Immediate Effects of Strain-Counterstrain Technique on Pressure Pain Threshold and Muscle Activity in Male Adults With Upper Trapezius Latent Trigger Point

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Abstract

The aim of this study was to determine the immediate effects of single treatment of strain-counter strain (SCS) on pressure pain threshold (PPT) and muscle activity during scapular plane abduction with 3% body weight load. Fifteen asymptomatic male adults with upper trapezius latent trigger point (LTrP) (PPT<2.9 kg/cm^2) participated in this study. Pressure algometer was used to measure PPT and surface electromyography was used to record upper, middle and lower trapezius, serratus anterior, infraspinatus and middle deltoid muscle activity and relative ratio during scapular plane abduction between pre- and post-intervention. There was a significant increase in upper trapezius PPT after a 90-second SCS (p<.05). The activity of the upper trapezius and middle deltoid was significantly decreased (p=.014, p=.001), coupled with a decreased muscle activity ratio between the upper and lower trapezius (p<.05). These results indicate that the SCS may effectively deactivate upper trapezius activity, thereby alleviating muscle balance and reducing pain sensitivity.

Key Words: Eletromyography; Latent trigger point; Muscle activity ratio; Pressure pain threshold; Strain-counterstrain; Upper trapezius.

Introduction

Upper trapezius (UT) trigger points are common soft tissue impairments that often affect neuromotor control in glenohumeral and scapulothoracic movement (Fischer, 1987; Sciotti et al, 2001). Approximately 90% of the healthy population have latent trigger points (LTrP) combined with muscle shortening and decreased pressure pain threshold (PPT) (Fischer, 1987; Simons, 2002; Simons et al, 1999). These trigger point pain syndrome are caused by postural alignment impairments, muscle imbalance, and repetitive overload or cumulative traumatic disorders (Huguenin, 2004). This is often manifested with chronic pain and abnormal motor control patterns, leading to functional movement impairments in the shoulder complex (Lucas et al, 2004; Nagrale, 2010). Previous studies (Lucas et al, 2004; Lucas et al, 2009) have shown that individuals with the UT LTrP demonstrated increased muscle activity and altered activation sequence. Prolonged and dominant spontaneous muscle activity in LTrP compromises normal muscle-tension relationship and in turn changes kinetic chain reaction associated with force coupling mechanism between the lower trapezius (LT), serratus anterior (SA), and deltoid muscles during scapulohumeral movements (Hubbard and Berkoff, 1993; Page et al, 2010). These altered kinesiological movement characteristics predispose to kinesiopathological movement impairments including

shoulder impingement and rotator cuff tendinitis (Cools et al, 2003; Kibler and Sciascia, 2010; Lucas et al, 2004; Page et al, 2010; Sahrmann, 2002)

Strain-counterstrain (SCS) is a commonly used soft-tissue mobilization technique to alleviate trigger point pain and associated with musculoskeletal dysfunction (Jones, 1981; Lewis, 2001). This technique encompasses two steps: (1) passively holding an involved body segment at a relaxed position for 90 seconds until the desirable level of muscle tension and associated pain reduction are achieved and (2) returning to neutral position slowly. The majority of clinical studies investigating the effect of SCS have specifically focused on pain (Eisenhart et al, 2003; Lewis, 2001; Pedowitz, 2005), which is often only a secondary source of the syndrome, rather than the primary cause-neuromuscular dysfunction. For example, recent studies using PPT and pain scale have shown that SCS is effective in relieving pain hypersensitivity (Lewis, 2010; Meseguer et al, 2006; Nagrale, 2010). However, SCS can be used in managing muscle imbalance and associated pain because this technique restores optimal movement control by inhibiting overactive muscles and facilitating inhibited muscles (Liebenson, 2007). Nevertheless, whether or not SCS has an inhibitory effect on the muscle of the involved muscle fibers is unknown.

Furthermore, there is a dearth of information about the mechanisms underpinning SCS on clinical management of trigger point pain syndrome. Hence, this study aims to determine the immediate effects of SCS at the UT LTrP on PPT and muscle activity patterns during scapular plane abduction with load. Our hypotheses were that (1) the UT pain threshold would be improved and (2) the SCS technique would decrease the UT activity and de-crease the associated muscle activity UT/LT ratios during shoulder scapular plane abduction.

Methods

Subjects

Fifteen healthy, young male subjects were recruited from Yonsei University. All subjects signed informed consent form prior to the participation of this study. Inclusion criteria included: (1) a LTrP in the UT muscle and (2) shoulder abduction at least 160° without compensatory motion. In this study, the LTrP was defined as tender point within a palpable taut band and less than 2.9 kg/cm^2 PPT. This cutoff pressure was selected because the lowest pressure threshold in the UT of normal male adults was previously identified (Fischer, 1987). Exclusion criteria included: (1) specific neck and shoulder pain such as radiculopathy, (2) systematic pathology, and (3) past or present neurologic or musculoskeletal diseases. The subjects' demographic and anthropometric data are presented in Table 1.

Instruments

Pressure algometer

The pressure algometer[1] comprising a force gauge with a 1 cm^2 rubber disk, was used to measure PPT. The rubber disk was placed vertically to the UT LTrP. Pressure was then gradually applied on the rubber disk (representing kg/cm^2) and recorded when the subjects started to feel pain or discomfort. Measurement was repeated three times before and after SCS. Mean recorded pressure threshold values were averaged and used for further analysis.

Table 1. General characteristics of subjects   (N=15)

Variable	Mean±SD
Age (years)	25.0±2.0
Height (cm)	174.8±6.4
Weight (kg)	70.9±8.1
Pain Pressure Threshold (kg/cm²)	2.3±.4

1) FPK 60, Wagner Instruments Inc, Greenwich, CT, U.S.A.

Figure 1. Measuring pressure pain threshold on upper trapezius latent trigger point. A: Measuring pressure pain threshold, B: Pressure algometer.

Electromyography

A surface electromyography (EMG)[2] was used to determine shoulder muscle activity and associated ratio during scapular plane abduction. The EMG data were collected at a sampling frequency of 1024 Hz with a 60 Hz notch filter.

Prior to the attachment of electrode, the skin was carefully prepared to reduce skin impedance by shaving hair and disinfecting with alcohol. Bipolar Ag/AgCl electrode was placed parallel to the six right shoulder muscles (UT, middle trapezius (MT), LT, infraspinatus (IS), SA, and middle deltoid (MD)) with a 25 ㎜ inter-electrode distance. Figure 2 depicts the experimental setup for EMG measurement and electrode placements. For the UT (scapula upward rotator), electrode was placed along the ridge of the shoulder, slightly lateral to and one half the distances between the C7 and acromion. For the MT, electrode was placed horizontally, 2 ㎝ apart, next to the scapula root. For the LT (scapula upward rotator), electrode was placed on a 55° oblique angle, approximately 5 ㎝ down from the scapular spine next to the medial edge of the scapula. For the IS (glenohumeral stabilizer and abductor), electrode was placed approximately 4 ㎝ below the spine of the scapula, on the lateral aspect, over the infrascapular fossa of the scapula. For the

SA (scapula upward rotator), electrode was placed just below the axillary area at the level of the inferior tip of the scapula, and just medial of the latissimus dorsi. For the MD (primary abductor), electrode was placed on the lateral aspect of the upper arm, 2 ㎝ apart, and approximately 3 ㎝ below the acromion (Criswell and Cram, 2011). A reference electrode was placed over the clavicle.

Raw EMG signal was analyzed using Telescan 2.993 software[3] and was band-pass filtered at 10-500 Hz. The EMG data were processed into the root mean square (RMS) using window for 100 ㎳. The maximal voluntary isometric contraction (MVIC) was used to normalize EMG data for each tested muscle and maximal voluntary muscle contraction test was performed according to Kendall's manual muscle testing position (Kendall, 2005). EMG data were recorded during a 5-second reference contraction and repeated three times and stored for data analysis. 30~50 seconds of resting interval was provided between the test trials. The mean EMG amplitude data obtained during the middle 3-second of each trial was used for statistical analysis.

Procedures

Subjects were asked to abduct their dominant arm

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2) WEMG-8, Laxtha Inc, Daejeon, Korea.
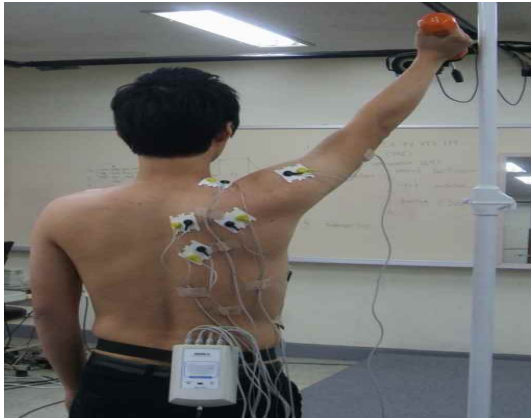3) Telescan 2.993, Laxtha Inc, Daejeon, Korea.

Figure 2. Experimental setup for EMG muscle activity measurement.

Figure 3. Strain-counterstrain technique in the upper trapezius muscles.

(right side) with 3% of their body weight (Mean=2.1 kg, SD=.28) (Thigpen et al, 2010) in standing position (Figure 2). The target abduction was set 160° to focus the action of the IS as a stabilizer rather than an external rotator. Abduction movement was guided at 30° scapular plane using a vertical pole, which was fixed from the ground to the ceiling. The postural sway was restricted by using a mirror approximately 2 m in front of the subjects at eye level (Lucas et al, 2010). The movement velocity was controlled by auditory cue using beep sound with verbal command. Scapular plane abduction was carried out using the 5-4-5-4-5 steps. 5-4-5-4-5 steps comprise five subsets: 5-second for rest, 4-second for raising the arm, 5-second for maintaining abduction posture, 4-second for lowering the arm, and 5-second for rest. Before the test, the subjects were given enough time to familiarize themselves with the 5-4-5-4-5 steps. Three trials were performed with a 4-second rest between trials.

Intervention

Subjects were neutrally sitting positioned for the SCS intervention. The subject's right shoulder was passively abducted. The examiner found the UT LTrP by palpation. After the detection of trigger point, the examiner applied a gentle pressure until subjects felt pain from pressure sensation. Subjects were passively positioned to reduce the pain level by approximately 70% (Jones, 1981). To determine whether the pain level decreased, the examiner asked the subjects their perception level compared with the initial condition. In this study, the most common positions that relieve pain are cervical flexion, ipsilateral side-bending and contralateral rotation. Manual pressure was maintained equally for 90 seconds. After the intervention, the subject's position was passively returned to the starting position (Meseguer et al, 2006).

Statistical Analysis

The descriptive data were expressed as mean and standard deviation. A paired t-test was used to determine SCS related changes on EMG activity and ratio and PPT. Statistical significance was assigned at p<.05. All statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 18.0 software.

Results

Pressure pain threshold

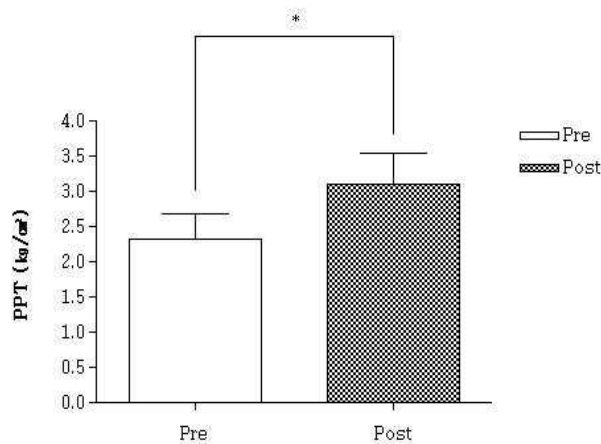The mean PPT of the UT showed significant difference between pre- and post- intervention (p<.05).

Figure 4. Comparison of the pressure pain threshold between the pre- and post-intervention (*p<.05).

The PPT was increased (33.04%) from 2.33 kg/cm² (SD=0.35) to 3.10 kg/cm² (SD=.45) following SCS intervention, indicating that pain sensitivity of the UT effectively relieved (Figure 4).

EMG muscle activity and ratio

Paired t-test showed significant difference in UT and MD normalized EMG activity during scapular plane abduction (p<.05) (Table 2). The UT and MD muscle activities were decreased 2.74% and 2.29%

respectively. The muscle activity ratio was determined: dividing normalized mean UT EMG amplitude by normalized mean EMG amplitude of MT, LT, and SA (Cools et al, 2007). The muscle activity ratio between UT and LT was significantly decreased (p=.030)(Table 3).

Discussion

The present study demonstrated the immediate effects of SCS on EMG muscle activity, relative changes in muscle activity ratio and associated PPT between pre- and post-intervention during the scapular plane abduction in male adults with UT LTrP. As anticipated, the application of SCS on UT LTrP effectively decreased UT EMG activity and relative changes in muscle activity ratios and reduced pain sensitivity as reflected in PPT. Especially, UT and MD muscle activity and UT/LT ratio were decreased by 2.74%, 2.29%, and 12.20% whereas PPT was reduced by 33.04%.

Certainly, our findings are in agreement with recent clinical studies that examined the effects of SCS (Meseguer et al, 2006; Nagrale, 2010) on pain

Table 2. The mean EMG amplitude during scapular plne abduction at pre- and post-intervention (Unit: %MVIC)

Muscles	Pre	Post	p
Upper trapezius	26.38±13.60[a]	23.64±10.60	.007
Middle trapezius	14.37±10.59	15.35±11.37	.081
Lower trapezius	24.20±9.44	24.58±10.34	.656
Infraspinatus	17.85±6.11	18.35±5.70	.357
Serratus anterior	41.11±10.54	39.34±9.86	.068
Middle deltoid	37.17±9.74	34.88±8.40	.001

[a]Mean±SD, Significant difference (p<.05).

Table 3. Muscle activity ratio during scapular plane abduction at pre- and post-intervention

Activity Ratio	Pre	Post	p
Upper trapezius/Middle trapezius	2.64±1.40[a]	2.34±1.45	.068
Upper trapezius/Lower trapezius	1.38±.88	1.23±.70	.030
Upper trapezius/Serratus anterior	.68±.31	.65±.29	.081

[a]Mean±SD, Significant difference (p<.05).

control. Meseguer et al. (2006) found that neck pain as measured by visual analogue scale (VAS) in individuals with mechanical neck pain was significantly reduced by 44% following the single application of SCS (p<.05). Similarly, Nagrale et al. (2010) demonstrated that the SCS combined with muscle energy technique decreased neck pain (as evident in VAS measure) when compared to the isolated muscle energy technique alone in patients with non-specific neck pain.

One important mechanism for SCS induced modulation of pain threshold may be accounted by mechanical and neurophysiological components. Mechanically, SCS, which utilizes the localized mechanical pressure on the fibrotic tissue (taut band or shortened sarcomere), can produce a positional release that restores resting sarcomere length or normalizes the sarcomere length-tension relationship (Simons, 2002). This normalized sarcomere length-tension relationship allows optimal actin and myosin cross-bridging to occur, which increases tissue extensibility of the taut band or the fibrotic tissue. In fact, individuals with the upper trapezius LTrP showed increased muscle activity and altered activation sequence in scapular rotators during scapular plane abduction (Lucas et al, 2004; Lucas et al, 2009). It was also noted that UT muscle activity in the LTrP area of individuals with LTrP or in the trigger point areas of patients with tension headache or fibromyalgia was more prolonged (up to 50 minutes) and dominant (2 times in the LTrP subjects; 9-10 times in patients) than the other non-trigger point area when probed with needle EMG measurement (Hubbard and Berkoff, 1993). This sustained increased muscle activity together with altered muscle activation sequence can change normal muscle-tension relationship and in turn changes kinetic chain reaction associated with force coupling mechanism between the LT, SA, and deltoid muscles during scapulohumeral movements (Page et al, 2010). This mechanism suggests that the trigger point pain syndrome is primarily associated with motor control dysfunction rather than pain itself (Simons, 2002).

The other neurophysiological mechanism may be associated with excessive and continuous action potentials cause the release of Ca^{++} from the sarcoplasmic reticulum. Subsequently, this results in spontaneous and prolonged muscle contraction unless AChE degrades ACh into acetate and choline, thus terminating the release of Ca^{++}. SCS may suppress this excessive release of ACh, which leads to the inhibition of the continuous contraction of sarcomere representing motor endplate noise (spontaneous EMG activity) (Hong and Simons, 1998; Hubbard and Berkoff, 1993; Huguenin, 2004).

Albeit that our preliminary investigation demonstrated novel effects of SCS on pain sensitivity and EMG activity during scapular plane abduction, several shortcomings should be taken into consideration and addressed in future studies. First, asymptomatic subjects were recruited in the present study; hence, it is difficult to generalize our findings to people with shoulder disorders. This invites a future study to examine if similar therapeutic effects exist in individuals with active trigger point pain syndrome. Second, the subjects in this study were small number of male adults threatening external validity. Third, a case-control study would have provided a more robust design to elucidate the differential effect of SCS on motor control and associated pain modulation in patient populations. Lastly, the long-term effect of SCS should also be explored in future studies.

Conclusion

This study examined the effects of SCS on pain threshold and muscle activity during scapular plane abduction in male adults with UT LTrP. The SCS effectively decreased UT muscle activity and concurrently improved pain threshold. Our results provide empirical evidence that SCS can be an effective soft tissue manipulation technique to reduce pain threshold in individuals with LTrP. Future studies are needed to examine the long-term effect of SCS on neuromuscular control and pain modulation in pathological population with myofascial impairments.

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