The Effects of Sensorimotor Training on Changes in Motor Control by Chronic Low Back Pain Patients’ Central Nervous System

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Abstract. This study aimed to examine changes in cerebral cortex potential related to movement (MRCP) and trunk muscle contraction onset time in chronic low back pain patients during sensorimotor training. Seven chronic low back pain patients who had undergone a stroke six months or longer before were selected as subjects and they conducted sensorimotor training for 40 minutes per each time, four times per week, for four weeks. According to the comparison result of cerebral cortex potential changes related to movement among movement related cortical potential, readiness potential activity at CZ, C3, C4, FZ, and F3, movement potential activity at CZ, C3, and F4, and movement monitoring potential activity at CZ, C3, C4, FZ, F3, and F4 decreased (p<0.05, p<0.01, p<0.001). In addition, changes in muscle contraction onset time were compared and there were significant differences in the trunk muscles transversus abdominis and the external oblique (p<0.001). Sensorimotor training was verified to trigger changes in motor control of the central nervous system and improve muscle functions in chronic low back pain patients.

Keywords: Sensorimotor training, Motor control, Chronic low back pain

1 Introduction

Ninety percent of patients with acute low back pain experience complete recovery within two months but without treatment it causes muscular disorder and psychological withdrawal [1]. The central nervous system orders anticipatory movements and this is called anticipatory postural adjustments (APAs) [2]. Activation of the cerebral cortex may be measured by movement related cortical potential (MRCP) [3]. Cerebral cortex potential related to movements consists of three stages of potential including readiness potential (RP), movement potential (MP), and movement monitoring potential (MMP) and the maximum values are recorded [4]. Cerebral cortex reaction of chronic low back pain patients is slow compared to normal people due to delay in the trunk muscle and it results in reduced postural control ability [5]. Sensorimotor training by such chronic low back pain patients maximizes sensory input of different parts of the body, recovering their motor control ability[6]. Therefore, this study intended to look at APA effect of sensorimotor training by
measuring changes in motor control by patients’ central nervous system and their trunk muscle contraction onset time.

2 subjects and methods

2.1 Subjects

The subjects of this study were seven chronic low back pain patients. The criteria for inclusion of the subjects were: those whose low back pain continued for longer than 12 weeks; who had not undergone lumbar surgery due to some orthopedic problem; and whose right side was the dominant side. All the subjects voluntarily consented to participate in this study.

2.2 Sensorimotor training & Brain wave (MRCP) measurement

A total of six kinds of exercises were designed; The area contacting the wobble board was made to become gradually smaller. Brain waves were measured with the brain wave system (QEEG-8; LXE3208, Laxtha Inc, Korea). The electrodes were attached to six areas of the cerebral hemisphere (CZ, C3, C4, FZ, F3, F4) and ground and reference electrodes (A1, A2) were attached to the mastoid process. The sampling rate to collect signals was 256Hz and the band pass filter was set at 4 to 50Hz for analysis. For measurement, the subjects swiftly bended the non-dominant shoulder joint to 90° in a standing position. Changes in RP, MP, and MMP activities were measured prior to and after the training.

2.3 Changes in motor control

Using an electromyography (EEG, Pocket EMG, BTS co, Italy), muscle contraction onset time related to movements was measured by attaching electrodes to the anterior deltoid, transversus abdominis (TrA), and the external oblique (EO). The frequency bandwidth to collect signals was set at 20 to 500 Hz. The measurement method was the same as that by EEG.

2.4 Data analysis

For data analysis, SPSS 18.0 Window version was used. For analysis of changes after the exercise, a paired t-test was conducted. A statistical significance level was set at α=0.05.
3 Results

3.1 Changes of brain wave (MRCP)

Changes in the cerebral cortex potential of the six regions related to movements during voluntary upper extremity movements were analyzed prior to and after the sensorimotor training. Among MRCP, RP activity at CZ, C3, C4, FZ, and F3 (p<0.05, P<0.01), MP activity at CZ, C3, and F4 (p<0.05, p<0.01, p<0.001), and MMP activity at CZ, C3, C4, FZ, F3, and F4 (p<0.05, p<0.01) decreased (Table 1).

Table 1. The changes of MRCP (µV)

<table>
<thead>
<tr>
<th></th>
<th>CZ</th>
<th>C3</th>
<th>C4</th>
<th>FZ</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td>RP</td>
<td>-3.34±2.28</td>
<td>-4.04±1.89</td>
<td>-3.46±0.22</td>
<td>-4.90±0.40</td>
<td>-4.69±0.47</td>
<td>-4.19±2.31</td>
</tr>
<tr>
<td>Post</td>
<td>-3.08±0.38*</td>
<td>-3.08±0.48*</td>
<td>-2.41±1.11***</td>
<td>-3.53±0.33***</td>
<td>-3.22±0.32***</td>
<td>-4.15±7.33</td>
</tr>
<tr>
<td>MP</td>
<td>-12.80±0.47</td>
<td>-10.60±0.44</td>
<td>-9.39±0.31</td>
<td>-11.44±5.60</td>
<td>-9.60±4.47</td>
<td>-7.13±7.84</td>
</tr>
<tr>
<td>Post</td>
<td>-9.55±4.75**</td>
<td>-8.77±0.58***</td>
<td>-7.50±0.60***</td>
<td>-7.82±6.00</td>
<td>-8.52±0.72</td>
<td>-6.23±0.60*</td>
</tr>
<tr>
<td>MMP</td>
<td>-15.57±0.67</td>
<td>-14.90±0.55</td>
<td>-15.25±0.48</td>
<td>-16.02±0.52</td>
<td>-15.64±0.39</td>
<td>-17.06±0.70</td>
</tr>
<tr>
<td>Post</td>
<td>-12.60±0.34***</td>
<td>-13.58±0.38***</td>
<td>-10.86±8.24*</td>
<td>-14.49±0.50***</td>
<td>-13.12±1.25***</td>
<td>-15.17±0.61***</td>
</tr>
</tbody>
</table>

All Values showed mean±S.D. Tested by paired t-test(*; p<.05 **p;<.01 ****p;<.001)

3.2 Changes of muscle activities

Changes in muscle contraction onset time were compared during voluntary movements before and after the sensorimotor training, and there were significant differences in TrA and EO (p<0.001) (Table 2).

Table 2. The changes of muscle activities(TrA & EO) (mS)

<table>
<thead>
<tr>
<th></th>
<th>DA</th>
<th>TrA</th>
<th>EO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre</td>
<td>0</td>
<td>67.64±6.76</td>
<td>81.27±9.58</td>
</tr>
<tr>
<td>Post</td>
<td>0</td>
<td>4.90±5.39***</td>
<td>43.55±10.58***</td>
</tr>
</tbody>
</table>

All Values showed mean±S.D. DA: Deltoid Anterior, TrA: Transversus Abdominis, EO: External Oblique Tested by paired t-test(*; p<.05 **p;<.01 ****p;<.001)

4 Discussion

Movements programmed in the central nervous system involve anticipatory responses of the musculoskeletal system. APAs by the central nervous system anticipatorily trigger responses of the body based on prior experiences, but chronic low back pain patients show delayed responses because of the weakened trunk muscles [7].
Accordingly, this study applied sensorimotor training to chronic low back pain patients and examined how changes in the cerebral cortex potential and trunk muscle contraction onset time affected their APAs.

When chronic low back pain patients to whom sensorimotor training was applied moved, their MRCP became low. Such change showed that during sensorimotor training, RP, MP, and MMP played an important role in MRCP. This meant that their cerebral cortex activity increased like normal people, triggering APAs. Sensorimotor training was applied to the subjects and changes in their APAs in the TrA and EO showed statistically significant changes in the muscle contraction onset time after the training. This signifies that trunk muscle activity of chronic low back pain patients was delayed before but after sensorimotor training their response time improved similar to that of normal people. The trunk muscles contributed to stability of the body and the trunk maintained a stable posture against external stimuli. Their muscle contraction onset time shortened after sensorimotor training like normal people, leading to strengthened trunk muscles. Resultantly, sensorimotor training was effective for chronic low back pain patients’ APAs in relation to their cerebral cortex potential and muscle activity responses related to movements. Recurrent low back pain affects the patients’ muscle functions by influencing planning and execution of movements by the cerebral cortex. Changes in cerebral cortex activity and muscle contraction onset time after sensorimotor training enabled APAs, thereby enhancing muscle functions.

References