The Effect of Proprioceptive Position Sense by Lumbar Flexors and Extensors

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Purpose: Muscle fatigue affects proprioception, and it causes problems in spinal stability. The purpose of this study was to examine the effect on the accuracy of reproducing the lumbar angles before lumbar exercise and after fatiguing isokinetic lumbar exercise.

Methods: Thirty healthy adults participated in this study. Before induction of fatigue by exercise, the proprioception was measured by Biodex. Lumbar positions were passively maintained on stimulation position (25° flexion and 25° extension), and back to the starting position. Subjects actively repositioned the remembered stimulation position, and error degrees between the stimulation position and reposition were measured. Using an isokinetic device at 120°/sec of velocity of angle lumbar flexion/extension exercise resulted in muscle fatigue. The post-fatigue proprioceptive position sense was used in the same way as in pre-fatigue measurement.

Results: Means of position sense of pre-fatigue were 2.19±1.97 on flexion angle, and 5.04±2.84 on extension angle. After exercise induced fatigue, means of position sense were 2.37±1.83 on flexion angle, and 4.93±2.57 on extension angle. Results of this study showed significant differences of lumbar proprioceptive position sense between pre- and post-fatigue.

Conclusion: Lumbar proprioception sense in active repositioning in flexion and extension was affected in the presence of muscle fatigue. Therefore, it should be noted that therapeutic exercise for patients with abnormal proprioceptive sense or elderly people must be performed with care because muscle fatigue can cause secondary damage.

Keywords: Muscle fatigue, Proprioception, Lumbosacral region

I. Introduction

Proprioceptive sense means to distinguish the joint movement or posture, including the direction, size, velocity, and tension of movements, and it plays an important role in reduction of joint function instability or recurrence. In particular, the input of proprioceptive sense on spine is a critical factor for stability and coordination, and it controls proper spinal movement. This proprioceptive sense is located on anatomical structures such as muscle, joint, and skin; its disability of proprioception is caused by injuries of muscle and joint. Proprioceptive sense is decreased by impairment of axons, and impairment of tissue on distributing receptors or changes of structures. Impairment of proprioceptive sense interrupts coordination with muscle groups in its associated region, therefore, an appropriate response regarding cooperative action cannot be made in order to meet the need. The loss of position sense causes difficulty in performance of activities of daily life, and causes degenerative changes because it reduces the effects of new motor learning. Individuals with low back pain have weakness on lumbar muscles as well as higher muscle fatigue on lumbar flexors and extensors. Muscle fatigue affects coordination ability and proprioceptive sense, sports activities, daily life, and rehabilitation treatments. And reduction of the ability to maintain muscle strength or proprioceptive sense due to
muscle fatigue decreases the ability to control motor, and affects control of postural sway. In particular, the deep muscles in individuals with low back pain are weaker and have imbalances, compared with healthy individuals, and the ability of reposition sense in individuals with low back pain decreases due to reduction of the proprioceptive function. Therefore, they have problems in spinal stability. As a result, the proprioceptive sense on the spine involves lumbar stability, and treatment and prevention of low back pain is important.

Many studies of the effect of proprioception on muscle fatigue, such as muscle fatigue on shoulder and knee joint, have been conducted.

In addition, studies of the relation between muscle fatigue and proprioception on the lumbar region have been conducted. Kim reported that lumbar pain affects the reduction of the coordination ability of lower extremities and proprioceptive sense. Hart et al. reported that muscle fatigue on paraspinal muscles induced experiment inhibit quadriceps femoris. Park et al. reported that lumbar extensor fatigue decreases the coordination ability for examination of the motor control of lower extremities, however, it did not induce a reduction of proprioceptive sense. In order to treat and prevent low back pain, conduct of studies of muscle fatigue and proprioceptive sense has shown a steady increase, however, the effects of lumbar muscle fatigue on proprioceptive sense have not yet been reported. Therefore, the purpose of this study was to recognize the effects of lumbar muscle fatigue on proprioceptive sense in healthy young adults.

II. Materials and Methods

1. Subjects
Thirty healthy adults who were in agreement with the purpose of this study, and do not have problems on position sense and back injuries participated in this study.

2. Experimental methods
1) Experimental equipment
Biodex (Biodex Inc., Shirley, NY, USA) was used to measure position sense. This equipment uses the isokinetic principle for diagnosis and analysis of seven major joints in humans and muscle power, endurance, and so on.

2) Procedure
While lumbar positions were passively maintained for 3 seconds on 25° flexion and 25° extension, which is the stimulation position, subjects had to remember the stimulation position. And lumbar positions were back to the starting position. Subjects actively repositioned the remembered stimulation position, and error degrees between the stimulation position and reposition were measured using the biodex system. Measurements were performed three times and used mean of the error degrees. It was the proprioceptive position sense of pre-fatigue. Both eyes of subjects were blinded during measurement of the position sense.

Lumbar muscle fatigue occurred using the Biodex system set at 120°/sec of angular velocity. Subjects continuously repeated lumbar flexion and extension for 20 times at their maximal strength. The post-fatigue proprioceptive position sense was used in the same way as in measurement of pre-fatigue.

3. Statistical analysis
IBM SPSS 19.0 for Windows (IBM Co., Armonk, NY, USA) and paired t-test were used for comparison of the proprioceptive position sense between pre- and post-fatigue. Significant level was 0.05.

III. Results

1. Characteristics of the subjects
The subjects included 30 healthy adults (16 male, 14 female), and characteristics of subjects are shown in Table 1.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Male (n=16)</th>
<th>Female (n=14)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height (cm)</td>
<td>174.8±5.4</td>
<td>161.3±4.6</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>68.2±10.5</td>
<td>51.9±3.6</td>
</tr>
<tr>
<td>Age (yr)</td>
<td>24.4±4.3</td>
<td>24.4±2.2</td>
</tr>
</tbody>
</table>

Values are presented as mean±standard deviation.
Proprioception is defined as the sense that mechanoreceptors detect joint position and movement through conscious/unconscious process on the sensorimotor system. It is classified as a kinesthesia for detection of limb movement and a joint position sense for detection of static limb position. It plays a greater role than pain related to prevention of impairments, the etiology of chronic damage, and degenerative joint diseases. However, if the function of proprioceptive sense is that input by appropriate response as movements is reduced by abnormal structures around joints due to lesion or disease, balance ability for postural control, protective reaction and joint motion ability, and altering postural sway might decrease.\textsuperscript{14,23-25}

In this study, in order to recognize the effects of proprioceptive position sense on muscle fatigue, lumbar position sense was measured as experimentally generated muscle fatigue on the lumbar region. Significant differences in position sense were observed between pre- and post-fatigue. Sterner et al.\textsuperscript{26} reported that joint position sense does not have an effect on muscle fatigue. However, Voight et al.\textsuperscript{2} reported significant differences in reposition of active and passive joint angle between pre- and post-fatigue. Miura et al.\textsuperscript{27} reported changes in proprioceptive sense between pre- and post-application of local load. Johnston et al.\textsuperscript{28} reported that proprioceptive sense has effects on muscle fatigue, and causes reduction of muscle response and ability to maintain balance. In addition, many previous studies have reported on the effects of proprioceptive sense on muscle fatigue: results of these studies were consistent with the results of this study.\textsuperscript{15-19,26,30}

Lumbar muscles in individuals with low back pain become fatigued by consistent activities of lumbar flexors and extensors, which is accompanied by weakness of the muscles. Because it decreases lumbar proprioceptive sense and reposition sense, it causes spinal instability. Eventually, it is the reason for recurrence.\textsuperscript{12} Therefore, many research studies investigating spinal proprioceptive training, local muscle strengthening, and lumbar stabilization training have been conducted for treatment and prevention of low back pain.\textsuperscript{31-35} In addition, many physical therapists have administered treatment in the same manner. The results
of this study showed that lumbar muscle fatigue induced a decrease in proprioceptive position sense; these results indicate that muscle fatigue can cause disability in motor or postural control. In particular, muscle fatigue decreases proprioceptive sense and ability of motor performance in patients in whom muscle fatigue is easily generated or injured professional athletes, as well as patients with low back pain. Therefore, it should be noted that therapeutic exercise for patients with abnormal proprioceptive sense or elderly people must be performed with care because muscle fatigue can cause secondary damage. Conduct of future studies will be needed in order to prove the relationship between muscle fatigue and proprioception in patients in whom muscle fatigue is easily generated or elderly people.

Acknowledgements

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References