The Effects of EMG Biofeedback Training on Shoulder Pain and Muscle Tone of Upper Trapezius in Patients with Spinal Cord Injury

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Purpose The purpose of this study was to determine the extent to which EMG biofeedback training plus exercise program are associated with a reduction in the shoulder pain and the muscle tone of upper trapezius in manual wheelchair users with spinal cord injury. ***Methods*** Exercise group (N=12) was instructed to do stretching and strengthening exercise to alleviateshoulder pain for 8-week, 50 minutes/day, 5 days/week. EMG biofeedback training group (N=12) was assigned to do the same program plus EMG biofeedback training to induce muscle relaxation. The level of pain was measured by WUSPI, and Myoton®PRO was utilized to measure the changes in tone, stiffness and elasticity of the upper trapezius. ***Results*** Both of experimental and control groups were effective for shoulder pain and muscle tone. However, in comparison between groups, EMG biofeedback training group showed a statistically significant difference in reduction of the shoulder pain and in muscle stiffness as compared with exercise group ($p<.05$). ***Conclusions*** EMG biofeedback training when combined with exercise program appear to show positive effects in the shoulder pain reduction.

Key words Spinal cord injury, Shoulder pain, EMG biofeedback.

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Ⅰ. Introduction

The primary aims of rehabilitation after spinal cord injury are to improve a physical activity level, recover various functions through using the muscles available, and to make activity daily of livings possible in sitting[1,2]. The research has reported that individuals with SCI move in a wheelchair, during which they were exposed to overuse of soft tissue around the shoulder due to compensatory movements with upper arm for the stability and mobility following an incomplete innervations on trunk muscle[3]. Most of the pain above neurologic SCI level appear due to musculoskeletal problem, which was affected by increased use of upper arm such as wheelchair transfer and wheelchair propulsion. Also, compressive stress such as weight bearing in the acute SCI phase has proven as one of the causes of the shoulder, elbow, wrist, and hand pain[4]. Many previous studies have suggested muscle strengthening and stretching exercises, which reported that muscle imbalance and repetitive use related to self-care and wheelchair were causes of shoulder pain in the SCI patients[5-10]. In addition to muscle strengthening and stretching exercises, biofeedback training have offered to control the pain due to overactive muscle[11]. Biofeedback training is the technique of providing biological information to patients in real-time that would otherwise be unknown and it is promotes active participation and thus may motivate patients to adopt an active role in establishing and reaching goals in rehabilitation[12, 13]. Manual wheelchair propulsion in chronic SCI, with its highly repetitive muscle activity, puts the wheelchair users at irregular work/rest cycles, and which results in secondary pain. In this case, EMG biofeedback to improve muscle balance and relax muscle tone of the shoulder was effective in pain control, decreasing to 64% compared with pre-treatment[6].

Despite the strong evidence supporting the tonic changes affecting pains for manual wheelchair users with SCI, most researchers have examined the muscle strengtheningand stretching for controlling pain in manual wheelchair users with SCI. Therefore, the purpose of this study was to examine the effect of EMG biofeedback training and exercise program are associated with a reduction in the shoulder pain and the muscle tone of upper trapezius.

II. Materials and Methods

1. Subjects

A total of 24 volunteered from Yeeun Hospital to participate in the study. Inclusion criteria were:[1] the individual had less than two years post SCI,[2] the individual had a spinal cord injury with C7 or lower base on classification of ASIA scale(The American Spinal Injury Association Impairment Scale),[3] the individual propelled a manual wheelchair 30 hours per week or more[6, 4] the individual had musculoskeletal pain in the shoulder girdle region (neck, shoulder, upper back) rated as 3 to 8 for VAS (on a scale of 0 to 10) that was evaluated during performance of daily activities, and[5] the individual was able to perform a resistance training using the upper arm. The participants were no given medication or intervention, for a particular purpose, that may affect the pain. Our study followed the principles of the Declaration of Helsinki and all patients provided informed consent.

2. Study design

This study was designed to be a randomized, prospective clinical trial, with 12 participants assigned to a exercise program for wheelchair user with shoulder pain and 12 participants assigned to the same exercise program plus EMG biofeedback. Participant were assessed at the baseline of pre-intervention and at the end of post-intervention, participated in a 8-week intervention period. Baseline and posttest data were collected by an evaluator who was blind to group assignment.

3. Outcome measure

1) WUSPI(Wheelchair User's Shoulder Pain Index).

The Wheelchair User's Shoulder Pain Index (WUSPI) is a self-report measure to rate shoulder pain in wheelchair users and consist of 15 different activities, including such as wheelchair mobility, transfer, and activities of daily living[14]. The WUSPI uses 15visual analog scales ranging from 0, no pain to 10, worst pain ever experienced, with a maximum total score of 150. We assessed with Korean-version of WUSPI, established reliability and validity.

2) Tone, stiffness, and elasticity

A hand-held myotonometer, uses painless and non-invasive means to provide quantitative and objective assessments of muscle properties. Mechanical characterization of the skeletal muscle, as measured by the myotonometer, may provide new insights into muscle function and help to diagnose the stage of pathologic processes taking place in the muscles.[15] Myoton calculatesa muscle tone, which indicate the oscillation period in seconds. This myometer assess muscle elasticity which is the ability of the muscle to restore its initial shape after contraction, and also test a stiffness which reflects the resistance of the muscle to the force deforming the muscle. The testing end of the Myoton-3 was placed perpendicular to the skin surface abovethe muscle to be measured, a brief mechanical impulse was applied, shortly followed by a quick release to the muscle through an acceleration probe, and the damped oscillations of the muscle response were recorded by the acceleration transducer at the testing end of the device. Adequate psychometric properties for the myotonometric measurement have been presented[16]

4. Intervensions

1) Exercise program group (EG)

Participants in this group attended 60-minute session for one-on-one instruction on an exercise program[5]. They performed once a day, 50-minute per one session, five days a week, for eight weeks, and noted in a daily exercise log[8]. Exercise programs consisted of both stretching and strengthening exercise. Stretching exercise was applied to the upper trapezius, biceps brachill, pectoralis, and muscles of posterior scapular region, and then strengthening exercises using elastic band focused on the external rotator, shoulder adductor, shoulder extensor, and scapular retractors, which was based on the previous researches[5, 7-9].

2) EMG biofeedback plus exercise group (EMG+Ex)

This was followed by additional sessions of 50 minutes, five days a week, for eight weeks. EMG biofeedback training targeted upper trapezius muscle. We conducted with Myo-EX and E-Link evaluation & exercise systems (Biometrics Ltd, U.K). Surface EMG was recorded using standard skin preparation techniquesand for electrode placement on the upper trapezius, electrode were placed lateral to the midpoint between the spinous process of C7 and the acromion. The Myo-Ex sensor use surface EMG for unique computer-based exercise and gives the patient immediate biofeedback for muscle reeducation and motor control. Each participant was evaluated for the muscle activity of upper trapezius to establish the baseline of exercise, and E-Link provided the participants with graded exercise program based on the evaluation.

5. Statistical analysis

Independent t-test was used to test the homogeneity of the dependent variables before training. To compare the difference between groups and the within groups, we calculated with ANCOVA (analysis of covariance), considering the pre-variables as the covariates. Power analysis[17] using an expected effect size (es) of 1.2 for the WUSPI indicated that 6 participants were sufficient to detect within group differences at P = .05 with a power of .80(β=.20), whereas 12 per group would be needed for between-group comparisons[7]. Accordingly, the effect of each intervention was tested separately as the within-group change in WUSPI score between 2 time points. SPSS18.0 program for Windows was used in this research to carry out all the statistical analyses.

III. Results

1. Participants

There was no statistically significant difference between groups for any variable. The general characteristics of participants was showed in Table 1. There were 8 males and 4 females in each group and mean of age were 46.75±11.50 and 42.08±14.10 in the EG and the EMG+EG, respectively. For length of stay in hospital were 15.91±7.50 and 16.00±4.76 in each group. In addition, 11 were diagnosed with cervical injury and 13 were with thoracic injury in both group. The duration of wheelchair use were a mean of 5.75±1.21 and 5.66±1.15 in each group and the number of wheelchair transfers for a day were 16.00±4.11 and 16.75±4.95 respectively.

Table 1. General characteristics of subjects.

	Exercise group (EG) (N=12)	EMG biofeedback plus exercise group (EMG+EG) (N=12)
Gender (male/female)	8/4	8/4
Age	46.75±11.50	42.08±14.10
Length of stay in hospital (month)	15.91±7.50	16.00±4.76
Injury		
Cervical	N=6	N=5
Thoracic	N=6	N=7
Duration of wheelchair use times (day)	5.75±1.21	5.66±1.15
wheelchair transfers no. (day)	16.00±4.11	16.75±4.95

Note. Values are mean ±standard deviation.

2. WUSPI(Wheelchair User's Shoulder Pain Index).

After 8-week intervention period in WUSPI score, EG showed a declines of 12.12±6.77 (t=6.204, P< .001) and EMG+EG had a lower score of 20.27±8.18 (t=8.586, P< .001) as compared with the baseline score (Table 2). Furthermore, for a comparison of between-groups, EMG+EG showed a higher improvement for a shoulder pain than EG(F1,20=2.87, P <.01).

3. Tone, stiffness, and elasticity

There was a decrease in tone, stiffness, and elasticity scores following the 8-week intervention period (P<0.05), and in comparison of between groups there was only a more reduction of stiffness in EMG+EG than EG (F=5.614, P= .027). (Table 3)

IV. Discussion

We performed this study to compare the effectiveness of exercise program and EMG biofeedback plus exercise for 8-week in manual wheelchair users with SCI. both of EG and EMG+EG showed the improvement in the shoulder pain, and there was also a reduction of the stiffness only in EMG+EG. Chronic or recurrent musculoskeletal pain in the cervical and shoulder region is a common secondary problem after spinal cord injury (SCI) that interferes with daily activities and reduces quality of life (QOL)[18, 19].

The interest and difficulty of the exercise program is closely related with the participation of subjects. Preceding researches have mentioned the needs of standard program, suggesting problems of the various degrees of comprehension and continuance of exercise[5, 6]. For that reason, we applied with a modified exercise position for the comfort, considering the level of injury to encourage a maximal participation.

Long-term static posture, inducing a continuous contraction of the surrounding skeletal muscle, has considered as one of the causes of neck and shoulder pain[20]. In this study, we conducted with EMG biofeedback training for the shoulder pain and muscle overactivity and demonstrated the effect of EMG biofeedback as well as the exercise program consisting of the stretching and strengthening. This results supported the previous research by Ma et al (2011) and

Table 2. Comparison of baseline and post−intervention WUSPI score between exercise group and EMG biofeedback training group.

	Baseline	Post-Intervention	t	p
Exercise group (N=12)	44.25±11.64	32.12±16.45	6.204	<0.001**
EMG biofeedback training group (N=12)	40.35±14.16	20.08±8.98	8.586	<0.001**

Note. Values are mean±standard deviation, WUSPI=Wheelchair User's Shoulder Pain Index, *P<0.05, **P<0.001.

Table 3. Comparison of upper trapezius muscle tone, stiffness and elasticity between exercise group and EMG biofeedback training group.

		Exercise group(N=12)				EMG biofeedback training group(N=12)					
		Baseline	Post-Intervention	t^a	p^a	Baseline	Post-Intervention	t^a	p^a	F^b	p^b
Tone (㎐)	Lt.	18.40±2.29	16.50±1.46	2.440	.033*	17.32±1.66	15.22±1.32	4.313	.001**	3.756	.066
	Rt.	19.07±2.21	16.73±1.41	2.950	.013*	17.35±1.55	15.50±1.22	3.694	.004*	3.792	.065
Stiffness (N/m)	Lt.	350.33±57.49	305.83±30.48	2.378	.037*	315.66±49.29	273.08±24.57	3.841	.003*	5.641	.027*
	Rt.	374.08±63.81	313.25±32.24	3.069	.011*	317.58±48.06	270.50±38.47	3.653	.004*	4.214	.053
Elasticity (D Log)	Lt.	1.07±0.18	1.15±0.17	−2.353	.038	1.08±0.15	1.12±0.21	−.509	.621	.255	.619
	Rt.	1.10±0.22	1.14±0.23	−.536	.610	1.07±0.13	1.08±0.20	−.158	.878	.366	.552

Note. Values are mean±standard deviation, D Log = Logarithmic Decrement, ^{a} within−group comparison, ^{b} between−group comparison, * P<0.05, ** P<0.001.

by Middaugh et al (2013), which showed the advantages for reducing a pain and decreasing a muscle tone of the neck extensor and the upper trapezius in EMG biofeedback training group as compared with general physiotherapy of pain or active exercise group. In addition, there also demonstrated a significant reduction of pain in exercise group (P<0.001), which is consistent with other previous studies that perform the programs of stretching and strengthening in wheelchair users with a chronic SCI[5-10].

EMG biofeedback procedures are widely used for increasing an activity of paralyzed muscle or decreasing an muscle overactivity in patients with neurologic or musculoskeletal problems[13]. In the review of muscle tone related to the pain by Simons와 Mense(1998), it has been suggested that unnecessary muscle tension may be able to produce a muscle pain during muscle contractions. And thus, we hypothesized that a reduction of muscle tone of the upper trapezius may be effective in treatment for shoulder pain which resulted from repetitive compensatory movements.

Our results should be interpreted with caution because of the small sample size. It is also important to note that the limited number of participants and the psychologic factors such as depression and motivation may have resulted in a lack of statistical power. generalization of the results should be performed with caution because the manual wheelchair users were included.

V. Conclusion

This study provides the evidence that EMG biofeedback adds value when combined with an exercise intervention to reduce shoulder pain in manual wheelchair users with SCI. The exercise program is also effective in reducing a shoulder pain and muscle tone. Shoulder pain for the SCI patients in early rehabilitation may be able to have been produced by the various musculoskeletal problems. Therefore, there will be needed the studies to demonstrate the methodto prevent and treat shoulder pain following a SCI, with considering a various problems.

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