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Effects of Neck Stabilization and Swiss Ball Exercises on the Recovery from Fatigue of Neck Muscles in Turtle Neck Posture: Preliminary Experimental Study

The purpose of this study was to examine the immediate effect of neck stabilization exercise and Swiss ball exercise on the recovery from the fatigue of neck muscles induced. The turtleneck posture was set artificially by using Smartphone with healthy adults. Repetitively measured ANOVA was executed to examine the changes in the muscle fatigue of sternocleidomastoid, upper trapezius, and splenius capitis among three-time intervals (at the time of general resting, work and after intervention) in the three intervention groups (neck stabilization exercise group, Swiss ball exercise group, and ordinary rest group). There were no significant differences in the changes of fatigue of sternocleidomastoid muscle among all three intervention groups at the time of general resting, work and after intervention (p>.05). Although there was no significant difference in the changes in the fatigue of upper trapezius and splenius capitis muscles between the intervention groups at the time of general resting and work (p>.05), there was the significant difference between the three intervention groups at the time of work and after intervention (p>.05). This study suggest that Swiss ball exercise is more effective in reducing the muscular fatigue of the neck and shoulder at a turtleneck posture than neck stabilization exercise.

Key words: *Muscle fatigue; Neck stabilization exercise; Swiss ball exercise; Turtle neck posture*

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INTRODUCTION

Increase in the aged population in the modern society is leading to increased manifestation of degenerative diseases of vertebrae with the trend of increase in the number of youth and office workers complaining of pains in neck and upper arm due to erroneous daily life habits in the younger generations. Although it is mostly office workers who conduct their works in front of computer and students who study in improper posture for prolonged period of time who correspond to this problem, majority of these cases develop into chronic pain or vertebral disorders because they do not undergo proper treatment in spite of the pain they experience. Pain syndrome in the neck is one of the pains with the highest prevalence rate. It can not only induce pain in neck, shoulder and upper arm, but also headache. It is known that approximately 71% of all adults experience neck pain during their life [1].

In the abnormal posture of tilting the turtle neck and looking into small liquid crystal display (LCD) for prolonged period of time as in the case of using mobile electronic devices, changes in the muscular contraction mechanism generates compression force on the facet joints and intervertebral disc of cervical vertebrae. Moreover, pain in head and neck is induced since muscular force to withstand the moment is generated in the opposite direction [2]. In particular, since cervical vertebrae, unlike thoracic or lumbar vertebrae, has lower weight load but greater mobility, it forms the foundation for movements, making it necessary to achieve stability of neck that supports head in order to protect the vertebral arteries and nerves [3]. Although pathological causes of neck pains are yet to be determined clearly, it is generally asserted that stiffness and pain in the neck muscles are induced as load is exerted continuously on the extensor muscles of the neck when moving the pupil or taking the posture of tilting the turtle neck to gaze on what is being worked on while reading and studying, or executing tasks such as information processing by using computer [4].

The weight of human head is in the range of approximately 3.5~4.5㎏ and head is supported through interactions among muscles in the neck and shoulder. Therefore, dysfunction of the neck is closely related to shoulder joints. Upper trapezius is an investing layer muscle in charge of supporting the head and is prone to occurrence of pain and blood circulation disorders due to stress [5]. In addition, longus colli and longus capitis that wraps around the cervical vertebrae are also known to play important role in adjustment of head and neck [6]. In particular, since longus colli and Longus capitis precisely controls the movements between vertebrae and forward bending of cervical vertebrae, they act as feedforward factor in the adjustment of posture and supports forward bending of the spine against the occurrence of buckling of spine due to contraction of powerful extensor muscles [7]. In terms of functional anatomy, although longus colli, which is a deep layer flexor muscle, is directly attached to the bones and joints of the cervical vertebrae, sternocleidomastoid, which is an investing layer muscle, is not attached to the cervical vertebrae [8]. Therefore, continuous activation of deep and investing layer muscles to maintain the head in a diverse range of anti-gravitational postures generates fatigue of muscles in the neck, which could act as the cause of manifestation of chronic pain.

Through examination of the pathophysiological causes of pain in the neck, it is possible to categorize the causes into specific causes including trauma, infection and degenerative changes, etc., and non-specific causes represented by erroneous habitual posture. Selective and continuous activities in Type I exercise unit by repetitively executing low intensity tasks in seated posture for prolonged period of time accumulate calcium in the exercise unit and generate homeostasis problems such as localized supply of blood and movement of metabolites within the muscle, thereby inducing muscle damages [9]. In addition, pain in the neck reduces movements, thereby inducing exercise dynamic restrictions between cervical vertebral diaphysis, which in turn induces characteristic clinical symptom of reducing the range of movement of neck joints [10]. That is, since the reduction of the range of movement of cervical joints degrades the movement of the articular surfaces, it induces dysfunctions such as buildup of muscular fibers, ankylosis and stiffness of muscles around the cervical vertebrae. As illustrated above, there are diversified causes and symptoms of chronic pain in the neck and opinions on the optimal treatment methods to solve these problems differ among scholars [11]. However, it can be deemed that therapeutic exercise is the most powerful fundamental means of solving the chronic pain in the neck as an intervention method [12].

Kim [5] asserted that functional harmony between the deep layer and investing layer muscles of cervical vertebrae is the essential element for natural movements of head and neck. It can be deemed that abnormal spinal curve and dysfunction of cervical vertebrae manifest due to erroneous posture due to weakening or imbalance of muscles around the neck and due to chronic lack of exercise rather than due to structural problem of the spine [13]. Therefore, necessary for neck stabilization exercise that induces positioning of the cervical vertebrae in neutral posture through strengthening of the deep layer muscles such as longus colli and longus capitis, which play the leading role in increasing the stability of cervical vertebrae is being emphasized.

Swiss ball exercise is a training method that can fortify the strength and balancing senses of muscles and joints joyously and safely by people of all ages and gender by assuming various postures including sitting and prone postures. Swiss ball exercise will not only increase the range of diversified joint movement and improve muscle strength or endurance as well as improve coordination movements, but also has the advantage of developing flexibility and stability of spine in particular since it is possible to use all parts of the body in comparison to other exercises [14]. Kim and Yang [15] asserted that Swiss ball exercise can assist with alleviation of pain in patients with chronic back pain by strengthening the central portion of the body by mobilizing the muscles that are not used frequently in maintaining balance through quick and reflexive actions of small muscle groups of the body in order to stabilize the instability induced in the process of performing the exercise. Moreover, they asserted that effective use of the exercise is possible through jumping, catapulting, siting and walking. In addition, Michael and Andre [16] stated that efforts to maintain balance on the basis of the instability of Swiss ball can comprehensively improve reflex nerves, cognition ability and sense of balance, etc., while Narshall and Murphy [17] asserted that Swiss ball exercise is useful in improving the stability of spine and fortifying the muscle strengths in neck and back areas.

Until now, pain therapy by using physical modalities such as heat, electric stimulation and phototherapy, traction, extension exercise for relaxing of tissues, exercise to strengthen the investing layer muscle of the neck and posture education for prevention of recurrence, etc. had been implemented as therapeutic and management methods for patients with chronic neck pain. Recently, although there had been a lot of studies on diversified intervention methods and effectiveness of neck stabilization exercise or Swiss ball exercise, there are not many studies on which exercise reduces the pain by reducing the generation of muscle fatigue in the neck area, and effective in improving the ability of the muscles to execute exercises including muscle strength and static muscle endurance. Therefore, this study, as preliminary experimental study, was executed to examine the immediate effect of neck stabilization exercise and Swiss ball exercise on the recovery from muscle fatigue of sternocleidomastoid, upper trapezius and splenius capitis induced while using Smartphone after having set the turtle neck posture artificially on normal adults as the subjects of experiment prior to the application of neck stabilization exercise and Swiss ball exercise for prolonged period of time on patients with postural problems in the neck such as abnormal spinal curve and dysfunction of cervical vertebrae as the subjects. In addition, it is aimed at providing basic clinical data in order for physiotherapist to decide on which physiotherapeutic intervention should be applied selectively in the future to restore the fatigue of neck muscles on patients with abnormal spinal curve and dysfunction of cervical vertebrae in the future.

SUBJECTS AND METHODS

Subjects

30 healthy adults without any particular illness were recruited as subjects of this study through simple and randomized sampling through preliminary medical examination by interview (past medical history, past family history and daily life habits, etc.). Prior to the commencement of the experiment, sufficient explanations on the purpose and method of study, and inconveniences that could occur during the experiment were provided to the subjects. Moreover, subjects signed letter of consent to participate in the experiment voluntarily.

Detailed selection criteria for the subjects included the following: first, those without structural abnormality or restrictions in the range of joint movements in neck, second, those without history of surgery due to traumatic damages in the neck in the last 6 months, third, those without pain in the neck or damages in the musculoskeletal system including sensory disorder, and, last, those without dermatologic side effects of attachment of electrodes for the surface electromyogram measurement.

18 males (60%) and 12 females (40%) participated in this study as subjects with average age of 26.34±2.97 years, average height of 172.21±6.38㎝ and average body weight of 63.77±7.24㎏.

Study design

This study was executed with three intervention groups, before-after measurement and quasi-experimental study design in order to examine the immediate effects of neck stabilization exercise and Swiss ball exercise on recovery from muscle fatigue of turtle neck posture with ordinary adults as subjects. In order to compare the immediate effects of the three intervention methods (neck stabilization exercise group, Swiss ball exercise group and ordinary rest group) on recovery from muscle fatigue induced by artificially set turtle neck posture, intervention method was selected through internet mock program and applied it in the sequence of the said method to subjects. However, only a single intervention method was selected and implemented over 3-day period in order to prevent recovery from muscle fatigue of particular exercise in accordance with the occurrence of muscle fatigue and order of application due to repetitive execution of intervention method by the subjects.

Intervention tools and Methods

Firstly, while the subjects were taking general resting for 10 minutes in supine posture on treatment table, for which height can be adjusted, in the most comfortable clothing, muscle fatigue in the neck area were measured and collected. Then, subjects were instructed to sit in front of a table by adjusting it so that the subjects needed to bend the hip and knee joints at right angle, and the soles of feet come in full contact with the supporting surface. While seated at the table, subjects were instructed to assume the turtle neck posture with extension of the upper portion of cervical vertebrae and bending of the lower portion of cervical vertebrae while positioning the lower arm to the center of femur. Then, subjects were instructed to look at and manipulate smartphone for 10 minutes in the said posture, while the muscle fatigue of neck area is measured and collected. Lastly, muscle fatigue of neck area was measured immediately after therapeutic intervention following the application of the three intervention methods in accordance with the internet mock program.

Neck stabilization exercise was executed by using stabilization device (Stabilizer; Chattanooga Group Inc, Hixon, TN), which is equipment for bio self-control device (pressure biofeedback device) using pressure generated with air. In addition, by making reference to the guidelines of the preceding study by Jull et al. [18] on craniocervical flexion exercise (CCFEx), movement of nodding the head as if saying 'Yes' in supine posture was emphasized. That is, neck stabilization exercise by using pressurized bio self-control device has the effect of calibration for generation of craniocervical flexion movement under the state of minimal activation of investing layer muscles of the neck.

Craniocervical flexion exercise (CCFEx) using stabilization device for subjects was carried out in the following order by making reference to the preceding study by O'Leary et al. [19, 20]. First, subjects were instructed to assume supine posture on treatment bed by fully extending legs and putting the back on the bed in most comfortable posture. Second, while in the supine posture, support the head with one hand and insert Stabilizer underneath the back of the head with the other hand. Third, while pulling back the chin to ensure that muscle activation of the investing muscles in the neck area does not occur, contact the craniocervical flexion muscle for 10 seconds in a diverse range of pressures (22~30mmHg, increasing to the maximum gradually) while monitoring the Stabilizer. However, subjects were trained to contract the craniocervical flexion muscles while consistently maintaining the scale in the gauge for pressure range in order for them to adapt to the use of the pressurized bio self-control device prior to the commencement of measurement in this experiment. In addition, they were trained to incrementally increase the pressure range by adjusting the Stabilizer on their own over 10-second period. Fourth, after having set 3 repetitions of maintaining craniocervical flexion exercise by using Stabilizer for 10 seconds and taking 10 seconds of general resting as 1 set, the subjects were instructed to execute 3 sets, with 1 minute of general resting taken between each set of exercise. Fifth, quickly remove the Stabilizer with one hand upon completion of the neck stabilization exercise and gradually lower to the floor by holding the back of the head with the other hand.

Swiss ball exercise was executed in the following order by correcting and supplementing the exercise manual for supporting the head and neck with the ball, written by Elaine Petrone [21] as the basic procedure, by me. First, subjects were instructed to assume supine posture on treatment bed by fully extending legs and putting the back on the bed in most comfortable posture. Second, while in the supine posture, support the head with one hand and insert small Swiss ball under near the back of the head with the other hand. Third, after having contacted the ball to the area below the back of the head, slowly turn the head and neck in the shape of the number '8'. Fourth, after having set 3 repetitions of rotating the head and neck for 10 seconds and then taking 10 seconds of general resting as 1 set of exercise, a total of 3 sets of exercise were executed with 1 minute of general resting taken between each set of exercise. Fifth, quickly remove the ball with one hand upon completion of the Swiss ball exercise and gradually lower to the floor by holding the back of the head with the other hand.

Measurement tools and Methods

Muscle fatigue in the neck area was measured by using surface wireless EMG system, Surface Electromyography system (TeleMyo 2400, Noraxon, USA). Firstly, foreign matter in the area of attachment of electrode (Ag/AgCl electrodes) of subject was removed and thoroughly cleaned with cotton ball soaked with alcohol before surface electrodes were attached. In this study, muscle fatigue of neck area was measured by selecting sternocleidomastoid, upper trapezius and splenius capitis, which are known to contribute towards maintenance of the posture of cervical vertebrae and to induce pain and fatigue due to the repetitive movement of the neck and shoulder [22]. Surface electrodes were attached symmetrically to the following location selected on both sides of the body by palpating the area of the aforementioned muscles of the subject along the running direction of the muscle fibers. For the sternocleidomastoid, electrode was attached to the center of muscle belly between mastoid process and 1/3 position between the manubrium of sternum and medial aspect of clavicle. For upper trapezius, electrode was attached to the center of muscle belly between the spinous process of the cervical vertebrate No. 7 and acromion. Lastly, for splenius capitis, electrode was attached to the position that is 2㎝ lateral to the cervical vertebrate No. 4. Surface wireless EMG measure was converted to digital signal and noise of electric signal was removed by setting the sampling rate at 1,000㎐ and by suing 60㎐ notch filter by means of MyoRearch XP 1.06, Master Edition in personal computer. In addition, for the changes in muscle fatigue, the wireless EMG signals were interpreted with power spectrum by using Fourier transformation (FT) and then compared as the mean value of the median frequency computed.

Data analysis

Data measured in this study was analyzed by using SPSS 23.0 program for Windows (IBM Corp, USA) and the level of significance for statistical verification (α) was set at .05. General characteristics of the subjects were computed in terms of frequency (%) and descriptive statistics. Repetitively measured ANOVA was executed to examine the changes in the muscle fatigue in accordance with the passage of time of the time of measurement (at the time of rest, work and after intervention) of the three intervention groups (neck stabilization exercise group, Swiss ball exercise group and ordinary rest group). In the event of occurrence of interaction effects among the three intervention groups, the differences in the quantities of changes in the muscle fatigue between the time of rest and work, and at the time of work and after intervention among the intervention groups were compared by means of one-way ANOVA while post-hoc verification was made by means of Boneferroni test..

RESULTS

Changes in the fatigue of sternocleidomastoid muscle

All three intervention groups displayed significant differences in the changes in fatigue of sternocleidomastoid muscle between the time of general resting, work and after intervention (Table 1, $p<.05$). Although there was significant difference in the changes of fatigue of sternocleidomastoid muscle in accordance with the time of measurement irrespective of the categorization of intervention groups, there was no significant difference in the interaction of fatigue of sternocleidomastoid muscle between the three intervention groups (Table 1, $p<.05$).
There was no significant differences in the changes of fatigue of sternocleidomastoid muscle among all three intervention groups at the time of general resting, work and after intervention (Table 2, $p<.05$).

Table 1. Comparison of sternocleidomastoid muscle fatigues within intervention period on each group and results of with-subjects effects for sternocleidomastoid muscle fatigues.

Group	Mean±SD			F	p
	Relax	Task	Post-intervention		
Stabilization	55.50±3.94	60.38±3.99	58.30±4.14	58.813	.000*
Swiss ball	56.93±2.98	61.94±3.97	59.65±3.29	65.668	.000*
General resting	53.74±3.87	58.15±4.46	57.85±7.13	7.633	.012*
	Type III SS	df	MS	F	p
Within-subjects effects					
SCM	425.067	1.588	267.737	53.511	.000*
SCM*Group	15.258	3.175	4.805	.960	.422
Error	262.135	33.000	7.943		

SCM : Sternocleidomastoid, unit : ㎷
* $p<.05$

Table 2. Comparison of average change in sternocleidomastoid muscle fatigues among relax vs task and post-intervention between groups.

Intervention period	Mean±SD			F	p
	Stabilization	Swiss ball	General resting		
Relax vs Task	4.88±1.66	5.00±1.88	4.41±2.07	.339	.715
Task vs Post-intervention	-2.08±1.09	-2.28±1.46	-.29±4.64	1.735	.192

unit : ㎷, * p<.05

Changes in the fatigue of upper trapezius muscle

All three intervention groups displayed significant differences in the changes in fatigue of upper trapezius muscle between the time of general resting, work and after intervention (Table 3, p<.05). There was significant difference in the changes of fatigue of upper trapezius muscle in accordance with the time of measurement irrespective of the categorization of intervention groups and there also was significant difference in the interaction of the fatigue of upper trapezius muscle between the three intervention groups (Table 3, p<.05).

Although there was no significant difference in the changes in the fatigue of upper trapezius muscle between the intervention groups at the time of general resting and work, there was significant difference between the three intervention groups at the time of work and after intervention (Table 4, p<.05). As the results of execution of post-hoc verification, there was significant difference between the Swiss ball exercise group and the ordinary general resting group (Table 4, p<.05).

Table 3. Comparison of upper trapezius muscle fatigues within intervention period on each group and results of with-subjects effects for upper trapezius muscle fatigues.

Group	Mean±SD			F	p
	Relax	Task	Post-intervention		
Stabilization	67.99±4.03	72.18±4.21	69.30±3.81	113.544	.000*
Swiss ball	69.65±4.58	73.92±4.36	69.24±5.34	10.909	.007*
General resting	68.17±4.48	73.92±4.00	71.80±4.03	32.258	.000*
	Type Ⅲ SS	Df	MS	F	p
Within-subjects effects					
UT	421.261	1.915	219.967	63.317	.000*
UT*Group	52.852	3.830	13.799	3.972	.007*
Error	219.555	63.199	3.474		

UT : Upper trapezius, unit : ㎷
* p<.05

Table 4. Comparison of average change in upper trapezius muscle fatigues among relax vs task and post-intervention between groups.

Intervention period	Mean±SD			F	p
	Stabilization	Swiss ball	General resting		
Relax vs Task	4.19±2.08	4.26±3.82	5.75±1.57	1.298	.287
Task vs Post-intervention	-2.88±1.06[a]	-4.68±3.29[b]	4.26±3.82[a]	5.015	.013*

unit : ㎷, * p<.05

Changes in fatigue of splenius capitis muscle

All three intervention groups displayed significant differences in the changes in fatigue of splenius capitis muscle between the time of general resting, work and after intervention (Table 5, $p<.05$). There was significant difference in the changes of fatigue of splenius capitis muscle in accordance with the time of measurement irrespective of the categorization of intervention groups and there also was significant difference in the interaction of the fatigue of splenius capitis muscle between the three intervention groups (Table 5, $p<.05$).

Although there was no significant difference in the changes in the fatigue of splenius capitis muscle between the intervention groups at the time of general resting and work, there was significant difference between the three intervention groups at the time of work and after intervention (Table 6, $p<.05$). As the results of execution of post-hoc verification, there was significant difference between the Swiss ball exercise group and the ordinary general resting group (Table 6, $p<.05$).

Table 5. Comparison of splenius capitis muscle fatigues within intervention period on each group and results of with-subjects effects for splenius capitis muscle fatigues.

Group	Mean±SD			F	p
	Relax	Task	Post-intervention		
Stabilization	86.27±5.52	90.52±4.50	86.95±5.08	62.028	.000*
Swiss ball	84.17±3.58	90.88±5.07	87.51±4.97	25.354	.000*
General resting	83.62±3.43	90.24±4.83	88.60±4.83	97.066	.000*
	Type Ⅲ SS	df	MS	F	p
Within-subjects effects					
SC	771.374	1.814	425.227	130.691	.000*
SC*Group	20.693	3.628	5.704	1.753	.163
Error	194.775	59.863	3.254		

SC : Splenius capitis, unit : ㎷
*p<.05

Table 6. Comparison of average change in splenius capitis muscle fatigues among relax vs task and post-intervention between groups.

Intervention period	Mean±SD			F	p
	Stabilization	Swiss ball	General resting		
Relax vs Task	6.25±1.69	6.72±3.99	6.62±2.66	.082	.921
Task vs Post-intervention	-3.57±1.20a	-3.57±3.13b	-1.64±1.05a	3.306	.049*

unit : ㎷, * p<.05

DISCUSSION

More people living in the modern information age are experiencing neck pain due to a long sedentary job [23]. In particular, when they perform a work of a static load, the center of mass (the head) leans on the front of the neck. To keep this posture, they need not only the active support by muscles but also the passive support by tendons, ligaments, and joints [24].

Swiss ball exercise is that a user puts the back of a head on it and relaxes the tensed muscles in the investing layer of the neck by moving the head and the neck in conformable motions [21]. In addition, the flexors in the deep layer play more important role in adjusting the posture of a neck and maintaining its stability. Therefore, we need to strengthen the flexors in the deep layer [25]. Neck stabilization exercise makes the flexors in the deep layer gain more static muscular endurance than a muscular strength in order to properly adjust the abnormal motions between the thoracic vertebrae and the body and thus stabilize them.

Swiss ball exercise is a new and fresh way to relax the muscles in the vertebral segments or the minor muscles that are not easily relaxed by stretching or bodily exercise. However, its clinical effects have not been verified. Although some studies have recently reported that neck stabilization exercise mitigates neck pain and improves strength and a static muscular endurance [18, 26, 27, 28] not many study have been made on the field.

In this respect, I conducted this study to examine the instant effect of neck stabilization exercise and Swiss ball exercise on the recovery of neck muscle fatigue caused by the work requiring repeated load such as using a smartphone at a static posture. However, I found some discrepancies between the findings of precedent studies and those of this experiment in terms of intervention method or the variables of measurement as well as subject's physical characteristics and functional state, which made it difficult to compare them precisely. Nonetheless, I tried to proceed the study by using the similarities in treatment methods and measured results.

Choi [29] maintained in his study with the adults having a turtle neck posture but not aware of it that when he conducted only posture correction exercise on the control group and both posture correction and muscle strength training program on the experimental group for 10 weeks, he found that the exercises improved the craniosacral angle and lowered cranial rotation angle of the experiment group, correcting their neck postures. In this study, I applied Swiss ball exercise to the upper trapezius and splenius capitis of the normal participants where spasticity or muscle tone occurs in their soft tissues while using a smartphone at a turtle neck posture at which the horizontal distance between the tragus of an ear and the posterior angle of acromion of a shoulder is more than 5㎝. The experimental group (treatment: Swiss ball) showed a remarkable recovery of muscular fatigue than the control group (treatment: neck stabilization), which was significantly different. This result can be explained as follows: longus colli muscles, which are connected to cervical spine, play a major role to maintain the stabilization of each segment of the cervical vertebrae [30]. When each segment loses its stability to some extent, the flexors in the shallow layer work more than those in the deep layer during antigravity motions, which triggers muscular fatigue [31]. Therefore, stretching with Swiss ball is more helpful in restoring the length of a muscular segment insider the muscular fiber than neck stabilization exercise, reducing abnormal tonus of muscle [32], relaxing the knotted muscles, and mitigating neck pain.

Kong et al. [27] categorized 60 participants into three groups and randomly assigned 20 to each: (i) neck bone stabilization group, (ii) neck joint mobilization group, and (iii) control group. There were treated for 3 weeks (3 times in total). As a result, the neck bone stabilization group and the neck joint mobilization group showed a significant change in the static strength and muscular endurance before and after the intervention. Especially, the neck bone stabilization group showed a remarkable improvement in static muscle (holding) time from 55.90 ± 1.51 (before) to 125.65 ± 43.92 (after), and muscular endurance from 90.10 ± 2.71 (before) to 181.80 ± 66.21 (after). In addition, Han et al. [3] reported that when they applied neck stabilization exercise with sling exercise and mat exercise in which patients can get actively involved, the sling exercised and the mat exercise increased physical strength by 13% and 20% and endurance by 10% and 7%, respectively. There said that when a neck has a functional disorder, it means the muscles are not in balance with one another. Particularly, because the strength of the flexor muscles in a neck is weak [33], a patient with a problem with a neck has more severe fatigue around the flexor muscles in a neck [6]. In this study, also, I found that when I applied neck stabilization exercise to the upper trapezius and splenius capitis where spasticity or muscle tone occurs in their soft tissues while using a smartphone at a turtle neck posture, the experimental group showed a significant difference in the recovery of muscular fatigue than the control group, Therefore, I consider that this exercise can better prevent the adaptive change of muscles and soft tissues afflicted by a poor posture than a general relaxation.

Hu [26] used Mckenzie method on the patients with chronic neck pain. In the experiment, he divided the participants into two groups (each of 19): one was treated with posture correction exercise while the order was treated with the stabilization exercise to improve the muscular strength of the flexors in the deep layer study for 12 weeks (3 times a week and one hour per each time). The effects before and after the treatment were compared. When measuring the holding time at maximum and minimum muscular contractility, the posture correction group didn't show a significant change before and after while the stability exercise group showed significantly increased holding time after the 6th week and the 12th week. In this study, however, both general relaxation group and the neck stabilization exercise group showed the muscular fatigue of upper trapezius and splenius capitis restored to the physiological at general resting after the intervention. However, the recovery of the neck stabilization exercise group was not significant while the change of the general relaxation group (10-minute rest) was. This difference may stem from the different experimental conditions that the participants of the previous studies voluntarily executed a posture correction exercise and neck stabilization for 12 weeks and were compared. Meanwhile, the participants in this study intentionally posed a turtle neck posture and applied Swiss ball and neck stabilization exercise for a short time before checking their muscular fatigue.

In this study, I asked a normal adults to pose a turtle neck posture sitting on a chair and watch a smartphone. And I applied neck stabilization exercise and Swiss ball exercise to them in order to know which one had the most instant and effective intervention effect on the recovery of muscular fatigue of sternocleidomastoid muscle, upper trapezius, and splenius capitis, which was triggered by the abnormal posture. The results showed that neck stabilization exercise and Swiss ball exercise showed a significant change in the muscular fatigue of upper trapezius, and splenius capitis than a general relaxation (10-minute rest). In particular, the posture where a head leans downward reduced the muscular tension on the neck and shoulders at a turtle neck posture by straightening the turtleneck. Here, Swiss ball exercise turned out more instant and better effect than neck stabilization exercise because the former strengthens the flexors in the shallow layer while the latter strengthens the flexors in the deep layer. However, this study has generalization problem because, for this study, I used normal healthy adults rather than the patients with chronic pain in neck and shoulder. And I asked them to take a turtle neck posture, on purpose, for a short time during which they bent down their heads excessively and stretch them upward excessively, too. I could not last the intervention for a long time. Therefore, I consider it necessary for the following studies to use a wider range of the patients with various functional disorder around the neck and musculoskeletal system and apply such intervention as neck stabilization exercise and Swiss ball. In addition, a randomly assigned clinical study is needed to know their long-term effect.

CONCLUSION

With the normal adults, this study was conducted to know the instant effect of neck stabilization exercise and Swiss ball exercise on the recovery of muscular fatigue of sternocleidomastoid muscle, upper trapezius, and splenius capitis, which occurs due to watching a smartphone at an intended turtle neck posture. The finding of this study showed that Swiss ball exercise is more effective in reducing the muscular fatigue of the neck and shoulder at a turtle neck posture than neck stabilization exercise. However, this study has generalization problem because I used normal healthy adults rather than the patients with spinal curvature and functional disorder. And they were asked to make a turtle neck posture on purpose. Then, this study failed to generalize the finding and find the long-term effect of this experiment. Therefore, the following study or studies need to verify the effects of various physical therapeutic interventions on the patients suffering actual problems with curved neck and functional disorder.

REFERENCES

1. Walker-Bone K, Reading I, Coggon D, et al., The anatomical pattern and determinants of pain in the neck and upper limbs: an epidemiologic study. Pain, 2004; 109(1-2), 45-51.
2. Gooch L. A Controlled study of sustained cervical spine flexion. Western australia: Master Thesis. Curtin University of Technology, 1993.
3. Han SW, Kim JY, Kang MS, et al., The effect of sling and mat exercise during 6 weeks on cervical coordination, muscle strength, and muscle endurance. Journal of KSSPT, 2007; 3(1), 37-46.
4. Yoo CU. Eletromyographic activity of the neck and shoulder muscles while watching a DMB phone with the neck flexed. Master's Degree of Yonsei University, 2008.
5. Kim SY. The association between a cervical dysfunction and muscle activity change. J Kor Acad Phy Ther, 2005; 12(1), 67-6.
6. Falla D, Jull G, Dall' Alba P, et al., An electromyographic analysis of the deep cervical flexor

muscles in performance of craniocervical flexion. Phys Ther, 2003; 83(10), 899–906.
7. Falla D, Bilenkij G, Jull G. Patients with chronic neck pain demonstrate altered patterns of muscle activation during performance of a functional upper limb task. Spine, 2004; 29(13), 1436–40.
8. Kamibayashi LK, Richmond FJ. Morphometry of human neck muscles. Spine(Phila Pa 1976), 1998; 23(12), 1314–23.
9. Visser B, van Dieën JH. Pathophysiology of upper extremity muscle disorders. J Electromyogr Kinesiol, 2006; 16(1), 1–16.
10. Hanten WP, Lucio RM, Russell JL, et al., Assessment of total head excursion and resting head posture. Arch Phys Med Rehabil, 1991; 72(11), 877–80.
11. Hudson JS, Ryan CG. Multimoal group rehabilitation compared to usual for patients with chronic neck pain : A pilot study. Man Ther, 2010; 15(6), 552–6.
12. Bekkering GE, Engers AJ, Wensing M, et al., Developement of an implementation strtegy for physiotherapy guidelines on low back pain. Aust J Pjysiother, 2003; 49(3), 208–14.
13. Sung DJ. Exercise prescription, 2005.
14. Moon SY, Choi TH, Kim KJ. Effects of core stabilization exercise and resistance training on pain relief and the change of center of gravity in chronic low back pain patients. Kor J Sport Med, 2008; 1226–39.
15. Kim MS, Yang JH. The effects of scoliosis correction and swiss ball exercises on scoliosis in high school male students. Kor J Phys Educ, 2003; 579–86.
16. Michael J, Andre NP. The Great Body Ball. Handbook, 2000.
17. Narshall PW, Murphy BA. Core stability exercise on and of a swiss ball. Archives of physical Medicine and Rehabilitation, 2005; 86(2), 242–9.
18. Jull G, Falla D, Treleavan J, et al., A therapeutic exercise approach for cervical disorders. In: Boyling JD, Jull G, eds. Grieve's Modern Manual Therapy. The Vertebral Column. Edinburgh, UK: Churchill Livingstone, 2004; 451–69.
19. O'Leary S, Jull G, Kim M, et al., Specificity in retraining craniocervical flexor muscle performance. J Orthop Sports Phys Ther, 2007; 37(1), 3–9.
20. O'Leary S, Falla D, Elliott JM, et al., Muscle dysfunction in cervical spine pain: implications for assessment and management. J Orthop Sports Phys Ther, 2009; 39(5), 324–333.
21. Elaine Petrone. The miracle ball method. 2th ed. Workman Publishing Company; Book and Access edition, 2003.
22. Vasavada AN, Peterson BW, Delp SL. Three-dimensional spatial tuning of neck muscle activation in humans. Exp Brain Res, 2002; 147(4), 437–48.
23. Kim SH, Kim MJ. The effect of cervical traction on pain & symptom for patients with cervical pain. J Kor Acad Orthop Manual Ther, 2001; 7(1), 67–75.
24. Finsen L. Biomechanical aspects of occupational neck postures during dental work. Int J of Industrial Ergonomics, 1999; 23(5–6), 397–406.
25. Boyd-Clark LC, Briggs CA, Galea MP. Muscle spindle distribution, morphology, and density in longus colli and multifidus muscles of the cervical spine. Spine, 2002; 27(7), 694–701.
26. Hur JG. Effects of neck stabilization exercise to the patients with chronic neck pain. Kor Sports Research, 2006; 17(1), 121–34.
27. Gong WT, Cheun HJ, Lee KM. The effect of cervical stabilized exercise and joint mobilization on maxium muscle strength and static muscle endurance of cervical region. J Kor Data Inform Sci Soci, 2010; 21(1), 33–42.
28. Ylinen J, Takala EP, Nykanen M, et al., Active neck muscle training in the treatment of chronic neck pain in women: a randomized controlled trial. JAMA, 2003; 289(19), 2509–16.
29. Choi YJ. Effectiveness of an cervical and thoracic stretching and strengthening exercise to improve forward head posture. Master's Degree of Korea University, 2007.
30. Crisco JJ, Panjabi MM, Dvorak J. A model of the alar ligaments of the upper cervical spine in axial rotation. 1991; 24(7), 607–14.
31. Winters JM, Peles JD. Neck muscle activity and 3D head kinematics during quasistatic and dynamic tracking movements. In: Winters, JM, Woo SLY, des. Multiple muscle systems: Biomechanics and movement organization. New York, NY: Springer-Verlag, 1990; 461–80.
32. Simons DG, Travell JG, Simons LS. Travell & Simons' Myofascial pain and dysfunction: The trigger point manual. 2nd eds. Baltimore: Williams & Wilkins, 1999; 5–193.
33. Vernon HT, Aker P, Aramenko M. Evaluation of neck muscle strength with a modified sphygmomanometer dynamometer: Reliability and validity. J Manipulative Physiol Ther, 1992;15(6), 343–9.