J. Phys. Ther. Sci. 33: 489–494, 2021

The Journal of Physical Therapy Science

Original Article

Cervicothoracic spinal alignment and neck flexor muscle endurance in young and older adult females with and without neck and shoulder pain (*Katakori* in Japanese)

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Abstract. [Purpose] The characteristics of neck and shoulder pain (NSP) in different age populations have not been sufficiently examined. Therefore, the purpose of this study was to compare and verify the cervicothoracic spinal alignment and neck flexor muscle endurance of young and older adult females with and without NSP. [Participants and Methods] We assessed 72 female participants (39 young participants, 33 elderly participants, 43 NSP, 29 non-NSP) aged 18–82 years who were recruited for this study. Cervicothoracic spinal alignment measurements were obtained with forward head alignment (FHA) along with the upper thoracic angle. The neck flexor endurance test was performed. [Results] There were no significant age-by-group interactions for any of the assessment variables. However, the upper thoracic angle and neck flexor muscle endurance showed significant effects in the groups. Age also had significant effects on FHA and upper thoracic angle. [Conclusion] These results suggested that the neck flexor muscle endurance was more appropriate as an evaluation tool for older adult females with NSP. It was also suggested that the cervical flexor muscle endurance and upper thoracic angle were more appropriate as evaluation tools for young adult females with NSP.
Key words: Neck and shoulder pain (NSP), Young and elderly females, Cervicothoracic spinal alignment and neck flexor muscle endurance

(This article was submitted Feb. 3, 2021, and was accepted Mar. 26, 2021)

INTRODUCTION

Katakori is a Japanese term that indicates nonspecific symptoms, including discomfort or dull pain caused by muscle stiffness around the occiput through the cervical spine to the acromion and scapular area[1)].

A comprehensive survey of the living conditions (health and welfare) of the general population conducted in 2016 showed that *Katakori* was the most common subjective symptom among Japanese females and the second most common among males in the past 20 years[2)]. Takagishi et al. reported that neck and shoulder pain or chronic nonspecific neck pain was similar to *Katakori* in terms of the associated symptoms, based on a review of previous studies published in the English literature[3)]. Therefore, *Katakori* was defined as "neck and shoulder pain" (NSP) in many research studies[4, 5)].

According to a report by Takasawa et al.[6)], the number of people with NSP was highest, especially among people in their 30s or younger, and the prevalence decreased as the age increased. Among them, the ratio of females was higher, and it is likely that many young females are aware of NSP. In addition, an epidemiological study of NSP in high school students reported that nearly 70% had NSP, and they were more common in females in senior year[7)]. In other words, the current

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situation is that younger females are complaining of NSP. Reportedly, more than 80% of elderly individuals experience musculoskeletal pain, and the prevalence of pain increases with age[8, 9]. Moreover, degenerative spinal disorders also increase with age as well[10]. Furthermore, the number of females with low back pain, for which there is a high rate of complaints in the comprehensive survey of the living conditions as is also the case with NSP, increases with age[2]. In other words, the age group complaining of NSP shows characteristics different from those with respect to the tendency to increase with age.

The characteristics of NSP have shown to be associated with multiple factors, including psychological distress, pain at other body sites, smoking, and other medical problems[11–19]. Only a few papers have described the relationship between these factors and *Katakori* written in Japanese over 10 years ago, but more than 550 papers about *Katakori* have been published in Japanese and English from 2011 to 2016[4, 5, 20, 21]. However, there is no standardized protocol to assess or treat the *Katakori*.

Several studies have reported the relationship between posture and NSP[22–24] or muscle endurance and NSP[25–27]. However, considering that multiple factors might cause NSP, it will be limited to determine the cause of the symptoms by utilizing only a single assessment tool. A question also remains as to which assessment tools will lead to a more effective treatment. Quantitative evaluation methods that can be conducted relatively easily and quickly are required in community facilities and clinical settings. For example, a combination of cervicothoracic spinal alignment and cervical flexor endurance evaluation can be easily performed and has frequently been reported to improve NSP. Alternatively, using an appropriately selected evaluation is very important for the effective treatment of NSP complaints that have different characteristics from general joint pain and spinal disorders.

Therefore, in this study, we compared and verified the evaluation of cervicothoracic spinal alignment and neck flexor muscle endurance of young and elderly females with and without NSP. Unlike many other pain symptoms, by focusing on the wide distribution of patients' age range, our purpose was to search for age-specific causes rather than common causes of NSP across ages.

PARTICIPANTS AND METHODS

Thirty-nine young female participants (21 NSP, 18 non-NSP, mean age; 20.6 ± 0.8 years) and thirty-three elderly female participants (22 NSP, 11 non-NSP, mean age; 71.1 ± 4.5 years) were recruited to this study (Table 1). The questionnaire for the intensity, location, and duration of symptoms was given to all the participants prior to the procedure. Written informed consent was obtained from each participant prior to the procedure as well. The inclusion criteria for the NSP group were symptom duration of more than one year and symptom location including defined area from previous studies[28]. The exclusion criteria for all participants were history of cervical surgery and immunological disease such as rheumatoid arthritis. Demographic data were collected, and weight and BMI were measured using a multi-periodicity body composition analyzer (Tanita, Japan).

Right lateral view photographs of head, neck and upper trunk were taken to measure the cervicothoracic spinal alignments. The method of angular measurement utilized in this study was adopted from previous studies[29] (Fig. 1). The participants were seated on a 45-cm wooden stool with feet placed flat on the floor and arms resting comfortably on their thighs. They were asked to extend their trunk, and then sit comfortably as usual as they were looking at the target on the wall, which was set on their eye height level. A digital camera (Everio, Victor, Japan) was positioned on a tripod at a distance of 2.5 m from the participant. The axis of the lens of the camera was placed orthogonal to the sagittal plane of the subject at a height that corresponded with the seventh cervical vertebra. Adhesive markers were placed on the tragus of the ear and spinous processes of the seventh cervical and fifth thoracic vertebrae. ImageJ (public domain free software) was used to detect each center of the markers as a digital point in image and measure angles between two intersecting lines including the lines connecting the points. Forward head angle (FHA) was measured as the acute angle between the vertical line and the line connecting the tragus of the ear and the seventh cervical vertebra. The sagittal posture of the thoracic spine (upper thoracic angle) was measured as the angle between the vertical line and the line from the seventh cervical spinous process to the fifth thoracic spinous process.

The neck flexor endurance test was performed in the same manner as described in a previous study (Fig. 2), and this test has been shown to have excellent reliability in participants with postural neck pain[25]. The test was performed with the participant in a supine position with a hook-lying position on a table. The participan's chin was maximally retracted and maintained isometrically. The participant was then asked to lift the head and neck until the head was approximately 2.5 cm above the table. Once in position, a line was drawn across two approximated skin folds along with the participant's neck, and the rater placed his hand on the table just below the occipital bone of the participant's head. The test was terminated if the participant was unable to hold the head in the correct position (the edges of the lines no longer approximated each other due to loss of upper cervical flexion). The holding time was measured in seconds.

For statistical analysis, two-way ANOVA was used to analyze the two-factor group (presence or absence of NSP) and age (young and elderly) (2 × 2). SPSS version 27.0 (IBM Japan, Ltd.) was used for statistical processing, and the significance level in all tests was set at 5%. The study received the approval by the Ethics Committee of Niigata University of Health and Welfare (Approval number:17870-170810, 18008-180628).

Table 1. Characteristics of the participant groups

	Elderly	Young
	(n=33) (NSP=22, non-NSP=11)	(n=39) (NSP=21, non-NSP=18)
Age (years)	71.06 ± 4.51 (range: 65–82)	20.64 ± 0.78 (range: 18–22)
Height (m)	1.53 ± 0.04	1.59 ± 0.05
Weight (kg)	53.43 ± 7.63	49.98 ± 5.03
BMI (kg/m^2)	22.87 ± 3.21	19.72 ± 1.80

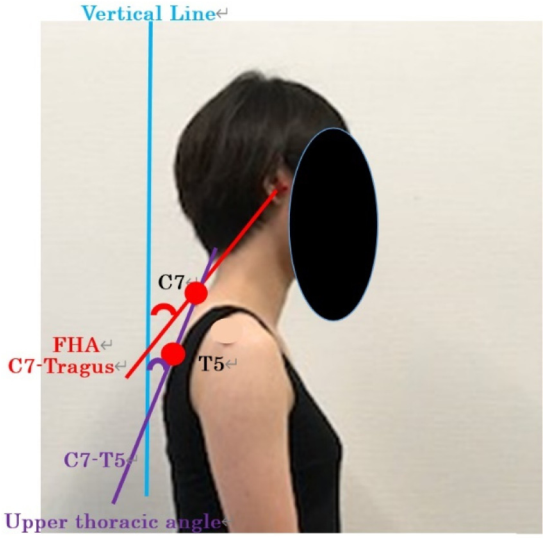

Fig. 1. Forward head alignment (FHA) and upper thoracic angle in sitting.
FHA: the angle between the vertical line and the line connecting the tragus of the ear and the seventh cervical vertebra.
Upper thoracic angle: the angle between the vertical line and the line from the seventh cervical spinous process to the fifth thoracic spinous process.

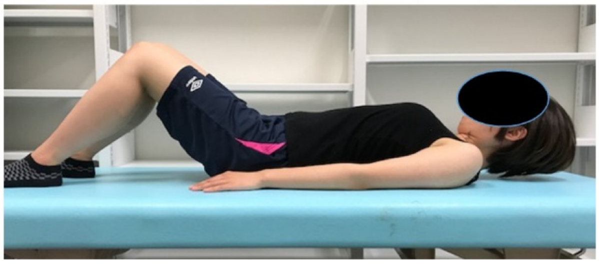

Fig. 2. Neck flexor endurance test.
The participant's chin was maximally retracted and lift the head and neck until the head was approximately 2.5 cm above the table.

RESULTS

Table 1 presents the demographic characteristics and Table 2 presents the values of the FHA, upper thoracic angle, and neck muscle endurance data for the two groups. There were no significant age-by-group interactions for any of assessment variables. However, the main effect of group on the upper thoracic angle was significant ($p<0.01$) such that persons with NSP had larger upper thoracic angle than persons without NSP. The main effect of group on the neck flexor muscle endurance was also significant ($p<0.01$) such that persons with NSP had lower level of neck flexor muscle endurance than persons without NSP. The main effects of age on the FHA ($p<0.03$) and the upper thoracic angle ($p<0.01$) were significant such that young persons had smaller FHA and the upper thoracic angle than elderly persons.

DISCUSSION

In this study, we compared and verified cervicothoracic spinal alignment and neck flexor muscle endurance of young and elderly females with and without NSP.

There was no significant age-by-group interaction for FHA. There was also no main effect of group; however, there was a significant main effect of age. Previous study related to age reported that patients aged 50 years or older with chronic neck pain of nontraumatic origin did not show a significant difference in FHA compared to those without neck pain[30]. In addition, in other previous studies, there was no significant difference in the comparison of habitual sitting postures with and without neck pain[31], and the spinal alignment of the sitting position of the young participants was not clearly associated with neck/

Table 2. Two-way ANOVA statistics of the data of FHA, upper thoracic angle, and neck muscle endurance in young and elderly female participants with and without NSP

	Age	Group			p-value		
		Total	NSP (n=43)	non-NSP (n=29)	Age × Group	Age	Group
FHA (°)	Elderly	45.33 ± 5.09	45.36 ± 5.14	45.26 ± 5.22	0.13	**0.03**	0.11
	Young	42.58 ± 5.93	44.51 ± 6.22	40.32 ± 4.81			
Upper thoracic angle (°)	Elderly	30.83 ± 7.09	32.28 ± 6.44	27.94 ± 7.76	0.45	**<0.01**	**<0.01**
	Young	22.96 ± 7.79	26.16 ± 7.50	19.24 ± 6.49			
Neck muscle endurance (s)	Elderly	54.81 ± 38.08	42.50 ± 28.54	79.42 ± 43.94	0.21	0.4	**<0.01**
	Young	65.68 ± 43.74	38.98 ± 15.33	96.84 ± 45.74			

Bold value: p<0.05.
ANOVA: analysis of variance; NSP: neck and shoulder pain; FHA: forward head alignment.

shoulder pain[32]. Previous study of cervicothoracic spinal alignment has shown that age-related changes can lead to a forward head posture with or without symptoms[33]. It has also been reported that age-related changes (enhancement of thoracic and lumbar kyphosis)[34] could lead to a forward head posture. In other words, the symptoms of NSP have little effect on the forward head posture. It is likely that kyphosis of the spine caused by age-related degeneration affects the forward head posture. This would explain why no significant difference was observed in the interaction of FHA.

From these findings, it was suggested that the increase in FHA is affected by aging, not by the presence or absence of NSP.

There was also no significant age-by-group interaction for upper thoracic angle. However, there were significant main effects of group and age. Previous study related to age reported an increase in kyphosis of the thoracic and lumbar spine with aging[34]. It has also been reported that more than two-thirds of women aged 65 and over have a severe increase in thoracic kyphosis even without a history of vertebral compression fractures[35]. Furthermore, among young and elderly females, it has been reported that the thoracic kyphosis in a relaxed position is significantly larger in elderly females than in young females[36]. In other words, it means that the upper thoracic angle increased with aging. Previous studies of cervicothoracic spinal alignment revealed sagittal alignment of the cervical spine is strongly influenced by the sagittal alignment of the thoracic spine, which is the lower adjacent spine[37, 38]. Another study reported a correlation between increased upper thoracic spine angle and neck pain[23]. Moreover, reports indicate that flexion of the entire spinal column increases the activity of the spinal erector and increases the compression of the posterior structures[29], while sitting in a slumped posture increases the thoracic spine flexion and head and neck extension, which thereby increases the cervicothoracic erector activity to maintain the forward head posture[39]. Thus, it can be inferred that the increase in the upper thoracic angle leads to increased load on the posterior structures. In other words, not only the symptoms of stiff shoulders but also kyphosis of the spinal column caused by age-related degeneration is likely to affect the anterior deviation of the head. However, neither the presence of NSP nor age-related degeneration affects the upper thoracic angle more than the other. Therefore, it is likely that no significant difference was observed in the interaction of the upper thoracic angle. From the above, it was suggested that the increase in the upper thoracic angle was affected by both the presence and absence of NSP and aging.

There was also no significant age-by-group interaction for neck flexor muscle endurance. There was also no main effect of age; however, there was a significant main effect of group. In previous studies related to age reported that the proportion of Type I muscle fibers in the longus colli and longus capitis muscles in the elderly decreased compared to that of the scalene muscles[40], and the antigravity muscle strength in the elderly decreased compared that in young individuals[41]. Conversely, the endurance of patients with neck pain is very low even among young people[42]. It has been also reported to be significantly declines in endurance of the neck flexor muscle in adolescents with neck pain[43]. In other words, muscle endurance is presumed to be affected regardless of aging. In previous studies related to muscle function, patients with cervical pain had decreased cervical flexor muscle strength and endurance[44–46]. Compared to healthy individuals, isometric cervical flexor endurance is reported to have clinically low values[25]. With respect to the stability of the cervical spine, bones and ligaments account for 20% and muscles account for 80%[47]. This suggests that muscle condition and degeneration have a considerable effect on the cervical spine. In addition, report revealed that in patients with cervical pain, the proportion of type II fibers was high, and the synchrony of motor units also changed[48], suggesting that pain was associated with muscle degeneration. In other words, the effect of aging on muscle endurance is small, and it is likely that muscle degeneration caused by symptoms of NSP affects neck flexor muscle endurance. Therefore, it is possible that no significant difference was observed in the interaction of neck flexor muscle endurance. From the above, it was suggested that the neck flexor muscle endurance is affected not by aging but by the presence or absence of NSP.

As a limitation of this study, the participants involved in this study were young and elderly females, and the study did not examine middle-aged females. Moreover, even though the participants in this study had complained of NSP symptoms, as the symptoms were not severe enough to require medical intervention, whether an underlying disease was present is unclear. Furthermore, as previously mentioned, this study was limited to participants with relatively high levels of physical ability and ADL function. Thus, in the future, it would be necessary to compare and examine the patients of different age groups, with or without the confirmation of an underlying disease at a medical institution, and participants with low ADL function.

In conclusion, we performed cervicothoracic spinal alignment and neck flexor muscle endurance for young and elderly females with and without NSP and compared and verified these findings. There were no significant age-by-group interactions for any of assessment variables. However, there were significant main effects of group for the upper thoracic angle and neck flexor muscle endurance. There were also significant main effects of age for the FHA and upper thoracic angle. These results suggest that the cervical flexor muscle endurance is more appropriate as evaluation tools for elderly females with NSP. It was also suggested that the cervical flexor muscle endurance and upper thoracic angle are more appropriate as evaluation tools for young females with NSP. Finally, it was suggested that FHA is more appropriate evaluation tool for cervicothoracic alignment due to aging, not for NSP.

Funding and Conflict of interest

No potential conflict of interest was reported by the authors.

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