The Immediate Effects of Passive Hamstring Stretching Exercises on the Cervical Spine Range of Motion and Balance

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Abstract. [Purpose] The purpose of the present study was to examine the immediate effects of passive hamstring stretching exercises on cervical spine range of motion and balance. [Subjects] The present study was conducted with 60 healthy university students without any musculoskeletal dysfunction as subjects. They were divided into an experimental group consisting of 30 subjects and a control group consisting of 30 subjects. [Methods] Cervical spine range of motion was measured using a cervical range of motion goniometer, and the stability test was conducted to assess balance. The experimental group were administered hamstring stretching with ankle dorsiflexion for 30 seconds three times, whereas the control group received the same treatment without ankle dorsiflexion. [Results] Cervical spine range of motion and balance immediately increased in the experimental group while there was no change in the control group. [Conclusion] The results show that hamstring muscle stretching exercises the fascia of the skeletal muscles of the human body and that the fascia are connected to each other by interactions of force. The human skeletal muscles interacted with each other to increase the flexion and extension range of motion of the cervical spine. In addition, the transfer of these forces to the stabilizer muscles of the pelvis and spine were the most important factor in the improvement of the subjects’ balance.

Key words: Hamstrings stretching, Range of motion, Myofascial meridian

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INTRODUCTION

Stretching exercises are used before and after competitions to ensure flexibility and prevent injuries in sports. They are also used to recover limited joint range of motion and maintain normal lengths of muscles in physical therapy. Hamstring muscles are composed of the biceps femoris located at the posterior lateral side of the thigh and the semitendinosus and semimembranosus located at the posterior medial side of the thigh which act in hip joint extension and knee joint flexion1). When the hamstrings are shortened, changes in posture, low back pain and limited knee joint range of motion occur. To resolve these problems, passive stretching exercises are used in clinical medicine2). Many researchers such as Gajdosik3) have reported that when hamstrings shortened, the anterior flexion of the pelvis and the lumbar vertebrae are limited and thoracic vertebral flexion increases in compensation. In such cases, stretching of the hamstrings would recover normal posture. An4) stated that patients suffering chronic back pain would increase and pain would the lumber flexion angles after they do stretching, and the pains were reduced. For the patients who have osteoarthritis5), pain would be reduced too. Depino et al.6), De Weijer et al.7), Ford and McMesney8) reported that knee joint range of motion of patients was increased after passive stretching exercises. According to Myers9), the hamstrings located at the posterior side of human body are connected by the superficial back line passing from the gastrocnemius through the hamstrings to the sacrotuberous ligament, the thoracolumbar fascia, the erector spinae, the iliocostalis, the epicranial, the galea aponeurotica and the frtalis muscles. The superficial back line is one of myofascial meridians transmitting the tension generated by the head or gastrocnemius to other muscles.

Balance is a dynamic process which maintains the standing or sitting postures. Balance maintained by the homeostasis of posture through complex processes such as perception and sensation informatization10). Balance is the ability to keep the center of gravity axis of the human body is aligned over the weight bearing surface11). Pelvic movements occur depending on the lengthened or shortened states of the hamstrings, and biomechanical reactions occurring in the upper and lower extremities compensate for these pelvic movements. This compensatory biomechanical adjustment affects balance too. Reid and McNair12), and Feland, et al.12) examined the effects of the lengthened and shortened states of hamstrings and reported they are related the range of motion of the joints that are adjacent to muscle origins or insertions, or regions of pain. Therefore, in the present study, in order to investigate the immediate actions...
of fascias connected to the superficial back line\(^9\), the joint range of motion and balance of the neck which is distant from hamstring origins and insertions were measured to examine whether the fascias connect the various human muscles with each other enabling them to interact with each other.

**SUBJECTS AND METHODS**

The subjects were 60 university students, who had not visited a clinic with a musculoskeletal disease in the previous 6 months, who agreed to participate in the experiment after they had listened to an explanation of the purpose and the methods of the study. Their maximum knee joint extension angle measured in the supine position at 90 degrees flexion of the hips, was 165 degrees or smaller. The 60 subjects were randomly divided into an experimental group and a control group. The balance index of all subjects in the experimental group and the control group was computed before the intervention using cervical spine range of motion and TETRAX. After the measurements, each subject in the control group adopted a comfortable supine position. Then, the tester passively stretched the hamstring of the subject by fixing the left lower extremity of the subject and holding the ankle region of the right lower extremity of the subject to extend the knee of the lower extremity to the maximum extent that could be endured by the subject without pain. The maximum stretching limit was maintained for 30 seconds with the ankle being maintained in the neutral position, and then the leg was returned to the initial position. This procedure was repeated three times with a rest for 10 seconds between each session. Each subject in the experimental group was also administered passive hamstring stretching exercises by simultaneous application of ankle joint flexion and dorsiflexion with the knee in extension. When subjects were in the supine position, the tester fixed the left lower extremity of each subject, causing ankle joint flexion and dorsiflexion, and stretched the hamstrings through the same procedure as used for the experimental group while holding the ankle region to extend the knee of the subject. The range of motion and balance index of the neck of all subjects measured in the experimental group and the control group were measured immediately after completing the passive stretching exercises.

A cervical range of motion goniometer (Performance Attainment Associates, MN, USA) was used to measure the range of motion of the cervical spine. A cervical range of motion goniometer is composed of three inclinometers. This is worn on the face as with glasses and fixed by adhesive bands behind the head. Two inclinometers, one on the forehead and another on the side of the head are used to measure of flexion, extension and lateral flexion, and the remaining inclinometer is a magnetic inclinometer that can measure rotation. The subjects sat on a chair with a backrest, kept their back in contact with the backrest of the chair, placed their feet parallel to the ground and kept their shoulders relaxed at the sides of their trunk while they performed two motions flexion and extension. To familiarize themselves with the posture and measuring method, the subjects practiced the motions two times before the motions were measured three times. Average values of the three measurements were used in the analysis. A TETRAX Portable Multiple System (TETRAX Ltd, 56 Miryam Ramat Gan, Sunlight, Israel) was used to measure the subjects’ balance. The TETRAX has two force plates (12×30 cm each), one for each foot and assesses postural motion through changes in loads on four points (2 toes, 2 heels)(sampling rate 34 Hz). Using the TETRAX stability test index, the mean balance condition was calculated. The measuring time of each test was 30 seconds with 20 seconds rest time between each measurement. The balance tests were conducted on stable and unstable surfaces with the subjects’ eyes opened and closed. The stability test index is calculated by calculating changes in the center of gravity and changes in the speed of the center of pressure derived from the changes in pressure on the four pressure plate points. A lower stability test index indicated better balance abilities.

The data collected in the present study were statistically processed using SPSS version 14.0 for Windows. The means and standard deviations of the data were analyzed for descriptive statistics, and the paired t-tests was used to compare the cervical spine flexion and extension, range of motion, and stability test index of the experimental group and the control group before and after the intervention with each other. The significance level, \( \alpha \), was chosen as 0.05.

**RESULTS**

The subjects who participated in the present study were 60 university students (26 males and 34 females) without any musculoskeletal diseases. Their mean age was 20.35 years, their mean height was 167.20 cm, and their mean weight was 61.65 kg. The experimental group consisted of 13 males and 17 females. Their mean age was 20.66 years, their mean height was 166.11 cm, and their mean weight was 61.60 kg. The control group consisted of 13 males and 17 females. Their mean age was 20.60 years, their mean height was 168.26 cm, and their mean weight was 61.70 kg. There were no significant differences in mean ages, heights or weights between the experimental group and the control group.

Before the experiment, there were no significant differences in cervical flexion and extension, range of motion, or stability test index between the experimental group and the control group (Table 1). After the experiment, in the experimental group, cervical spine flexion range of motion increased from 50.06 degree to 55.13 degree and the cervical spine extension range of motion increased from 58.86 degree to 64.26 degree, while the stability test index decreased from 15.27 to 13.56 showing an increase in balance ability (p<0.001). In the control group, there were no differences between before and after the intervention in cervical spine flexion or extension, or the stability test index (Table 2).

**DISCUSSION**

Kim and Kim\(^3\) reported that knee joint range of motion increased immediately after administering passive stretching exercises to the hamstrings of 45 young person for 30 seconds, and Depino et al.\(^7\), De Weijer et al.\(^6\) Ford
Table 1. Comparison of neck flexion and extension between the experimental and control group before the intervention

<table>
<thead>
<tr>
<th>Category</th>
<th>Experimental group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neck flexion (degree)</td>
<td>50.06 ± 11.09</td>
<td>54.13 ± 9.97</td>
</tr>
<tr>
<td>Neck extension (degree)</td>
<td>58.86 ± 9.68</td>
<td>60.33 ± 8.08</td>
</tr>
<tr>
<td>Stability test index</td>
<td>15.27 ± 4.36</td>
<td>14.68 ± 4.42</td>
</tr>
</tbody>
</table>

* p<0.05, Values are mean ± SD

Table 2. Pre- and post test comparison of neck flexion and extension

<table>
<thead>
<tr>
<th>Group</th>
<th>Category</th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Experimental group</td>
<td>Neck flexion** (degree)</td>
<td>50.06 ± 11.09</td>
<td>55.13 ± 10.12</td>
</tr>
<tr>
<td></td>
<td>Neck extension** (degree)</td>
<td>58.86 ± 9.68</td>
<td>64.26 ± 10.04</td>
</tr>
<tr>
<td></td>
<td>Stability test** indexes</td>
<td>15.27 ± 4.36</td>
<td>13.56 ± 3.78</td>
</tr>
<tr>
<td>Control group</td>
<td>Neck flexion (degree)</td>
<td>54.13 ± 9.97</td>
<td>53.53 ± 9.75</td>
</tr>
<tr>
<td></td>
<td>Neck extension (degree)</td>
<td>60.33 ± 8.08</td>
<td>61.20 ± 7.56</td>
</tr>
<tr>
<td></td>
<td>Stability test index</td>
<td>14.68 ± 4.42</td>
<td>13.82 ± 4.00</td>
</tr>
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</table>

** p<0.01, Values are mean ± SD

and McCesney\(^8\) reported that knee joint range of motion increased immediately after administering passive stretching exercises to the hamstrings of young persons. Feland et al.\(^5\) reported that knee joint range of motion increased immediately after administering passive stretching exercises to the hamstrings of elderly persons for 30 seconds, and Zakas et al.\(^4\) also reported that knee joint range of motion increased immediately after administering passive stretching exercises to 20 elderly persons for 60 seconds. Reid and McNair\(^3\) reported that knee joint range of motion increased immediately after administering passive stretching exercises to the knees of osteoarthritis patients for 60 seconds.

Most previous studies have examined immediate increases in the range of motion of the knee joints, which is adjacent to the hamstrings, after passive hamstring stretching exercises. In the present study, to confirm that human muscles are connected with each other by fascias enabling interaction with each other, the range of motion of the cervical spine which is distant from the knee joints was measured after passive hamstring stretching exercises. Cervical flexion showed an increase in the joint range of motion of around 5 degree and cervical extension showed an increase in the joint range of motion of around 4.5 degrees. Given these results, it can be seen that through the action of the superficial back line\(^3\), that connects muscles on the posterior side of the body with each other, passive hamstring stretching exercises stretched the cervical extensors, and the stretched extensor loosened the flexors increasing cervical flexion and extension. The passive hamstring stretching exercises also transmitted the force of stretching to muscles related to the pelvis and spine, thereby improving static balance.

With regard to the immediate increases in the range of motion of adjacent joints after passive stretching exercises, Magnusson et al.\(^3\) suggested that the increases were due to increases in learning effects resulting from changes in the perception of passive characteristics, stretching of the muscles, and pain-controlling effects occurring in the muscles and joints through noxious nerve endings. Immediate increases appeared in the range of motion of joints distant from the region where the stretching was applied in the present study. We consider this resulted from the action of fascias that transmitted forces to different muscles.

Gajdosik et al.\(^3\) stated that shortened hamstrings would cause problems at the pelvis and the spine, and stretching of the hamstrings would restore normal posture. The results of the present study, show that passive stretching of muscles on the posterior side of the thigh restores the lengths of the muscles related to the pelvis and the spine, and that the restoration of the lengths of those muscles also restores normal posture, thereby improving static balance.

As suggested by previous studies, passive hamstring stretching exercises increases the range of motion of the knee joints which are adjacent to the hamstrings. In addition, as shown in the present study, through the action of fascias that connect human skeletal muscles with each other, passive hamstring stretching exercises also increase the range of motion of distant joints, and this force transmission stabilizes the pelvic and spinal muscles, thereby improving balance.

REFERENCES

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