Cervical Stabilization Exercises improve Postural Balance

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Key Words: cervical deep muscles, stabilization exercises, postural balance function

【Abstract】

Cervical spine is the site where disease occurs frequently because it requires both stability and mobility. In cervical diseases, there is a problem of cervical instability due to dysfunction of cervical muscles. Therefore, we practice Cervical Stabilization Exercises (CSEx) that activate cervical deep muscles in our physical therapy treatment. Cervical deep muscles are believed to not only contribute to neck stability but also play an important role to control posture because they contain muscle spindles of the proprioceptive receptor in high density. We conducted this research with an aim to clarify the effect of CSEx on postural balance. We measured sway of the center of gravity of the body in the standing position and compared measurements before CSEx with those after CSEx. As a result, CSEx is found effective to correct postural balance. This is presumably because the tectonics stability of cervical segment was improved by activated cervical deep muscles and because the postural control mechanism of proprioceptive sensibility was promoted. In this study, CSEx is effective not only to stabilize neck but also to improve postural balance.

【Introduction】

Cervical spine is located at the top of spine. It protects nerve and blood vessels and offers attachment sites for muscles and ligaments, not to mention supporting the heavy head. On top of that, head has organs of such special senses as vision, smell, and hearing, and spine has a big range of motion to secure these functions for the execution of diverse motions[1]. That is, spine is a site required to comply with two incompatible requests of securing head stability and securing its diverse mobility[2]. For this reason, cervical spine is the site where orthopedic diseases occur frequently.

As problems occur frequently in cervical spine, manipulative physical therapy is practiced for the treatment. We, therefore, practice CSEx to improve cervical stability.

CSEx is the exercise based on the concept of Kaltenborn-Evjenth OMT that is a manipulative physical therapy[3]. It is a low load exercise to retrain muscle functions of cervical deep muscles that contributes to the stability of joints. Exercising cervical deep muscles allows them to operate in coordination with surface muscles and improves the stability of the neck. Lately, a group of Australian manipulative physical therapists took initiative in studying the effect of exercising cervical deep muscles and demonstrated that it is effective to improve both muscle function and motor function[4,5].

On the other hand, cervical deep muscles transmit information on sensorimotor control because it contains many spindles that are proprioceptive receptors. Above all, cervical deep muscle has muscle spindle in high density and actually has more muscle spindles than joint[6,7], indicating that cervical deep muscles are rather influential as a sensor to detect length and tension.

As mentioned above, cervical deep muscles are supposed to play an important role in controlling posture because it contains muscle spindle of the proprioceptive receptor besides contributing to the stability of neck. In clinical practice, it has been proved that conducting CSEx to cervical deep muscles alleviates pain and improves motor function. However, the effects of CSEx on postural balance still remain unknown. In this research, we verified the effects of CSEx from the viewpoint of postural balance.

【Methods】

(1) Subjects

Subjects are 14 healthy adults(male, 24.1±4.8 years, 168.6±7.4cm), without orthopedic disease.

(2) Measurement condition (Fig.1)

We asked the subjects to stand on the stabilometer (UM-BAR, UNIMEC, Japan) and measured their sway of the center of gravity of the body before and after CSEx(30 sec, sampling frequently 60 Hz) .

The measurement position was stand on the stabilometer with closed legs with medial edges of both feet. After subjects focused on the marker at the height of subject' s eye, closed eyes and kept their head and neck in the same position during measurement.

(3) Analysis

We analyzed six measurement parameters. They are total locus length (TL), anteroposterior locus length (A-P L), right and left locus length (R-L L), outer peripheral area (OPA), anteroposterior maximum amplitude (A-P Max), and right and left maximum amplitude (R-L Max).

We compared measured values before CSEx and those after CSEx. We used IBM SPSS Statistics ver. 25 (IBM Japan) for statistical analysis (Wilcoxon signed rank test, $p<0.05$).

(4) Method of CSEx (Fig.2)

CSEx is an exercise therapy based on Kaltenborn-Evjenth OMT that is a manipulative physical therapy[3]. It is made up of two

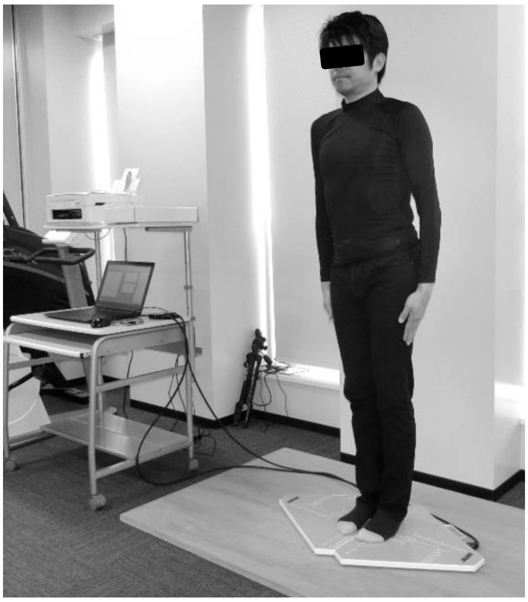

Fig.1: Measurement position

exercises that we developed by adding methods developed by previous studies[8-10]. 1) We asked the subjects to gaze by moving the eyeball upward and downward direction (10 sec. x 10 rep for each direction). 2) We asked them to put the cuff of the sphygmomanometer into the posterior neck in line with the lordosis curve and push the cuff lightly. While they were keeping this position, we asked them to apply resistance to glabella by themselves using their thumbs and do nodding (chin-in) motion with mouth open (10 sec x 5 rep). While subjects were following our instructions, we measured the compression using the cuff of the sphygmomanometer and kept the compression stable while giving them feedback. We increase the compression up to about 4 mmHg and asked them to keep it. During these procedures, we paid attention to control excessive contraction of sternocleidomastoid muscle.

Fig.2: Cervical Stabilization Exercises (CSEx)

(5) Ethical consideration

We conducted this research in conformity with the Ethical Standards of Bukkyo University(Ethical Approval Number: H30-9B).

【Results】

The results are shown in Table 1. As the table shows, we got significantly low values after CSEx in each of total locus length (TL), anteroposterior locus length (A-P L), outer peripheral area (OPA), and anteroposterior maximum amplitude (A-P Max) ($p<0.05$). However, we failed to get significantly low values both in right and left locus length (R-L L) and right and left maximum amplitude (R-L Max), though we got low values in these two items after CSEx.

【Discussion】

We verified the effects on postural balance of CSEx that we practice for patients with cervical spine disease. From the measured results, we observed that CSEx decreased body anteroposterior sway and reduced anteroposterior maximum amplitude (A-P Max) that shows the width of sway. This means that neck motion was stabilized especially in

Table1: Results of measurement parameters

	before CSEx	after CSEx	*p*
Total Locus Length (mm)	784.1 ± 273.6	683.1 ± 132.1	*
Outer Peripheral Area (mm^2)	729.7 ± 536.1	508.3 ± 220.1	*
Anteroposterior Locus Length (mm)	458.5 ± 141.2	393.5 ± 63.5	*
Right and Left Locus Length (mm)	534.6 ± 216.9	471.4 ± 107.7	
Anteroposterior Maximum Amplitude (mm)	31.6 ± 13.8	23.9 ± 4.8	*
Right and Left Maximum Amplitude (mm)	28.9 ± 9.2	25.6 ± 8.0	

*$p < 0.05$

sagittal plane. Thereby, the outer peripheral area (OPA) that shows the outermost area of gravity sway became narrow. Previous studies clarified that exercising cervical deep muscle is effective to ease the pain of patients with neck pain and improve the motion function[4,5]. Results of this research clarified that exercising cervical deep muscle is also effective to improve postural balance. That is, we can say safely that CSEx is also an exercise to improve postural balance.

The results can be attributed to the fact that cervical deep muscles activated by CSEx improved the tectonics stability at cervical spine and promoted the posture control mechanism by proprioceptive sensitivity of cervical deep muscle.

Muscles especially important as cervical deep muscles are extensor and flexor muscles. The former includes suboccipital muscle group, multifidus muscle, and semispinalis cervicis muscle(Fig.3). The latter includes longus colli muscle, longus capitis muscle, rectus capitis muscle, and rectus capitis lateralis muscle[2,11] (Fig.4). These deep muscles are designed to supply spinal segments with stability[12]. Surface muscles can produce big torque than deep muscle because the former has a bigger lever arm and cross-sectional area than the latter. On the contrary, deep muscles attach to each segment and function only in restricted areas as compared with surface muscles. In addition, they have muscle spindles in high density and a composition that allows muscle fibers to support the motions of spinal segments [7,13].

Longus colli muscle and longus capitis muscle, each of which is the deep muscle located anterior cervical spine, cover cervical spine in the deep layer of front surface and their functions are associated with stabilization of head and neck and with flexion of neck[2]. At the same time, longus colli muscle has an extremely important role to modify cervical lordosis and stabilize cervical spine[14]. Suboccipital muscles, which are neck dorsal deep layer located suboccipitally, is much smaller than large muscle located in the surface layer. While large muscles are anatomical terms of muscles, suboccipital muscle group adjust the motion of head and neck delicately in response to the request of special sense organ[2].

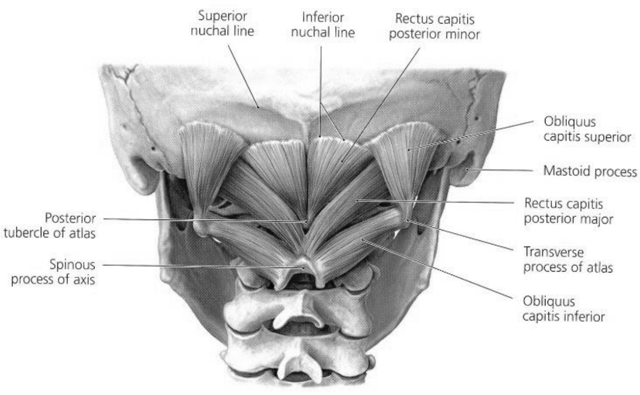

Fig.3: Cervical deep muscles (back)

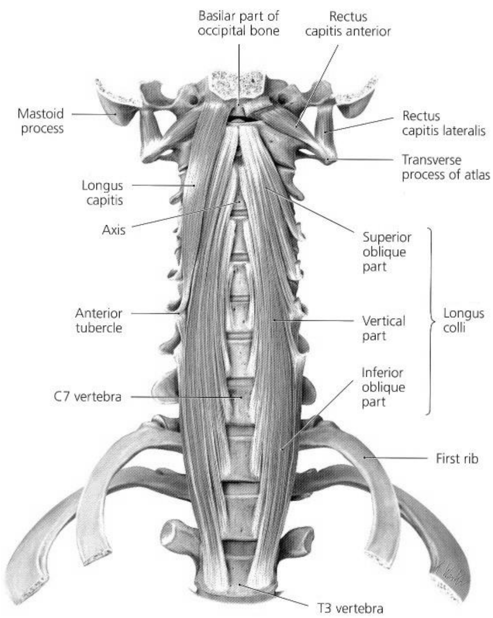

Fig.4: Cervical deep muscles (front)

These cervical deep muscles do not have a moment arm advantageous dynamically because they do not have short muscle length and because they located in a short segment. Consequently, they are not involved much in coarse movements. Instead, muscle spindles of proprioceptive receptor exist in neck muscle at higher density than in other region[6,7] (Table 2). This indicates that cervical deep muscle is rather influential as a sense organ to detect changes of length and tension.

Afferent nerve coming from neck is associated with the central nervous system and involved in the output of appropriate efference[15,16]. In addition, some reports indicate that they are closely associated with the eye.

Judging from the specific morphological and functional characteristics of cervical deep muscle and existence of high density muscle spindle, deep muscles not only simply control the movements of neck and head but also play such important roles as transmitting proprioceptive information, controlling head positon, and collaborative control of eye and head.

It has become clear that the cervical deep muscles play diverse and important roles, and patients with neck pain impair its muscle function greatly, causing instability of retaining head and movement of head[17-22]. Once these muscle functions deteriorate, they cannot recover them naturally easily[23,24]. For this reason, treatment to recover the function is necessary. This is exactly the reason why we practice CSEx.

CSEx is an exercise that focuses on cervical deep muscles. We practiced CSEx in two steps. Firstly, 1) we activated cervical deep muscles by up-and-down eyes movements. The receptor of neck muscle plays an important role especially to control sensory movement[15,16]. Controlling eye movement is included, and this exercise is meaningful to relearning of the collaborative movement between eye and cervical deep muscles. Secondly, 2) we asked to co-contraction of flexor and extensor muscles of cervical deep muscles by nodding motion. In the nodding motion, we asked them to retrain longus colli muscle and longus capitis muscle intentionally. Especially, as longus colli muscle has the function to decrease cervical lordosis, we adjusted the compression force using cuff of the sphygmomanometer put on the back of the head. At the same time, we

Table2: Muscle spindle content and spindle density of human muscles

Muscle	muscle weight (g)	Spindle content	Spindle density (/g)
Obliquus capitis superior	0.19	36	189.5
Obliquus capitis inferior	0.33	88	266.7
Rectus capitis posterior (major, minor)	0.59	58	98.3
Longus colli	3.22	143	44.4
Opponens pollicis	2.5	44	17.6
Latissimus dorsi	246	368	1.5
Trapezius	201	437	2.2

facilitated the contraction of extensor muscle by putting the back of the head lightly, and increased the bearing properties.

Cervical deep muscles we focused on CSEx contributed the stability of neck segments, and muscle spindles of proprioceptive sensibility are contained in high densities. Therefore, CSEx is thought to have retrained cervical deep muscles and realized constructive stability. At the same time, it became possible to maintain the physiological muscle length of the muscle, and functional stability was obtained by the accurate functioning of proprioceptors. It is our opinion that postural control functioned effectives and improved postural balance with the help of these factors.

【Conclusion】

It is clinically accepted that CSEx is effective to alleviate neck pain and improve joint's range of motion. In this research, we verified the effects of CSEx from the viewpoint of postural balance and observed that postural balance improved after CSEx. This is because CSEx trained cervical deep muscles, improved the stability from the viewpoint of tectonics, and facilitated the function of proprioceptive sensitivity of cervical deep muscles. Taking these outcomes into consideration, we can conclude that CSEx is an exercise competent enough to improve postural balance.

[References]

1. Neumann DA : Kinesiology of the Musculoskeletal System：Foundations for Rehabilitation 3rd Edition. Mosby, 2016.
2. Oatis CA：Kinesiology: The Mechanics and Pathomechanics of Human Movement (2nd Edition). Lippincott Williams & Wilkins, 2008.
3. Freddy M. Kaltenborn,et al : Manual Mobilization of the Joints：VolumeⅡ The Spine, 6th edition. Orthopedic Physical Therapy, 2012.
4. Jull GA, Falla D, et al：The effect of therapeutic exercise on activation of the deep cervical flexor muscles in people with chronic neck pain. Man Ther 14：696-701, 2009.
5. O'leary S, Falla D, et al：Muscle dysfunction in cervical spine pain: Implications for assessment and management. J Orthop Sports Phys Ther 39：324-333, 2009.
6. Kulkarni V, et al：Quantitative study of muscle spindles in suboccipital muscles of human foetuses. Neurol India 49：355-359, 2001.
7. Boyd Clark L, Briggs C, et al：Muscle spindle distribution, morphology and density in the longus colli and multifidus muscles of the cervical spine. Spine 27：694-701, 2002.
8. O'Leary S, Jull G, et al：Craniocervical flexor muscle impairment at maximal, moderate, and low loads is a feature of neck pain. Man Ther 12：34-39, 2007.
9. Chiu T, Law E, et al：Performance of the craniocervical flexion test in subjects with and without chronic neck pain. J Orthop Sports Phys Ther 35:567-571, 2005.
10. Jull GA, Kristjansson E, et al : Impairment in the cervical flexors: a comparison of whiplash and insidious onset neck pain patients. Man Ther 9：89-94, 2004.
11. Michael Schuenke, Erik Schulte : PROMETHEUS Allgemeine Anatomie und

Bewegungssystem: LernAtlas der Anatomie 4.Auflage, Thieme Georg Verlag ,2014.

12. Carolyn Richardson,et al : Therapeutic Exercises for Spinal Segmental Stabilization in Low Back Pain: Scientific Basis and Clinical Approach. Churchill Livingstone, 1998.
13. Boyd Clark LC, Briggs CA, et al : Comparative histochemical composition of muscle fibers in a pre- and a postvertebral muscle of the cervical spine. J Anat 199 : 709-716, 2001.
14. A.I.Kapandji : The Physiology of the Joints Volume 3: The Spinal Column, Pelvic Girdle and Head - 6th edition, Churchill Livingstone, Inc, 2008.
15. Bolton PS, Tracey DJ : Spinothalamic and propriospinal neurons in the upper cervical cord of the rat—terminations of primary afferent fibers on soma and primary dendrites. Exp Brain Res 92 : 59-68, 1992.
16. Corneil BD, Olivier E, et al : Neck muscle responses to stimulation of monkey superior colliculus. I. Topography and manipulation of stimulation parameters. J Neurophysiol 88 : 1980-1999, 2002.
17. Silverman JL, Rodriquez AA, et al : Quantitative cervical flexor strength in healthy subjects and in subjects with mechanical neck pain. Arch Phys Med Rehabil 72 : 679-681, 1991.
18. Watson DH, Trott PH : Cervical headache: an investigation of natural head posture and upper cervical flexor muscle performance. Cephalalgia 13:272-284,1993.
19. Jull G, Barrett C, et al:Further clinical clarification of the muscle dysfunction in cervical headache. Cephalalgia 19 : 179-185, 1999.
20. Jull G : Deep cervical flexor muscle dysfunction in whiplash. J Musculoskel Pain 8 : 143-154, 2000.
21. Cholewicki J, Panjabi MM, et al : Stabilizing function of trunk flexor-extensor muscles around a neutral spine posture. Spine 22 : 2207-2212, 1997.
22. Elliott J, Jull G, et al : Fatty infiltration in the cervical extensor muscles in persistent whiplash-assodated disorders: a magnetic resonance imaging analysis. Spine 31 : 847-855, 2006.
23. Sterling M, Jull G, et al : Development of motor dysfunction following whiplash injury. Pain 103 : 65-73, 2003.
24. Uhlig Y, Weber BR, et al : Fiber composition and fiber transformations in neck muscles of patients with dysfunction of the cervical spine. J Orthop Res 13 : 240-249, 1995.