

EFFECT OF TELEREHAB SYSTEM FOR POSTURAL CORRECTION

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ABSTRACT—As abnormal posture caused by prolonged smartphone use increases, its related disease also increases. It is time to prevent this problem. This study aim to figure out how much telerehab system has an effect on postural correction. Healthy 34 participants were instructed to keep neutral posture and then use smartphone. Each participant was instructed to maintain a neutral posture with their elbows positioned in line with the trunk and flexed 90–120° and keep the trunk upright, chin tucked, scapula slightly protracted and depressed and sole of the foot on the floor 1) for 15 minutes in non-feedback condition, after 3 minutes resting period, 2) for 15 minutes in visual feedback condition while maintaining their original posture. When participants consciously apply feedback for postural correction, participants can check the movement of scapula and forward head level as they apply posterior visual feedback. The result of this study had a significant difference in the meaning of interval at Tragus and all Z-coordinate. ($p<0.05$) Also, there was significant difference in the meaning of cervicoscapular posture angle. ($p<0.05$) Both results indicated that the participants maintained the original posture well. In this study, it proved that visual feedback for postural correction has a positive effect. Further study needs to demonstrate this measurement to real clinical patients..

keywords—Telerehab, Visual feedback, Forward head posture, Abnormal posture, Postural correction.

I. INTRODUCTION

Clinical theory contends that aberrant scapular posture and any associated changes in axioscapular muscle activity may contribute to, or exacerbate painful neck disorders by adversely affecting mechanical stresses on pain sensitive cervicobrachial structures[1]. One study have shown the trend of symptomatic office workers having greater head tilt, neck flexion and greater acromion protraction[2]. Problems of cervicoscapular region caused by computer using posture is less frequent than smartphone using posture. Since 2013, smartphone users have skyrocketed in many countries[3]. Compared with compute, smartphone has much narrow screen and lower eye level. So it brings about larger range of cervical protraction, flexion, and shoulder protraction. Using smartphone is associated with higher activity in neck extensor, but lower activity in upper and lower trapezius[38]. Hence it leads to forward head posture and round shoulder with trunk flexion[4].

The forward head posture places greater stress on the levator scapula and semispinalis capitis muscles. The rectus capitis posterior major-one of the suboccipital muscle- actively extends the upper craniocervical region. The highly active and stressed muscles are sternocleidomastoid and scalenus anterior[5]. As smartphone use causes

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exceeded neck flexion, scapula retraction and elevation, post neck muscle can elongate and cause pain at trapezius muscle. And scapula movement caused by smartphone use can result in 'round shoulder'. As a result, to correct posture you should protract and depress scapula. Postural correction is an effective technique used by rehabilitation professionals to treat chronic neck and shoulder pain, and it aims to reduce mechanical loads on cervicoscapular muscles by adopting a neutral posture.

Visual feedback(VF) may enhance motor performance by effectively tuning the control-structure[6]. Ng et al.(2008) reported that the present result reveals the incorporation of an electromyography(EMG) feedback into a exercise program could promote the activation of vastus medialis oblique muscle so that the muscle could be recruited during daily activities[7]. Van et al.(2016) reported that real-time ultrasound imaging VF can improve ability to activate the multifidus muscle of healthy subjects[8]. Pinsault et al.(2008) reported the effects of scale display for VF on postural control during noiseless standing in healthy elderly subjects[9]. VF has been found to have effect on the control of posture and muscle activation[10]. A method of posture correction using VF aims to change posture through looking at the screen which directly shows the posture. Through the VF, subject can check and change personal posture immediately.

In previous study, feedback interface used what turns red when the threshold value of muscle activation exceeds. Another feedback interface was the method that controls own muscle thickness by using real-time ultrasound imaging[11]. Using EMG signal and ultrasound imaging wasn't economical and was hard for the participants or the patients. However, VF interface used in this study was relatively economical and easier to set and understand. Previous study was about computer use at work station. But we conducted postural correction research on widespread and prolonged smartphone use. This study is closely related to human's daily life.

Compared to muscle, VF research of change and analysis on cervicoscapular region is lacking. In this study, we use intervention that has a good accessibility and reinforces the weaknesses of the previous study. And we observed the movement of cervicoscapular region.

Aim of our study is to figure out 1) whether the presence of posterior VF affects the movement of cervical and scapula region and 2) how much posture change occurs between VF and non feedback(NF) condition.

Over this study, we will present an efficient method for posture correction. We anticipate that our VF interface will reduce neck pain by ideal posture and further prevent forward head posture and round shoulder.

II. METHOD

A. Participant

Using sample size calculation program (G*Power, 3.1.9.2), we inputted the value of mean and standard deviation(SD) obtained in this study.

Thirty four healthy participants with no prior history of neck and shoulder pain participated in this investigation. The study was conducted in accordance with the procedure approved by Sunmoon University Institutional Review Board, and written informed consent was required from all participants prior to the experiment. There is an exclusion criteria below.

- 1) Patient history of pain on the neck and shoulder region

- 2) Surgery on neck and shoulder region
- 3) Visiting hospital because of pain on the neck and shoulder region
- 4) Inflammatory, degenerative osteoarthritis, connective tissue diseases

B. Experimental Protocol

Each participant was instructed how to sit with a neutral posture without arm rests and otherwise adjusted according to ergonomic recommendations with the elbows positioned in line with the trunk and flexed 90–120°. Each participant was instructed to maintain a ‘neutral’ posture with the trunk upright, chin tucked, scapula slightly protracted and depressed and sole of the foot on the floor. The researcher requested the participants to hold the smartphone with both hands[34]. After coaching, each participant performed 15 minutes of watching a video task under two different conditions:

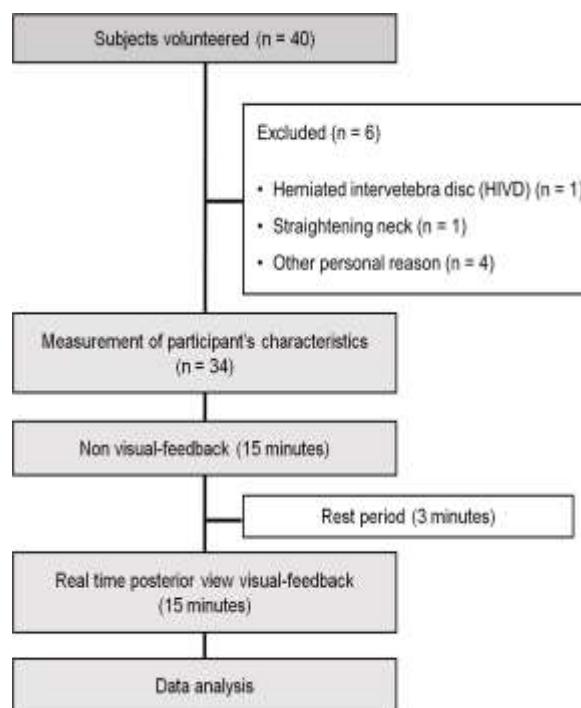


Figure 1: Experiment protocol flow chart

1. NF to adopt a neutral posture prior to watching a video task, with no subsequent verbal que(No Biofeedback Condition).
2. Real-time posterior VF from the computer screen to maintain a neutral posture throughout the task(Biofeedback Condition).

Each participant was instructed to watch a video using smartphone(at least 15 minutes)and to consciously correct the posture while watching the computer screen in VF condition. Each participant rested for one to 3 minutes between feedback conditions. [Figure 1]

A custom VF interface which displayed real-time posterior view included head, both shoulder and scapula(head to T12 level). There are two laptop computers that are located in front of the participant and behind

of the participant[Figure 2-b]. Distance between the participant and laptop computer was set differently for each participant. Screen shot in front of the participant showed posterior view which was recorded at the behind of the participant. When we measured, the chair had no back and it had no marker indicating location on the floor.

Spherical passive markers for three-dimensional motion analysis was placed on the Tragus of the ear, seventh cervical vertebrae(C7) and the Acromion process. Marker placement was standardized over all participants according to the previous work[12].

C. Instrumentation

Before the experiment begin, participants measured their height, weight and body mass index(BMI) using automatic BMI measuring stadiometer(BSM 370, Korea, 2011).

Spherical passive marker was placed on the Acromion process, C7 and the Tragus of the ear. These three locations indicated coordinate and we calculated the means of interval, cervicoscapular posture angle in both feedback condition. Motion capture signals were recorded with a sampling frequency of 60Hz using software ‘QTM(Qualisys Track Manager) ver 2.5. Each condition was set to 15m(900s). Motion capture camera (Oqus 101, Qualisys, sweden) detected location from the attached marker.

VF interface we used was a mobile messenger program LINE(LINE Cop. Japan). By using a video call function, the laptop located behind the participant shoot participant’s posterior view and that screen shot was showed at the laptop located in front of the participant[Figure 2]. Both laptop used in VF had 15.6 inch screen.

D. Data processing

Cervical and scapular postures were quantified during each feedback condition: cervicoscapular movement angle. The cranial-vertebral angle (θ CV) was defined as the angle formed between C7 and the Tragus with respect to the frontal plane expressed in a torso-fixed reference frame. Scapular posture was quantified by the angle formed by C7 and the Acromion process in the frontal and transverse planes as defined in a torso reference frame : scapular protraction/retraction was defined as the angle between C7 and the Acromion



Figure 2 : Experiment setting ; (a) Non feedback (b) Visual feedback (c) Panorama
Cervical posture(θ_{CV}), scapular elevation/depression (θ_{EL}) and scapular protraction/retraction (θ_{AB})
defined by planar angles in the sagittal, transverse, and frontal planes posture angles expressed in a torso-fixed
reference frame with origin at C7 in the transverse plane (θ_{AB}), and scapular elevation/depression was defined as
the angle between C7 and the Acromion in the frontal plane (θ_{EL}).

By using the scalar product formula, we can find out the value of θ [Figure 3].

$$|\mathbf{a} \cdot \mathbf{b}| = \|\mathbf{a}\| \times \|\mathbf{b}\| \times \cos\theta$$
$$\cos\theta = \frac{|\mathbf{a} \cdot \mathbf{b}|}{\|\mathbf{a}\| \times \|\mathbf{b}\|}$$

Figure 3: The scalar product formula

As cervical flexion and extension were movement of sagittal plane, X-coordinate excluded and coordinate was expressed (y,z). We set the standard vector a to (0,1) and another vector b to differentiate the Tragus and C7 coordinate.

As scapula retraction and protraction were movements at transverse plane, Z-coordinate excluded and coordinate was expressed (x,y). We set the standard vector a to (1,0) and another vector b set difference between Acromion and C7 coordinate.

As scapula elevation and depression were movement at frontal plane, Y-coordinate excluded and coordinate was expressed (x,z). We set the standard vector a to (1,0) and another vector b set difference between Acromion and C7 coordinate.

The change in the value of a quantity was divided by the elapsed time. For a function, this was the change in the y-value divided by the change in the x-value for two distinct points on the graph. In this study, y-value was set angle for cervicoscapular posture.

The means of interval was what averages the difference between the starting coordinate and each coordinate at the measure-point.

E. Statistical analysis

To determine whether the posture had changed as a function of time during each 15 minutes of watching a video task, the mean slope for angle was tested against zero with two-tailed one sample t-tests. Differences in each dependent variables between the two feedback conditions were examined using paired t-tests. All statistical calculations were performed with R : a programming environment for data analysis and graphics(Ver3.3.1, The R foundation, Vienna, Austria). Level of significance was set at 0.05 for all statistical tests.

III. RESULT

result analysis in this study used three dimensional coordinate value(x,y,z). Each location (Tragus, C7, Acromion) had total, X, Y, Z-coordinate. In this study, we calculated the means of interval, angle in cervical posture (θ CV), scapular retraction/protraction (θ AB) and scapular elevation/depression (θ EL).

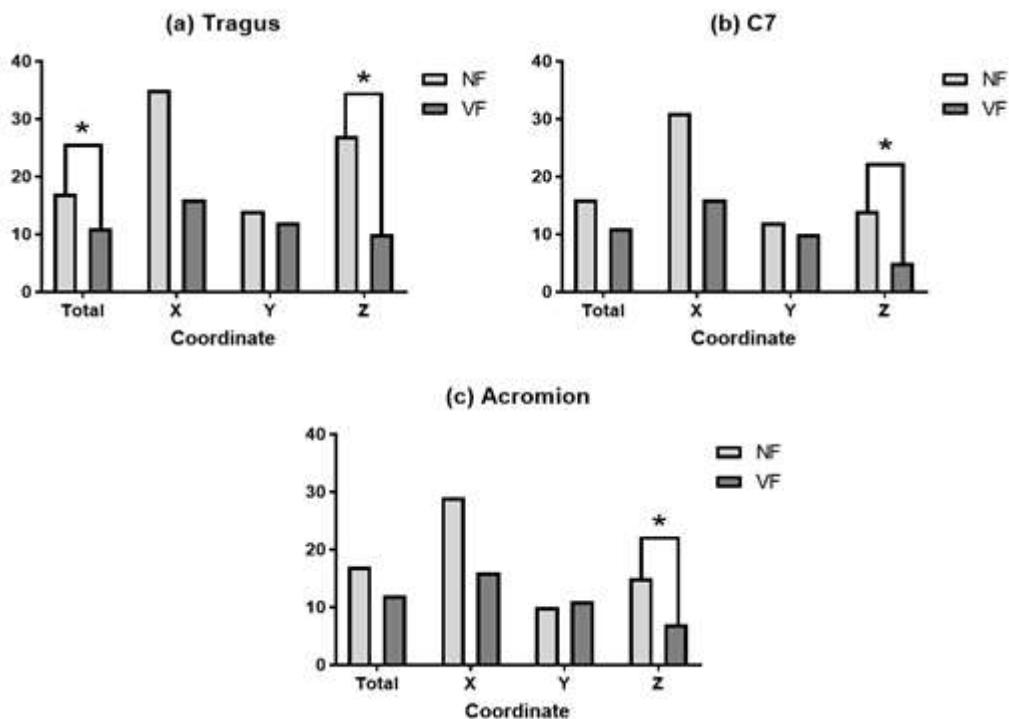


Figure 4: The mean of interval between starting point and each measure point in (a) Tragus. (b) Seventh cervical vertebrae(C7). (c) Acromion.

3.1 The mean of interval

At total coordinate of Tragus, VF was 6.01 ± 4.26 smaller than NF. There was a significant difference in both feedback condition. Also, there is a significant difference in Z-coordinate of each location[Figure 4].

3.2 Cervicoscapular posture

There were participant's cervicoscapular angle and its variation[Figure 5]. θ CV was $5.66 \pm 5.33^\circ$ smaller in VF condition($p < 0.05$). There was no significant variable of mean ratio of change. However, the mean ratio change of θ CV was positive in both conditions. It meant the increase of θ CV. Therefore, it indicates that participants gradually flexed their neck during watching video using smartphone. The mean ratio of change of θ AB and θ EL was negative in both condition. It meant decrease of θ AB and θ EL. It indicated that participants gradually retracted and elevated their scapula.

IV. DISCUSSION

Opposed to smartphone use, there are numbers of study about VF for posture correction during computer use. In many previous studies, it has been reported that smartphone use cause abnormal posture. According to the article in Canadian Journal of Ophthalmology, prolonged smartphone use can change the angle of tilted head and then it causes abnormal cervicoscapular posture[13]. Kim and Koo(2016) investigated that muscle fatigue has increased if you used smartphone 20 minutes more[14]. And from 10 minutes use, there was a significant difference in visual analog scale(VAS). As smartphone penetration rate has been increased, study for disease and abnormal posture caused by prolonged smartphone use is needed. present study had sufficient meaning to solve posture problem caused by smartphone use, and this study also obtained results enough to support it.

Current study was conducted to prove whether real-time posterior VF affect postural correction and got result supporting this. In total coordinate of Tragus and all Z-coordinate at measured location, value in NF condition decreased after VF was applied. In angle of cervicoscapular movement, θ_{CV} in NF condition decreased after VF was applied, θ_{AB} in NF condition decreased after VF was applied and θ_{EL} in NF condition increased after VF was applied.

Main problem of prolonged smartphone use is forward head posture. In the current study, element indicated forward head level is the value of Y, Z-coordinate. Means of interval on Y-coordinate at Tragus and C7 had no significant difference. After VF was applied, however, means of interval decreased. According to the result we mentioned, we can see VF interface used in present study has an impact on forward head posture correction. Although VF interface shows only the participant's posterior view, they can guess how much posture have changed. So participants corrected their neck posture together while they corrected scapula posture.

Sigurdsson and Austin(2008) investigated that when VF is applied, it is possible to enhance the working efficiency to create a stable posture[15]. Sayenko et al.(2012) reported that there was an effect on matching posture symmetry with VF[16]. Park and Yoo(2012) revealed that the VF reduces forward head posture and flexed-relaxed posture when using computer with VF utilizing EMG[17]. These studies and the present study have something in common.

From many previous studies, researchers used various types of feedback for postural correction. For example, one study used vibrotactile feedback for wearable posture corrective system[18]. Another study used feedback equipment with vibrating and alarming for sitting postural correction[19]. The other study used anterior VF interface for motor learning. These 3 studies said that feedback is highly effective in postural correction. This study's real-time posterior VF is also effective for postural correction. Therefore, it can be analogized that feedback has

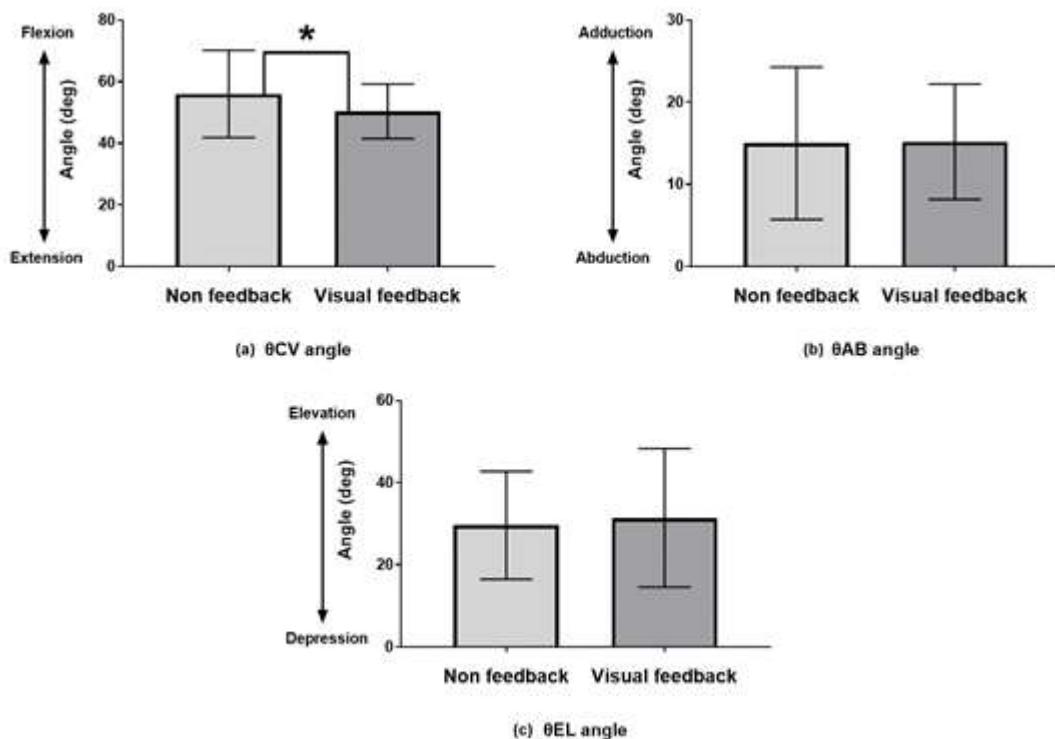


Figure 5 : Angle in (a) Cervical posture (θ_{CV}). (b) Scapular retraction/protraction (θ_{AB}). (c) Scapular elevation/depression (θ_{EL}).

influenced whether it chooses any sensory or the way for postural correction. It may be that participants can control ideal standard line more accurately when they use feedback interface versus controlling their posture by themselves.

Contrary to these studies, Franklin et al.(2007) reported that the vision is only used to minute movement, and VF didn't contribute to stability or instability during exercise[20]. However, this study reveals the importance of VF and focuses on effect of correction in stable posture, not dynamic.

Among the study on real-time VF, Sigurdsson and Austin's study(2008) had so small sample size that it can't be generalized. On the other hand, current study got the sample size using sample size calculation program(G*power 3.1.9.2). This sample size is evidence based result, and the result of this study can be generalize.

VF is used as treatment of pusher syndrome or balance training. Sayenko et al.(2012) revealed that if the balance maintenance training with caos applies VF, it has an impact on maintaining balance]. Yang et al. reported that VF using computer had an effect on pusher syndrome treatment[21]. Walker et al.(2016) investigated that VF helped chronic stroke patient's gait training to stay stable[22]. Ghilardi et al.(2000) proved that there was a clinical effect on postural control to parkinson's disease and alzheimer's disease[23]. Currently, VF has been

used in many clinical condition and has proved its effect. Later, VF used in current study needs the verification on the effect on postural correction for patient.

Mirror therapy using VF is intervention that can improve lack of postural control, thereby leading movement that use body images reflexed to mirror[24]. In the learning process, self control feedback finding imformation for oneself is more effect on motor learning than passive participation to receive feedback from other people or device. Becaues it deeply deals with information related task[25]. Current study is simillar with aforementioned study, as it improves lack of postural control for oneself.

The scapula functions as a bridge between the shoulder complex and the cervical spine. Also, scapula plays a role in providing both stability and mobility of the cervicoscapular region[26]. In this study, the reason why we chose VF for posterior view is the importance of scapula at upper extremity. As we suspected, current study has a significant difference in postural correction by adopting posterior view. It is because that participants control their scapula using real-time posterior VF interface. According to the relationship between thorax and scapula, when thorax flexed scapula protract and when thorax extended, scapula protracted. As described above, arrange of spine is affected by location of scapula. Location of scapula affects shoulder girdle function, so inappropriate location control leads to cervicoscapula region disorder[27].

VF in current study can be utilized for treatment program of movement abnormality in cervicoscapular region like scapular dyskinesis. Furthermore, it can also be easily used without a specialist for installation and explanation for use. In this study, it was planned as an experiment for smartphone use, but it can apply to other situations like workstation, daily life, reading documents, and even making something.

Two limitations should be considered in current study. First, researcher instructed the participants to keep holding the original posture by verbal que. Unfortunately, this instruction became a limitation of present study. Before the measurement, researcher recommended not to be conscious but to use smartphone as usual, but some participant endured pain while maintaining their posture. It is predicted that there is a dramatic change in the angle and the location, but actually did show a significant difference on θ CV and Tragus and all Z-coordinate. In our opinion, trunk muscle is easier to maintain posture, but neck muscle is harder to maintain posture because when the measurement started, neck flexed already. So participant flexed their neck more gradually. As a result, there are significant difference on the means of interval and cervicoscapular movement angle. Second, the ratio of men to women was organized one to one, but physique of participants wasn't constant. So these factors act as a variable in the current study. For distribution of various physique, the larger physique of participants is, the higher coordinate moving distance is. Angle of cervicoscapular movement looks different because of the participants varies neutral angle. Further study needs to proceed experiment that recruits participants in various age, similar physique or same gender group

V. CONCLUSION

To prevent forward neck posture and round shoulder caused by prolonged smartphone use, current study conducted real-time posterior VF. This study figures out the change of cervicoscapular region movement using the value of mean ratio of angle change. When all the results were combined, it is proved that there is an effect on VF

for postural correction. Further study needs to demonstrate this measurement to real clinical patients and recruit participants in various age, simillar physique or same gender group.

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