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Research Article

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Effect ofthe Exam Period on the Pressure Pain Thresholds and Perceived Stress Levels of Students with Forward Head Posture

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| Abstract |

PURPOSE: Forward head posture (FHP) is associated with neck pain and is influenced by physical and psychological factors. Pressure pain threshold (PPT) has been reported to be inversely related to psychological stress such as anxiety. This study aimed to determine the effect of the exam period on PPT and perceived stress in students with FHP.

METHODS: There were 32 college students in this study. Based on a cranio-vertebral angle (CVA) of 50°, the students were divided into the FHP group (CVA < 50°; n = 16; mean age, 21.06 ± 1.57 years) and the normal alignment group (CVA ≥ 50°; n = 16; mean age, 21.25 ± 1.57 years). The visual analog scale (VAS) scores, the Korean version of the perceived stress scale (K-PSS) scores, and PPT of the bilateral trapezius muscles were assessed during the semester and exam period.

RESULTS: The FHP group showed significant differences in the VAS score, K-PSS score, and bilateral PPT between the semester and exam period, while the normal alignment group showed a significant difference only in the right PPT. Pearson bivariate correlation analysis of all participants revealed a moderate correlation of CVA with the right PPT ($r = .408$, $p = .020$) and left PPT ($r = .462$, $p = .008$) during the exam period, but a weak correlation with the semester.

CONCLUSION: Students with FHP showed higher neck pain and stress scores and lower PPT during the exam period than during the semester, highlighting the importance of maintaining correct posture to reduce neck pain and manage stress during periods of academic demand.

Key Words: Cervical vertebrae, Musculoskeletal pain, Myofascial pain, Neck

Ⅰ. Introduction

Neck and shoulder pain is one of the most common musculoskeletal disorders among modern office workers and students who spend long hours sitting at desks. Neck and shoulder pain is caused by prolonged work in a neck flexion position with the head down, shifting the center

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of gravity forward, thus increasing the tension and fatigue in the muscles around the cervical spine and shoulder blades [1,2]. Poor posture also contributes to neck and shoulder pain, as chronic poor posture causes unnecessary tension in the muscles around the neck and shoulder blades, leading to imbalances throughout the musculoskeletal system over time [3]. Such imbalances can cause changes in the muscle length and pain, restricting neck movement and decreasing the quality of life [4].

Forward head posture (FHP)refers to a poor posture type that is out of normal alignment, with the head positioned ahead of the central line of the spine [5,6]. FHP can cause mechanical stress on the neck due to the head position and abnormalities in muscle metabolism due to constant involuntarily contracted muscles, which can lead to myofascial tissue abnormalities and myofascial pain. This process is caused by the accumulation of the end products from metabolic processes and insufficient oxygenation due to low blood flow [7]. FHP causes changes in the length of the muscle-tendon units of the neck extensors and flexors [8], which typically results in shortening of the neck extensors and sternocleidomastoid muscles, decreasing the cranio-vertebral angle (CVA) and increasing the cranio-rotational angle [9]. FHP causes changes in the upper-extremity muscle activity and influences the development of trigger points [10,11]. Specifically, it is associated with trigger points in the upper trapezius muscles, and these trigger points correlate with neck pain [12]. FHP also increases the load on the neck structures, which can lead to peripheral nociceptive nerve sensitization, thereby lowering the pressure pain threshold (PPT) [13].

Neck pain is associated with various physical and psychological factors [14]. Particularly, FHP, a cause of neck pain, has been linked to factors other than pain, such as psychological stress [15],and recent studies have even suggested its association with depression [16].Although FHP, pain sensitivity, and psychological stress are often discussed together in relation to musculoskeletal pain, the exact nature of their interrelationship remains unclear. Each factor may independently contribute to neck and shoulder pain, yet it is uncertain whether these associations represent causal mechanisms or simple correlations. In light of this uncertainty, the present study aimed to explore these relationships under different psychological conditions without presuming direct causality.

College students who spend long hours in a sitting position studying for exams and using electronic devices experience high levels of psychological stress [17]. In college students, the prevalence of FHP is 64–73% [18,19]. Unfortunately, the reality is that it is difficult to avoid a prolonged sedentary lifestyle and use of electronic devices. Therefore, it is important to recognize the importance of good posture and maintain it to prevent pain during the exam period. A previous study reported that college students exhibited a higher prevalence of neck and shoulder trigger points during the exam period [20]. However, PPT was paradoxically higher than during the semester, contrary to the authors' hypothesis and previous findings [20]. This inconsistency suggests that the relationship between psychological stress and PPT is complex and may be influenced by multiple factors. Therefore, we aimed to investigate the effects of the exam period on PPT and perceived stress levels between college students with FHP and those with normal alignment. Students with FHP should be made aware of the importance of correct posture to manage neck pain and the danger of sitting in poor posture for long hours. This study hypothesized that PPT of the upper trapezius muscles decreases and the perceived stress level increases in college students with FHP during the exam period.

Ⅱ. Methods

1. Design

This study was designed as a repeated-measures study with no interventions. The study protocol was approved by the Institutional Review Board (Date: December 14, 2023; Approval No.: CUPIRB-2023-054). Each variable was measured once during the regular semester and once during the exam period. In this study, the exam period was defined as the one-week period during which students took their examinations. The order of the measurements was randomized, with half of the participants assessed first during the semester and the others assessed first during the exam period. Different investigators were assigned to each measurement period to blind the results of the primary assessment and minimize potential bias. The outcome measures included the cranio-vertebral angle (CVA), a visual analog scale (VAS) to assess neck and shoulder pain, the 14-item Korean version of the Perceived Stress Scale (K-PSS) to assess stress levels, and the pressure pain threshold (PPT) of the bilateral upper trapezius muscles. Measurements were performed in the following order: CVA, VAS, K-PSS, and PPT.

2. Participants

This study included adult male and female college students who voluntarily consented to participate after being informed of the experimental procedure before starting the study. Based on CVA, the participants were divided into the FHP group, comprising students with CVA < 50°, and the normal alignment group, comprising those with CVA > 50°. CVA is one of the common metrics to evaluate FHP, with its reliability and validity confirmed previously [21].

Theexclusion criteria of this study were previous or ongoing neck surgery, neck trauma, taking medications to reduce pain in the neck and shoulder area, fibromyalgia, and other neurological problems in the neck.

This study used G*power to determine the sample size, referring to the study by Kalichman et al. [20] regarding the effect of trial duration on the prevalence of pain trigger points and FHP. The study reported that the subjective pain level was significantly higher during the exam period than during the semester (6.21 ± 2.20 vs. 3.72 ± 2.61), with no significant difference in the FHP angle. The total number of participants was 39, with an effect size of 1.03. Using this study design, the sample size required in our study for each group was 16, assuming α = .05, β = .8, and effect size = 1.03. Therefore, our study included 32 male and female adults.

3. Measurement methods and tools

1) CVA

For an objective assessment of FHP, a side view of the participant was recorded using a camera positioned on a leveled floor. CVA measurements are reportedly more sensitive when the participants are in a seated position than in a standing position [22]. Therefore, each participant was asked to sit in a chair positioned at a certain distance from the camera, which was adjusted to shoulder height, and asked to look at a point marked on the wall with the neck comfortably bent and relaxed [23]. Fluorescent stickers were placed at the midpoint of the tragus of the right ear and the midpoint of the spinous process of the C7 vertebra as markers to increase the measurement accuracy. The photographs were then transferred to a computer to measure CVA using the digital protractor for the Windows operating systems (MB Ruler, MB-Softwaresolutions, Germany) [20]. The CVA was determined by measuring the angle between the line connecting the two markers and a horizontal line passing through the height of the spinous process of the C7 vertebra [22].

2) PPT of the bilateral upper trapezius muscles

To measure PPT of the upper trapezius muscles, painful trigger points were identified according to the diagnostic criteria proposed by Travell and Simons [24]. The process was performed by two investigators, and preliminary experiments were conducted, followed by discussion and standardization to ensure consistency in the location of trigger points, palpation techniques, and applied pressure. The investigator identified the pain trigger point by palpating the upper trapezius muscles to find a taut band, checking for pressure pain at that point, and applying pressure to the nodule. The investigator asked the participant whether this pressure caused pain. Following this, a pressure of 2.5 kg/cm^2 was applied continuously at a rate of 1 $kg/cm^2/s$ using a pressure algometer (FPK 60, Wagner Instruments Inc., USA) to identify the painful points accurately (Fig. 1). If pain (VAS score $\geq$ 3) was detected before applying 2.5 kg/cm^2 pressure, the point was considered a pain point [25]. If there were multiple trigger points in the trapezius muscle on the same side, the most severe and clearly identifiable pain point was recorded [20,26].

After identifying the pain trigger point, PPT (kg/cm^2), defined as the minimum pressure at which the pressure sensation changes to pain, was assessed [27]. Measurements were recorded while the participant was seated comfortably in a chair with a backrest, leaning back, and looking straight ahead. The investigator positioned the metal rod perpendicular to the surface of the skin and applied progressive pressure to the skin in the area of the marked trigger point. When applying pressure, the participant was asked to express a signal that was previously agreed upon with the investigator at the point of pain at the pressure site. The investigator recorded the algometer reading at that time as PPT value. Three measurements were recorded for each trigger point on each side using the same method at intervals of 30 sec between each measurement. The mean of the three measurements was calculated and used for the analysis [28].

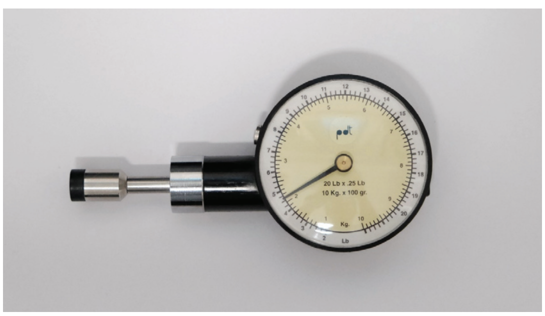

Fig. 1. Pressure pain threshold measurement using a pressure algometer.

3) K-PSS scores

The K-PSS developed by Cohen Kamarck and Mermelsein in 1983 and adapted to Korean conditions was used to assess the subjective level of stress [29]. This scale was validated for reliability and validity among college students by Park and Seo in 2010 [30]. The scale consisted of negative perceptions (1, 2, 3, 9, and 10) and positive perceptions (4, 5, 6, 7, and 8) scored on a 5-point Likert scale from 0 to 4. A higher total score indicated a higher level of perceived stress.

4) VAS scores

The VAS, commonly used for pain measurement purposes, was used to measure subjective pain. It is a subjective assessment of pain intensity on an 11-point scale ranging from 0 (no pain) to 10 (maximum pain). The scale has a high reliability with an intra-class correlation coefficient score of .9 [31].

4. Data Analysis

All data analyses were conducted using IBM SPSS version 28.0 (IBM Corp., Armonk, N.Y., USA). The data are presented as means and standard deviations or percentages; all statistical significance levels were set at .05. The normal distribution of the data was confirmed by the Kolmogorov–Smirnov test.

Based on the CVA of 50° as the threshold, the participants were classified into the FHP and normal alignment group. The variables measured during the semester and exam period were analyzed using an independent t-test to compare the means between the groups and a paired t-test to compare the means within each group.

Pearson correlation coefficient analysis was performed using data from all participants to examine the relationships among CVA, PPT, and perceived stress during both the semester and exam period. The correlation coefficient values were interpreted as follows: ≤ .35, weak correlation; .36–.67, moderate correlation; and .68–1.0, strong correlation [32].

Ⅲ. Results

Among the demographic characteristics of the participants, no statistically significant differences were observed in age, height, and weight between the groups (Table 1). The mean CVA was 44.84 ± 3.14° in the FHP group and 53.69 ± 1.27° in the normal alignment group, showing a significant difference between them.

Within each group, paired sample t-tests were performed to compare the mean VAS score, K-PSS score, and bilateral PPT between the semester and exam period (Table 2). In the FHP group, VAS and K-PSS scores were significantly higher, and bilateral PPT values were significantly lower, during the exam period compared with the semester (VAS: 3.44 ± 1.93 vs. 2.19 ± 1.60; K-PSS: 20.25 ± 4.09 vs. 16.13 ± 3.6; right side PPT: 2.51 ± .81 kg/cm^2 vs. 3.28 ± 1.06 kg/cm^2; left side PPT: 2.63 ± .77 kg/cm^2 vs. 3.21 ± .75 kg/cm^2).

No statistically significant differences were observed in the VAS score, K-PSS score, and left PPT in the normal alignment group. However, the mean PPT on the right side was significantly lower during the exam period than during the semester (3.39 ± .98 kg/cm2 vs. 3.79 ± 1.10 kg/cm2).

These analyses were limited to within-group and between-group comparisons at each period; the interaction effect between group and period was not statistically tested.

Pearson correlation analysis was conducted to examine the associations among CVA, PPT, and perceived stress during both the semester and exam periods. All participants exhibited a moderate correlation between CVA and PPT of the bilateral upper trapezius muscles during the exam period (right side: r = .408, p = .020; left side: r = .462, p = .008). However, during the semester, CVA the bilateral PPT of the upper trapezius muscles showed a weak correlation (right side: r = .218, p = .230; left side: r = .099, p = .590) (Table 3).

No correlation was observed between the perceived

Table 1. General characteristics of students (n = 32)

	FHP (n = 16)	Normal (n = 16)	t	p
Age (yr)	21.06 ± 1.57	21.25 ± 1.65	-.329	.744
Sex				
Female	7 (43.8)	12 (75.0)		
Male	9 (56.2)	4 (25.0)		
Height (cm)	166.06 ± 8.56	168.31 ± 8.44	-.749	.460
Weight (kg)	66.06 ± 7.82	62.69 ± 10.36	1.040	.307
CVA (°)	44.84 ± 3.14	53.69 ± 1.27	-10.445	<.001*
Dominant hand				
Right	12 (75.0)	13 (81.2)		
Left	4 (25.0)	3 (18.8)		

*p < .05
Values are presented as mean ± standard deviation or number (%).
CVA: cranio-vertebral angle, FHP: forward head posture.

Table 2. Within-group outcomes during semester and exam period (n = 32)

Within-group Outcomes	Groups	During semester	During exam period	t	p
VAS	FHP	2.19 ± 1.60	3.44 ± 1.93	-2.660	.018*
	Normal	2.50 ± 1.43	2.22 ± 1.56	.783	.446
PSS	FHP	16.13 ± 3.65	20.25 ± 4.09	-3.149	.007*
	Normal	17.56 ± 6.76	19.06 ± 5.07	-1.873	.081
RightPPT (kg/cm^2)	FHP	3.28 ± 1.06	2.51 ± .81	6.011	<.001*
	Normal	3.79 ± 1.10	3.39 ± .98	2.995	.009*
Left PPT (kg/cm^2)	FHP	3.21 ± .75	2.63 ± .77	3.355	.004*
	Normal	3.34 ± .97	3.34 ± .83	.000	1.000

*p < .05
Values are presented as mean ± standard deviation or number (%).
FHP: forward head posture, PPT: pressure pain threshold, PSS: perceived stress scale, VAS: visual analogue scale.

Table 3. Correlation of CVA and PSS with PPT across semester and exam period (n = 32)

			Correlation coefficient (r)	p
CVA	During semester	Right PPT	.218	.230
		Left PPT	.099	.590
	During exam period	Right PPT	.408	.020*
		Left PPT	.462	.008*
PSS	During semester	Right PPT	-.154	.401
		Left PPT	-.238	.190
	During exam period	Right PPT	-.204	.263
		Left PPT	-.192	.292

*p < .05
Values are presented as mean ± standard deviation.
CVA: cranio-vertebral angle, PPT: pressure pain threshold, PSS: perceived stress scale.

stress and PPT of the bilateral upper trapezius muscles during the exam period (right side: r = -.204, p = .263; left side: r = -.192, p = .292). Similarly, no correlation was observed during the semester between the perceived stress and PPT of the bilateral upper trapezius muscles (right side: r = -.154, p = .401; left side: r = -.238, p = .190) (Table 3).

This supplementary analysis provided additional insight into the interrelationships among CVA, PPT, and perceived stress. Although the correlations between perceived stress and PPT were not significant, the moderate association between CVA and PPT during the exam period suggests that postural alignment may influence pain sensitivity under stress-related conditions.

Ⅳ. Discussion

This study investigated the effects of the exam period on the factors associated with neck and shoulder pain in college students with FHP. Furthermore, we evaluated the correlation between FHP and PPT of the upper trapezius muscles by examining the differences in subjective neck and shoulder pain, PPT of the upper trapezius muscles, and perceived stress levels between college students with FHP and those with normal alignment during the semester and exam period.

Our results showed that neck pain and perceived stress levels were significantly higher during the exam period than during the semester in college students with FHP. These results corroborated the findings of previous studies, reaffirming that neck pain and perceived stress levels were higher in college students during the exam period than during the semester [20]. However, unlike previous studies, this study classified participants according to their CVA and compared outcomes across periods. No significant difference was noted in the neck pain and perceived stress levels during the semester and exam period in college students with normal alignment; however, those with FHP showed significant differences in the neck pain and perceived stress levels. These results suggest that subjective neck and shoulder pain and perceived stress levels in college students with FHP may be influenced by stressful situations, such as exam periods. Siivola et al. [33] identified risk factors for neck pain in young adults and found an association between neck pain and perceived stress in men but not women. The inconsistent results between sexes in previous studies could be attributed to the failure to account for postural alignment, such as FHP, due to changes in CVA.

In this study, PPT of the bilateral upper trapezius muscles of college students with FHP were significantly lower during the exam period than during the semester. Moreover, a moderate correlation was observed between CVA and PPT of the upper trapezius muscle during the exam period. These results are in contrast to previous study that reported no significant association between CVA and PPT and that FHP does not affect tissue sensitivity of the neck and upper trapezius muscles [34]. This discrepancy may be explained by methodological and sample-related differences. Unlike earlier studies that did not account for postural alignment or psychological stress, the present study classified participants according to CVA and examined them under acute academic stress, which may have heightened sympathetic nervous system activation and muscle tension. In addition, the repeated-measures design across distinct time points may have increased the sensitivity to detect stress-related changes in pain thresholds. These findings suggest that psychological stress during exam periods may interact with postural misalignment to influence muscle sensitivity in individuals with FHP.

Although no significant correlations were found between perceived stress and PPT, this result likely reflects the complex and multifactorial nature of pain modulation under psychological stress. The association between stress and pain sensitivity is not necessarily linear; transient or moderate stress may activate descending inhibitory mechanisms that elevate pain thresholds, whereas chronic or excessive stress can enhance central sensitization and reduce pain thresholds. In addition, individual variability in stress perception, coping strategies, and autonomic responses, as well as the relatively mild and short-term stress experienced by healthy students during exams, may have attenuated the expected relationship between perceived stress and PPT.

The results of this study indicate that exam periods, a situation of relatively high psychological stress compared to the rest of the semester, may contribute to neck and shoulder pain in college students with FHP. These findings imply that maintaining optimal posture and effectively managing stress are essential for the prevention and management of neck and shoulder pain.From a clinical standpoint, an integrated approach that addresses both biomechanical and psychosocial factors should be emphasized. Interventions such as postural retraining, relaxation techniques, and stress management programs may help prevent reductions in pain thresholds and mitigate the impact of psychological stress on musculoskeletal function during academically demanding periods.

This study has certain limitations, such as the limited number of participants, the limited range of participants, and the fact that self-rated perceived stress levels may not correspond to actual stress levels. In addition, several potential confounding factors that could influence stress PPT such as sleep quality, caffeine intake, and physical activity were not controlled in this study. Moreover, posture and PPT are dynamic variables that can fluctuate depending on the time of day or day of the week. Because all measurements were performed only once per period, without controlling for the specific time of assessment, temporal variations may have influenced the results. Future studies involving larger and more diverse populations, together with the use of objective stress biomarkers and standardized control of these confounders and measurement timing, are warranted to validate and extend the present findings.Although this study adopted a repeated-measures design, the statistical analysis was confined to t-tests comparing within- and between-group differences. Future research should consider applying more advanced statistical approaches, such as two-way repeated-measures ANOVA, to better identify potential group–period interaction effects and to clarify the multifactorial relationship among FHP, PPT, and psychological stress. In addition, further research on exercise program methods and education to help improve posture in college students with FHP is needed.

Ⅴ. Conclusion

This study suggests that FHP, a form of postural malalignment, is not only associated with physical factors, such as musculoskeletal pain and PPT, but also psychological factors. Moreover, in specific stressful times, such as exam periods, incorrect posture has a greater correlation with physical and psychological factors than normal posture, underscoring the need to recognize the importance of correct posture.

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