 120 degrees [32]. Electrical stimulation cueing of the LT may result in a change in TSS distance at 90 to 120 degrees and this is important because it may indicate that the nervous system is re-establishing normal LT firing that was previously dominated by UT hyperactivity.

The purpose of adding ES to this patient case was to provide peripheral and central nervous system input to improve lower trapezius muscle function. It is hypothesized that the addition of trigger switch ES resulted in an improvement in scapular position (normalized TSS) and improved LT function and strength as demonstrated by improved manual muscle test, improved self-report outcome scale scores and decreased pain. Carefully prescribed triggered ES, combined with low UT to high LT ratio exercise, may promote an electrically evoked sensory volley during the simultaneous voluntary muscle contraction, that result in a central nervous system contribution [29].

Electrical stimulation cueing of the LT at 90 to 120 degrees is important because it provides nervous system input (peripheral and central) for a maladaptive hypoactive lower trapezius [6,8,12,14,23]. The trigger switch cue allows for an application with perfect timing and duration during the deficit muscle recruitment pattern [14].

Conclusion

This case demonstrates the use of ESTherex with trigger switch cueing, and correct ES parameter selection, to promote selective activation of the LT muscles for a muscle contraction that does not ablate a sensory volley, as a possible efficacious treatment to facilitate maximal neurologic reorganization in a subject with chronic shoulder pain and scapular dyskinesis.

Limitations

This case study included multiple treatment interventions that may have contributed to the positive patient outcomes. Investigators assumed lower trapezius hypoactivity, not weakness, because the ESTherex protocol did not work the muscle at 80% of one maximal voluntary isometric contraction. Results from this case should be interpreted with care. This case study provides justification for future randomized controlled studies that compare ESTherex to ShamTherex in subjects with shoulder pain and scapular dyskinesis. Furthermore, this case provides a follow up to the pilot study by Walker et al. [33]

that compared ESTherex to Sham ESTherex in a subject with scapular dyskinesis without shoulder pain.

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