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A study on the correlation of VDT, posture and shoulder function in women with neck pain

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Abstract

Background: This study was conducted to examine the correlation of VDT, posture and shoulder function among each group divided by according to the neck pain disorder index (NDI) scores for female patients with neck pain.

Design: Cross-sectional study.

Methods: Fifty adult women with neck pain voluntarily participated in this study and the neck pain disorder index questionnaire, VDT syndrome assessment tool questionnaire, craniovertebral angle, thoracic kyphosis angle, round shoulder posture, pectoralis minor length, shoulder joint hypermobility, and serratus anterior strength tests were conducted respectively. Subjects were divided into two groups where 21 subjects were allocated to the mild pain group whom have rated below 14 points on the NDI scores, and 29 subjects were in the severe pain group, whom have rated above 15 on the NDI score.

Results: The study found that in the mean difference between variables in each group, VDT syndrome showed a higher mean score in the severe pain group than the mild pain group (p<0.05). In the group correlation and regression analysis, the mild pain group showed a significant negative correlation between the craniovertebral angle and round shoulder posture (r=-0.467, p<0.05), and the round shoulder posture for craniovertebral angle was shown to have significant positive influence (B=10.162, p<0.05). The severe pain group showed that the NDI and the VDT syndrome had a significant amount of correlation (r=0.520, p<0.01), the VDT syndrome showed significant positive influence (B=0.330, p<0.05), and the craniovertebral angle showed significant negative influence (B=-0.809, p<0.05). It was also shown that shoulder joint hypermobility had a significant negative correlation with the serratus anterior strength (r=-0.437, p<0.01), and that serratus anterior strength had a significant negative influence on shoulder joint hypermobility (B=-4.175, p<0.05).

Conclusion: This study is of clinical significance in that it presented variables that should be considered depending on the degree of neck pain in treating patients with neck pain and that it presented patients with not only posture but also the function of the shoulder joint as factors to consider.

Key words: Neck pain, Female, Posture, Shoulder joint.

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Ⅰ. Introduction

Pain refers to unpleasant sensory and emotional experiences associated with actual or potential damage, and chronic widespread pain due to musculoskeletal disorders is a major social challenge (Cimmino et al., 2011; Yang et al., 2004). Particularly, neck pain is a prevalent musculoskeletal pain experienced by 86.8% of adults and 30%-50% of one year (Genebra et al., 2017; Hoy et al., 2014). It is a major cause of diseases and disabilities in daily life and work, and affects the physical, social, and psychological well-being of individuals, leading to an increase in social and corporate costs (Genebra et al., 2017; Ann and Bang, 2019). Generally, women experience neck pain more than men because they have weaker endurance, muscle strength, general physical condition, and different acute pain pathways than men (Koltyn et al., 2001; Cote, 2012). Moreover, women experience neck pain more than men because they have a low mechanical input pressure pain threshold (Bartley et al., 2016; Fillingim et al., 2009; Racine et al., 2012).

As of 2020, 20.2% of women in Korea are office workers, and a high percentage of women are expected to work using visual displays for long periods (Statistics Office, 2020; Kim et al., 2018). Using visual displays for a long time induces a prolonged abnormal posture and has a great effect on the vulnerability of the neck to injuries or stress that cause structural changes due to high motility and low stability (Chiu et al., 2002; Ann et al., 2015). When looking down at visual displays, the bend at the level below the cervical vertebrae increases so that the neck extensors support the weight of the head (Straker and Mekhora, 2000), and when looking up at visual displays, the extension of the upper level of the cervical spine increases. The deep inferior occipital muscles can withstand increased loads (Burgess-Limerick, 2000). The posture in which the head is bent slightly forwards is called the anterior frontal posture. This posture allows the neck muscles, such as the upper trapezius, cervical extensors (suboccipital, semispinalis, and splenius muscles), sternoclavicular muscles, and serratus anterior, to stabilize the neck, leading to excessive contractions (Fathollahnejad et al., 2019; Szeto et al., 2002). The forward head posture is accompanied by the bent shoulder posture (Szeto et al., 2002) and thoracic kyphosis (Lynch et al., 2010) and is caused by the forward scapular posture (Fathollahnejad et al., 2019).

The anterior scapular posture is defined as the anterior inclination of the scapula, and its main causes are the round shoulder posture, thoracic kyphosis (Wu et al., 2005; Fathollahnejad et al., 2019), shortening of the pectoralis minor muscle (Borstad and Ludewig, 2005), and weakening of the serratus anterior muscle strength (Ekstrom et al., 2004; Kibler and Sciascia, 2016). The altered scapular position due to the anterior scapular posture reduces the range of motion and muscle strength of the concave upper arm (Smith et al., 2002; Smith et al., 2006) and alters the neuromuscular activation pattern (Cools et al., 2004) by inducing an anterior scapular glenoid inclination, leading to an increased load on the posterior upper concave (Glenoid labrum) (Kibler and Sciascia, 2016; Weiser et al., 1999) and causing injuries to the upper arm and joint. This disrupts the concave border from maintaining neck stability (Burkhart et al., 2003; Veeger and van der Helm, 2007). Consequently, the anterior scapular posture reduces the shoulder function (Lin et al., 2006).

Previous studies have shown a correlation between the use of electronic devices and neck pain and posture (Nejati et al., 2015; Kim et al., 2016; Akodu et al., 2018; Raoofi et al., 2019). Studies on the correlation between neck pain and shoulder dysfunction have also been conducted (Castelein et al., 2016; Shin et al., 2017; Helgadottir et al., 2013).

However, neck pain is not only related to neck structure, but also shoulder structure and is deeply related to shoulder function. This is thought to be because the neck is structurally connected to the shoulder, and many structures of the neck share an origin with the shoulder (Castelein et al., 2016). Therefore, this study analyzed the correlation between neck pain and electronic device use, neck shoulder posture, and shoulder function as measurement variables. We divided groups according to neck pain and analyzed the correlation between the average difference of variables between groups and the variables within each group. We are curious to find the relationship between the aforementioned variables and neck pain.

Ⅱ. Methods

1. Subjects

Based on previous studies, this study recruited 50 subjects between October 9 and 27, 2020, targeting women in their 20s and 30s with neck and shoulder pain who visited the R Hospital in Seoul. The selection criteria were neck and shoulder pain, aged between 20 and 30 years, and no history of shoulder surgery limitations in the range of active shoulder motion. Those with severe shoulder pain, shoulder lesions, or structural problems, neurological disorders, who underwent shoulder or orthopedic surgery, or with limited activities due to shoulder pain were excluded (Lee et al., 2014).

Before the experiment, the purpose and necessity of this study were explained in detail to the study participants. This study was approved by the Institutional Bioethics Review Committee of Sahmyook University and followed the ethical guidelines of the Declaration of Helsinki. The participants were informed that they could withdraw from the study at any time. Signed informed consents were obtained from all participants. Therefore, subject rights were protected according to the ethical principles of the aforementioned declaration.

2. Experimental Procedures

Subjects who met the study criteria and gave consent were selected; before starting the experiment, the experimental method and procedure were explained to the study subjects, and after they fully understood the contents of this study, the consent form to participate was signed. After conducting the experiment, general characteristics of the study subjects, and neck pain disorder (NDI) index and VDT syndrome scores were investigated using a questionnaire. Twenty-one subjects, who had a NDI index score of $\leq$14 points, were allocated to the mild pain group, and 29 subjects, who had a NDI score of $\geq$15 points, were allocated to the severe pain group. The total measurement time was 30 min, and appropriate rest time was given according to variables. Both groups were provided the same environmental conditions, and statistical analysis was performed by synthesizing the results after the experiment.

3. Experimental Methods

This was a cross-sectional study, and 50 women were divided into mild and severe groups, which had NDI scores of $\leq$14 and $\geq$15, respectively. The study consisted of one research director and one assistant for experimental measurement. The order of the experiment was to obtain an image with the subjects in a sitting position, and after collecting craniovertebral angle and thoracic kyphosis angle scores, the serratus anterior strength was measured with the upper arm shoulder at a 90° flexion. Subsequently, the subjects were instructed to lie down on a table while looking at the ceiling, and then the length between the coracoid process and the fourth rib was measured to collect the pectoralis minor length. The round shoulder posture values were collected by measuring the distance between the table and the acromion, and the shoulder joint hypermobility was measured by instructing the subjects to lay on the edge of the table as much as possible. All procedures were repeated twice based on the dominant arm. When measuring the serratus anterior strength, a 30 s rest period was given between measurements. Considering gender, two physical therapists were independent and experimented in the same test site. In each group, the physical therapist participating thoroughly performed and understood the measurement of the variables to be applied to the patient in advance, and the same therapist performed the measurements.

4. Experiment Tool and Analysis

1) Neck pain

This study used the NDI index to measure neck pain (Kocur et al., 2019). This index consists of pain intensity, lifting, reading, concentration, headache, self-management, working, sleeping, and leisure activities. Each item has a score of 0-5, the total score is calculated by adding the scores of all items, and the scores indicate the following: 0-4, no disability; 5-14, slight disability; 15-24, moderate disability;−25-34, severe disability; 35 or more, complete disability. This index does not cause any pain and has a low influence on daily life movements; the higher the score, the greater the limit on daily life and the discomfort due to pain when performing daily movements (Vernon, 2008; Shin et al., 2017). Measurement-remeasurement reliability was very high (ICC=0.96) (Shaheen et al., 2013). The subjects were asked to write a NDI index evaluation sheet in advance.

2) VDT Syndrome

The VDT syndrome assessment tool questionnaire was used by Moon et al(1991) to measure the subjective symptoms of VDT syndrome. This tool consists of a total of 33 items, including five sub-areas: musculoskeletal symptoms (5 items), eye-related symptoms (11 items), skin-related symptoms (3 items), psychological symptoms (7 items), and systemic symptoms (7 items). Each question has a 5-point Likert scale from 0 to“very severe”; the score ranges from 0 to 132, and the higher the score, the more severe the VDT syndrome. At the time of tool development, the reliability was Cronbach's α=0.97. The subjects were asked to prepare a tool to measure the subjective symptoms of VDT syndrome in advance.

3) Posture measurement

Posture was measured using the craniovertebral and thoracic kyphosis angles, and the round shoulder posture. The craniovertebral and thoracic kyphosis angles were measured by taking pictures with an iPad (iPad mini 5; Apple, America, 2019) camera. The bent shoulder posture was measured using a Vernier caliper (Hogetex, The Netherlands, 2005).

The craniovertebral angle is the angle between the line from the tragus to the 7th cervical vertebrae and the horizontal line at the level of the 7th cervical vertebrae; if the craniovertebral angle is ≥ 51°, the patients is considered to have an anterior head posture (Kim et al., 2015). The measurement-remeasurement reliability of the craniovertebral angle was high (ICC=0.88-0.98) (Quek et al., 2013; Raine and Twomey, 1997). Subjects were seated in a chair with a backrest, both feet touching the floor, hands naturally on the thighs, and comfortably staring straight ahead. The measurer then marked the 7th cervical spine (Lewis et al., 2005), and two photographs were taken from the side of the dominant arm. After taking one picture, the subject was instructed to get up and sit back. To minimize parallax errors, the camera was set perpendicular to the ground with the lens pointing directly to the side of the subject's shoulder at a distance of 80 cm (Yoo et al. 2008). Subsequently, a line was drawn from the tragus to the 7th cervical vertebrae using the iPad photo editing function; a horizontal line was also drawn at the level of the 7th cervical vertebrae using ImageJ software (Image analysis software, National Institutes of Health, USA) to determine the angle between this line and the aforementioned line (Kim and Kim, 2016).

Thoracic kyphosis is defined as the angle between the 1st thoracic vertebrae, 3rd thoracic vertebrae, 12th thoracic vertebrae, and 1st lumbar vertebrae; a positive angle indicates thoracic vertebrae flexion, and a negative angle indicates lumbar vertebrae extension. The reliability of each measurement is high (ICC=0.91) (Kuo et al., 2008; Tully et al., 2005). As a study procedure, first, the measurer instructed the subject to sit in a chair with a backrest, place both feet on the floor, hands resting naturally on the thighs, and then gaze comfortably forward. The 1st thoracic vertebrae, 3rd thoracic vertebrae, and 12th thoracic vertebrae were marked on the 1st lumbar vertebrae. The research director took a picture with an iPad camera from 2 m away (Lee, 2014), and then used the iPad photo editing function to draw a line connecting the 1st and 3rd thoracic vertebrae, and the 12th and 1st lumbar vertebrae. After drawing a connecting line, the angle was calculated from the photograph using ImageJ software (Kuo et al., 2008; 2009).

The round shoulder posture is the vertical distance between the back of the acromion and the table in the supine position (Sahrman, 2002; Lewis and Valentine, 2007), and the reliability of this measurement is high (ICC=0.88). We measured variables in a way to keep the subject in a neutral posture to avoid variables caused by upper arm rotation while the subject was lying supine and looking at the ceiling (Borstad and Ludewig, 2005). The measurer measured the vertical distance between the back of the subject's acromion and the table, and a Vernier caliper was used. The distance was recorded in millimeters.

4) Shoulder function

The shoulder function was measured using the length of the pectoralis minor muscle, shoulder joint hypermobility, and serratus anterior muscle strength. The length of the pectoralis minor muscle is the distance between the coronoid process and the part of the muscle connected to the sternum of the 4th rib (Borstad and Ludewig, 2005). Both intra-measurement reliability (ICC=0.95-0.97; SEM=0.31-0.42 cm) and inter-measurement reliability (ICC=0.95-0.97; SEM=0.31-0.42 cm) were good and so was the daily reliability (ICC=0.95; SEM=0.40-0.41 cm) (Rosa et al, 2016). First, the measurer asked the subject to lie supine while looking at the ceiling. Thereafter, a sticker was attached to the part of the muscle connected to the sternum of the 4th rib and the coracoid process, and the length between them was measured. A Vernier caliper was used as a measuring tool, and after measuring once, length was measured again after a 2-minute break. At the time of measurement, the subject was instructed to exhale, and the sticker was peeled off after measurement and re-attached again at the time of measurement (Borstad and Ludewig, 2005).

Shoulder hypermobility is defined as horizontal shoulder abduction (Jung et al., 2017). This method has good intra- and inter-meter reliabilities (inratester ICC=0.91; intertester ICC=0.89). The intra- and inter-meter agreement (mean, 0.3±4.4°) was acceptable when compared to the standard deviation of the measurement (range, 6.2−7.4°) (Lin et al., 2006). The procedure first allowed the subject to reach the edge of the table in a supine position so that the arm to be measured could fall under the table. When 90° shoulder flexion and abduction were achieved, the measurer held the subject's arm away from the humeral condyle of the elbow and pushed the lateral edge of the scapula in the direction of the table to fix it. Accordingly, the abduction under the chest was manually performed until there was a hard end feel and was measured using a digital inclinometer (Level Box; Bluetec, Korea, 2018) (Jung et al., 2017).

The serratus anterior strength refers to the protraction strength of the scapula during 90° shoulder and elbow flexions on the scapular plane (30° anterior to the forehead) (Kramer and Ng, 1996). This is the most reliable posture for measuring independent serratus anterior strength using a portable dynamometer (IJspeert et al., 2019) (model 01163, Lafayette Instrument, Lafayette, IN, USA, 2003). Measuring the serratus anterior strength was highly reliable in subjects (ICC=0.90) (Wang et al., 2006). The procedure involves having the subjects sit in a chair with a backrest and then asking them to look forward and perform 90° shoulder elbow joint flexions on the scapular plane (30° anterior to the forehead) (Kramer and Ng, 1996). Subsequently, the portable dynamometer was placed around the elbow, and the examiner instructed the subject to protract the scapula.

5. Stastical analysis

This study was analyzed using SPSS version 22.0 (IBM, Armonk, NY, USA). The independent sample t-test was performed to compare the general characteristics and the average of each variable between the two groups. A Pearson correlation analysis was performed to determine the correlation of variables, and a multiple regression analysis was performed to determine if there was a significant influence between variables. A p-value < 0.05 was considered statistically significant.

Ⅲ. Results

1. General characteristics

Table 1 presents the general characteristics of the subjects, which were apparently homogeneous for all items between both groups.

Table 1. General characteristics and homogeneity tests of study subjects (*N*=50)

	Mild pain group (*n*=21)	Severe pain group (*n*=29)	t(*p*)
Age (years)	25.38 ± 4.54[a]	25.31 ± 3.63	0.059(0.953)
Height (cm)	160.91 ± 3.26	162.47 ± 6.05	-1.062(0.294)
Weight (kg)	53.50 ± 6.87	54.45 ± 6.27	-0.500(0.620)
body mass index (BMI)	20.65 ± 2.51	20.62 ± 1.97	0.056(0.955)

[a]Mean ± Standard deviation.

2. Comparison of variables between both groups

Table 2 shows the average comparison of the measured variables for each group in the mild and severe pain groups. There was a significant difference in the VDT syndrome questionnaire score (30.86 points in the mild pain group and 47.48 points in the severe pain group) between the groups (p<0.05). The serratus anterior muscle strength was 2.55 lb in the mild pain group and 3.04 lb in the severe pain group (p<0.05)<Table 2>.

Table 2. Differences between variables in two groups (N=50)

	Mild pain group (n=21)	Severe pain group (n=29)	t(p)
VDT Syndrome	30.86 ± 14.00[a]	47.48 ± 18.45	-3.622(0.001)
Craniovertebral angle (°)	50.27 ± 5.23	51.15 ± 5.06	-0.598(0.553)
Thoracic kyphosis (°)	30.20 ± 7.67	26.38 ± 8.17	1.690(0.098)
Bent Shoulder Posture (mm)	71.11 ± 15.08	73.48 ± 14.07	-0.563(0.576)
pectoralis minor length (mm)	150.64 ± 11.21	148.69 ± 14.28	0.539(0.592)
Shoulder hypermobility (°)	41.29 ± 7.87	40.34 ± 8.34	0.407(0.686)
serratus anterior muscle strength (LB)	2.55 ± 0.82	3.04 ± 0.87	-2.041(0.047)

[a]Mean ± Standard deviation, VDT=visual display terminal syndrome index.

3. Correlation between variable in the mild pain group

Correlations between variables in the mild pain group are shown in Table 6. Regarding main variables, the craniovertebral angle and the round shoulder posture were significantly negatively correlated (r=-0.467, p<0.05). However, there was no significant correlation between other variables<Table 3>.

Table 3. Correlation between variables in mild pain group (N=21)

	Neck Pain Disability Index	VDT syndrome	two vertebral angle	thoracic spine kyphosis	bent shoulders posture	pectoralis minor Length	shoulder joint hypermobility	serratus anterior
Neck Pain Disability Index								
VDT syndrome	0.393							
two vertebral angle	0.033	0.284						
thoracic spine kyphosis	0.291	0.254	0.033					
bent shoulders posture	0.152	0.152	-0.467*	0.105				
pectoralis minor Length	0.273	-0.066	-0.275	0.101	0.246			
shoulder joint hypermobility	-0.103	-0.222	-0.122	0.180	-0.043	0.325		
serratus anterior muscular strength	-0.003	0.224	-0.003	0.250	-0.199	-0.319	-0.239	

*p<.05, VDT=visual display terminal syndrome index.

Table 4 shows the effect of the round shoulder posture on the craniovertebral angle in the mild pain group. The round shoulder posture was found to have a significant positive effect on the craniovertebral angle (B=10.162, $p<0.05$). However, other variables did not have a significant influence<Table 4>.

Table 4. Effect of bent shoulder posture on cranial spine angle in mild pain group (*N*=21)

	non-standard coefficient		standard coefficient	*t*	*p*	VIF
	B	SE	β			
bent shoulder posture	-0.162	0.070	-0.467	-2.300	0.033	1.000

Excluded variables=neck pain disability index, VDT syndrome score, thoracic kyphosis, pectoralis minor muscle length, shoulder hypermobility. serratus anterior muscle strength.

4. Correlation between variable in the severe pain group

Correlations between variables in the severe pain group are shown in Table 5. Regarding major variables, the NDI index and VDT syndrome were significantly positively correlated (r=0.520, $p<0.01$), and the VDT syndrome and the length of the pectoralis minor muscle were significantly positively correlated (r= 0.457, $p<0.05$). Moreover, shoulder hypermobility and serratus anterior strength were significantly negatively correlated (r=-0.437, $p<0.01$). However, there was no significant correlation between other variables<Table 5>.

Table 5. Correlation between variables in severe pain group (*N*=29)

	Neck Pain Disability Index	VDT Syndrome	two vertebral angle	thoracic spine kyphosis	bent shoulder posture	pectoralis minor Length	shoulder joint hypermobility	serratus anterior muscular strength
Neck Pain Disability Index								
VDT Syndrome	0.520**							
two vertebral angle	-0.324	0.070						
thoracic spine kyphosis	0.155	0.071	0.081					
bent shoulder posture	0.097	0.077	-0.336	-0.045				
pectoralis minor Length	0.265	0.457*	0.178	0.034	0.026			
shoulder joint hypermobility	0.029	0.108	0.038	0.257	0.129	0.183		
serratus anterior muscular strength	-0.161	-0.334	0.215	-0.127	0.223	-0.300	-0.437**	

*p<.05, **p<.01, VDT=visual display terminal syndrome index.

Table 6 shows the effects of VDT syndrome and the craniovertebral angle on the NDI index in the severe pain group. VDT syndrome was found to have a significant positive effect on the NDI index (B=0.330, $p<0.05$). Moreover, it was also found that the craniovertebral angle had a significant negative influence on the NDI index (B=-0.809, $p<0.05$)<Table 6>.

Table 6. Effect of VDT syndrome and craniospinal angle on neck pain disability index in severe pain group (*N*=29)

model	non-standard coefficient		standard coefficient	*t*	*p*	VIF
	B	SE	β			
1VDT	0.315	0.100	0.520	3.165	0.004	1.000
2VDT	0.330	0.092	0.546	3.587	0.001	1.005
craniovertebral angle	-0.809	0.339	-0.363	-2.385	0.025	1.005

Excluded variables=thoracic kyphosis, flexed shoulder posture, pectoralis minor length, shoulder hypermobility, and serratus anterior muscle strength.

Table 7 shows the effects of the NDI index and pectoralis minor muscle length on the VDT syndrome in the severe pain group. The NDI index was found to have a significant positive effect on VDT syndrome (B=0.709, p<0.05), and the pectoralis minor muscle length was found to have a significant positive effect on VDT syndrome (B=0.444, p<0.05) <Table 7>.

Table 7. Effect of neck pain disability index and pectoralis minor muscle length on VDT syndrome in severe pain group (*N*=29)

model	non-standard coefficient		standard coefficient	*t*	*p*	VIF
	B	SE	β			
1 Neck Pain Disorder Index	0.859	0.271	0.520	3.165	0.004	1.000
2 Neck Pain Disorder Index	0.709	0.264	0.429	2.680	0.013	1.076
pectoralis minor length	0.444	0.207	0.344	2.146	0.041	1.076

Excluded variables=craniovertebral angle, thoracic kyphosis, bent shoulder posture, shoulder hypermobility, and serratus anterior muscle strength.

Table 8 shows the effect of the serratus anterior strength on shoulder hypermobility in the severe pain group. The serratus anterior strength was found to have a significant negative effect on shoulder hypermobility (B=-4.175, p<0.05) <Table 8>. However, other variables did not have a significant influence.

Table 8. Effect of serratus anterior muscle strength on shoulder joint hypermobility in severe pain group (*N*=29)

	non-standard coefficient		standard coefficient	*t*	*p*	VIF
	B	SE	β			
serratus anterior muscle strength	-4.175	1.653	-0.437	-2.526	0.018	1.000

Excluded variables=neck pain disability index, VDT syndrome score, cranial spine angle, thoracic kyphotic angle, flexed shoulder posture, pectoralis minor length.

Ⅳ. DISCUSSION

Neck pain is a chronic musculoskeletal pain experienced by the majority of adults and is very prevalent (Genebra et al., 2017; Hoy et al., 2014). As the number of long-term repeated use of digital terminals increases, certain clinical symptoms may appear. This is called VDT syndrome. Recently, as neck and musculoskeletal pains have been mainly attributed to VDT syndrome (Parihar et al., 2016), maintaining prolonged abnormal posture has been reported as a major cause of neck pain (Park et al., 2014).

As a result of examining the mean difference between the variables of both groups in this study, there was a significant difference between the two groups in the VDT syndrome questionnaire (30.86±14.00 points in the mild pain group, and 47.48±18.45 points in the severe pain group). The questionnaire score was significantly higher in the severe pain group than in the mild pain group (p<0.05). Moreover, the serratus anterior length was significantly lower in the mild group than in the severe pain group (2.55±0.82 lb in the mild pain group and 3.04±0.87 lb in the severe pain group) (p<0.05).

As the neck has high mobility and low stability (Chiu et al., 2002), the long-term use of visual displays results in an increased flexion moment and an anterior head posture (Harms-Ringdahl, 1986; Yoo, 2008). This fatigues the surrounding muscles and induces the mobilization of more muscle fibers (Shariat, 2018), which can lead to shoulder pain and dysfunction (Sahrmann, 2002; 2013). This phenomenon explains well why the VDT syndrome in the severe pain group had higher results than in the mild pain group. Consequently, this study has clinical significance in that it suggests the use of visual displays as a risk factor in patients with neck pain or disability in the musculoskeletal system. The forward head and round shoulder postures are factors of neck pain (Sahrmann, 2013), resulting in an anterior scapular posture (Fathollahnejad et al., 2019). The anterior scapular posture causes an imbalance in scapulothoracic muscles (Cools et al., 2004), causing pain by transferring mechanical loads to the cervical spine (Castelein et al., 2016). Moreover, the anterior scapular posture is associated with the weakening of the serratus anterior, which is one of the scapular stabilizing muscles. However, the serratus anterior strength results contradict the aforementioned theory, which is related to neck pain and shoulder dysfunction; nevertheless comparing the average difference by dividing groups does not consider physical characteristics, such as individual muscle mass and strength. Therefore, serratus anterior strength may have possibly caused bias.

In this study, as a result of examining the correlation and influence of each variable in the mild pain group, the craniovertebral angle and the round shoulder posture were significantly negatively correlated (r=-0.467, p<0.05). The round shoulder posture was found to have a significant positive influence on the craniovertebral angle (B=10.162, p<0.05).

Changes in the cervical spine curvature cause peripheral muscle imbalance, leading to upper limb crossover syndrome (Janda, 1994). The upper limb crossover syndrome results in the rounded shoulder posture (Shrmann, 2002). Janda (1994) reported that the upper limb crossover syndrome was accompanied by a forward head posture and the round shoulder posture. However, Singla and Vequar(2017) analyzed several studies and found that there was a correlation between the craniovertebral angle and the round shoulder posture; however, these variables may exist independently or in combination. Therefore, in this study, there was a significant negative correlation between the craniovertebral angle and the round shoulder posture in the mild pain group, and the curved shoulder posture had a significant negative effect on the craniovertebral angle. We believe that all of these results are valid.

In this study, as a result of examining the correlation and influence of each variable in the severe pain group, the NDI index and VDT syndrome had a significant positive correlation (r=0.520, p<0.01). The VDT syndrome had a significant positive effect on the NDI index (B=0.330, p<0.05), and the craniovertebral angle had a significant negative effect on the NDI index (B=-0.809, p<0.05). Moreover, the VDT syndrome and the pectoralis minor length were significantly positively correlated (r=0.457, p<0.05), and the pectoralis minor length had a significant positive effect on the VDT syndrome (B=0.444, p<0.05). Shoulder hypermotility was significantly negatively correlated with the serratus anterior strength (r=-0.437, p<0.01), and the serratus anterior strength had a significant negative effect on shoulder hypermotility (B=-4.175, p<0.05).

The increase in the use of electronic devices causes VDT syndrome (Cho, 2008) because individuals maintain the same posture for a long period (Szto et al., 2002). Consequently, a posture involving a forward head posture causes pain (Szeto et al., 2002; Harrison et al., 2003). This means that the head is structurally in front of the centerline of the body, and consequently, the neck supports the weight of the head with a larger load than it is capable of. Since the forward head posture appears with the round shoulder posture (Szeto et al., 2002), the forward scapular posture, which is associated with the shortening of the pectoralis minor (Borstad and Ludewig, 2005), is induced (Wu et al., 2005). Therefore, in this study, the NDI index and VDT syndrome had a significant positive correlation, whereas the VDT syndrome had a significant positive effect, and the craniovertebral angle had a significant negative effect on the NDI index.

If the serratus anterior, which is the main muscle that performs the scapular anterior and upward rotations, is weakened by itself, not by neurological problems, the anterior scapular posture is induced (Muscolino, 2016). This is because the serratus anterior stabilizes the inferior angle of the scapula against the posterior thoracic wall (Ekstrom, 2004; Kibler and Sciascia, 2016). The position of the scapula changes as the anterior scapular posture induces an anterior inclination of the shoulder concave surface and increases the load on the posterior upper glenoid labrum (Kibler and Sciascia, 2016; Weiser, 1999), causing injury and shoulder concavity, which disrupts the concave border from maintaining joint stability (Burkhart et al., 2003; Veeger and Van der Helm, 2007). Therefore, the anterior scapular posture is caused by various shoulder disorders, such as subacromial shoulder impingement syndrome, adhesive arthritis, and brachial plexus myositis (Lee, 2014; Kuhn, 1995). The anterior scapular posture is thought to be the cause of the negative correlation between shoulder joint hypermobility and serratus anterior strength in the current and previous studies.

To summarize the results of this study, in the mild pain group, the craniovertebral angle and the round shoulder posture were significantly negatively correlated and showed a significant influence on each other, whereas in the severe pain group, the craniovertebral angle and the round shoulder posture were not significantly correlated and did not have an influence on each other. These results imply that the smaller the craniovertebral angle, that is, the deeper the forward head posture, the more severe the round shoulder posture. In this study, the reason why this relationship was pronounced only in the mild group and why there were contradictory results in the severe-pain group is that, as previously stated by Singla and Vequr(2017), there is a correlation between the craniovertebral angle and the round shoulder posture. This is thought to be because variables can exist independently or with each other. In the severe pain group, there was a significant positive correlation between the NDI index and the VDT syndrome, and the NDI index had a positive effect on the VDT syndrome; however, in the mild pain group, the NDI index and the VDT syndrome were not correlated and did not have an influence on each other. These results indicate that the increase in neck pain may be due to the use of visual displays and the resulting musculoskeletal pain, which is prominent in patients with some degree of pain. Moreover, in the severe pain group, the NDI index and craniovertebral angle were not correlated, but the craniovertebral angle had a significant negative effect on the NDI index, meaning that the greater the neck pain, the smaller the craniovertebral angle. In other words, this does not mean that the forward head posture is not expressed as a variable, but as the craniovertebral angle decreases, that is, as the forward head posture appears, neck pain increases. This phenomenon was not observed in the mild pain group; however, it was apparent that the forward head posture as a cause of neck pain is more pronounced in patients with some degree of neck pain. In contrast, in the severe pain group, there was a significant negative correlation and negative influence between shoulder joint hypermobility and serratus anterior strength, whereas in the mild pain group, there was no correlation and influence between these variables, meaning that the greater the hypermobility of the shoulder joint, the weaker the muscle strength of the serratus anterior. This phenomenon appears in patients with some degree of neck pain.

In this study, the VDT syndrome questionnaire score was higher in the severe pain group than in the mild pain group. This is because the severe pain group used a visual display for a longer period compared to the mild pain group. This result is obvious. Accordingly, it can be seen that the correlation and mutual influence between the NDI index and the VDT syndrome would only appear in the severe pain group and that the craniovertebral angle harmed neck pain also appeared only in the severe pain group.

The lack of activity and mobilization of the serratus anterior negatively affects scapula stability (Kibler and McMullen, 2003). Therefore, by applying an ideal load to the thoracic and cervical vertebrae, mechanical dysfunction can be sustained; this causes recurrent or exacerbated neck pain (Jull et al., 2008).

The clinical significant of this study is that it presents variables that should be considered important according to the degree of neck pain. Moreover, unlike previous studies that compared only shoulder hypermobility and serratus anterior strength due to shoulder lesions or continuous stimulation, the correlation and influence of shoulder hypermobility and serratus anterior strength were analyzed according to the degree of neck pain. It can be said that this study presented direct results regarding this relationship. The results of this study are clinically significant, implying that shoulder function can be considered as an important factor according to the degree of neck pain and disabilities when treating patients with neck pain.

Ⅴ. Conclusion

This study evaluated the NDI index, VDT syndrome score, craniovertebral angle, thoracic kyphosis, serratus anterior strength, pectoralis minor length, round shoulder posture, and shoulder hypermotility in women with neck pain. By dividing patients into mild and severe pain groups, we investigated the correlation and mutual influence of variables within each group. Consequently, regarding the mean difference between the variables of each group, the average score of the VDT syndrome questionnaire was higher in the severe pain group than in the mild pain group (p<0.05), and the difference in the average score between the remaining variables was not significant. The craniovertebral angle and the round shoulder posture were significantly negatively correlated in the mild pain group (r=-0.467, p<0.05), and the round shoulder posture was found to have a significant positive effect on the craniovertebral angle (B =10.162, p<0.05). In the severe pain group, the NDI index and VDT syndrome questionnaire had a significant positive correlation (r=0.520, p<0.01), and the VDT syndrome had a significant positive effect on the NDI index (B=0.330, p<0.05); the craniovertebral angle was also found to have a significant negative influence on the NDI index (B=-0.809, p<0.05). Shoulder hypermotility was significantly negatively correlated with serratus anterior strength (r=-0.437, p<0.01), and serratus anterior strength had a significant negative effect on shoulder hypermotility (B=-4.175, p<0.05). The clinical significance of this study is that it presents variables that should be considered important according to the degree of pain when treating patients with neck pain. Furthermore, it presents not only neck and shoulder posture, but also shoulder function as a variable to consider for patients with neck pain.

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