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ORIGINAL ARTICLE

Objective evaluation of neck muscle tension and static balance in patients with chronic dizziness

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Abstract

Conclusion: Increase in the average value of bilateral neck muscle tension (ANT) indicates the increase in neck muscle tension to stabilize static posture resulting from vestibular compensation. Asymmetry of neck muscle tension was closely related to postural imbalance. *Objective:* Patients with dizziness often complain of neck symptoms with stiff neck. This study was conducted to clarify the pathophysiological mechanism of neck symptoms in patients with dizziness. *Methods:* We objectively measured bilateral trapezius muscle tension in patients with chronic dizziness and determined its relationship with static postural perturbation. The study included 26 patients with chronic dizziness caused by unilateral vestibular deficit and 24 healthy controls. The tension of bilateral trapezius muscles was objectively measured using a neck muscle tension meter. ANT and the ratio (right/left) of the bilateral neck muscle tension (RNT) were calculated. Static posturography was performed to measure total length of path (LNG). *Results:* ANT was negatively correlated to LNG under the eyes closed (EC) condition only in the case of the patients ($r = -0.44$, $p < 0.05$). In the case of both the controls and the patients with a unilateral vestibular deficit, RNT was positively correlated to LNG under the EC condition.

Keywords: *Posturography, neck muscle, vestibular compensation, vestibular input*

Introduction

Postural adjustments are based on visual, vestibular, and somatosensory inputs integrated in a complex feedback regulatory system. Animal studies have demonstrated the importance of cervical sensory information for postural control. Receptors in the cervical spine make important connections to the vestibular and visual apparatus as well as to several areas of the central nervous system. The importance of neck input is clear from the fact that dizziness and subjective balance disturbances are common complaints in cervical pain syndromes. When one of these sources of input is impaired, a process known as vestibular compensation acts to stabilize postural adjustments. This process of vestibular compensation is multimodal, and the loss of vestibular input is compensated by the potentiation of other inputs. For example, the cervico-ocular reflex (COR) compensates for the loss of angular vestibulo-ocular reflex [1].

Symptoms of head and neck/shoulder pain are significantly more common in patients with dizziness, pointing to important links between neck input and dizziness, which are supported by animal studies. Neck muscle activity after the acute phase of unilateral labyrinthectomy in the alert guinea pig is a model of unilateral severe vestibular dysfunction [2]. In the presence of a unilateral vestibular deficit, a decrease in tonic electromyography (EMG) activity was observed contralateral to the lesioned neck muscle, while an increase in tonic EMG activity was detected in the ipsilateral neck muscle. This phenomenon illustrates vestibular compensation. Vestibular compensation is a process proved after vestibular deficit, and it involves multiple, parallel plastic processes [3].

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The relationship between neck muscle tension and static balance has not been thoroughly investigated. Muscle tension, measured using a tension meter, is known to be altered in chronic tension-type headache. Patients with tension-type headache exhibit proprioceptive disturbances related to chronic pericranial muscular contractions and increased muscular tension. The positive correlation between muscle hardness and tenderness supports the common clinical observation that tender muscles are harder than normal muscles [4].

Posturographic analyses have clearly shown effects on the balance system in patients with vertigo and dysfunctions of the cervical spine [5]. Abnormal static and dynamic balance parameters have been observed in chronic neck pain patients with vertigo, and these findings can be explained by impaired cervical proprioception [6]. Afferent information from cervical receptors can be altered via a number of mechanisms, including functional impairment of the receptors and changes in muscle spindle sensitivity caused by vestibular compensation from neck proprioceptive receptors [7]. Furthermore, localized areas of tenderness are thought to be caused by muscular hypertonicity that is dependent on the hyperactivity of proprioceptors [8].

We are interested in the relationship between tension in neck muscles and static posturography. We used objective measurement tools to measure muscle tension in trapezius muscles in patients with chronic dizziness, and compared these parameters with results from static posturography.

Material and methods

There were 26 patients (8 men and 18 women; average age 54.3 ± 17.6 years) with chronic dizziness (lasting for more than 3 months) due to chronic unilateral vestibulopathy, and 24 age- and gender-matched healthy controls (6 men and 18 women; average age 50.3 ± 13.6 years). All patients underwent a conventional neurologic evaluation including pure tone audiometry, posturography, balance examinations, and magnetic resonance imaging (MRI) if required. Spontaneous and positional nystagmus was carefully investigated with an infrared CCD camera. If the nystagmus was observed, the patients were not included in this study. Patients with central lesions were excluded. All patients with orthopedic disorders in the neck, shoulder or back were excluded from this study to omit subjects with neck muscle tension who were affected by reasons other than vestibular hypofunction. With respect to the hearing level of the subjects, the averages of four consecutive frequencies (500, 1000, 2000, and 4000 Hz) were 31.1 ± 17.9 dB in the right ear and 27.1 ± 14.5 dB in left.

Tension in the trapezius muscle was measured with a tension meter using the TDM-N1 system (NEUTONE, Japan) at the midpoint between either side of the spinous process of the seventh cervical vertebra and the superior angle of the scapula. To perform manual palpation of a pericranial muscle to assess tension, we pressed the muscle with the fingers and noted the amount of distortion in the muscle and the amount of back pressure felt by the fingers. The TDM-N1 simulates such manual palpation and converts it into quantitative data [9,10]. Measurements were repeated three times on either side and the values were averaged. We calculated the average of bilateral neck muscle tension (ANT) and the ratio (right/left) of bilateral neck muscle tension (RNT).

Static posturography was performed to measure the total length of the path (LNG) for 60 s under eyes open (EO) and eyes closed (EC) conditions. Subjects stood quietly on a force platform (Gravicorder G-6100; Anima, Tokyo, Japan) while looking at a filled black circle with a diameter of 5 of the visual angle and placed 1.5 m straight ahead of the eyes. Subjects stood with both feet close together and both arms at their sides while the measurements were obtained. Under these conditions, the trajectory of the center of pressure was recorded at a sampling rate of 20 Hz. Statistical analysis was performed using GraphPad Prism 3 (GraphPad Software Inc., CA, USA); differences between groups were assessed using an unpaired *t* test and results were considered statistically significant when p was < 0.05. The correlation coefficient between LNG and either ANT or RNT was calculated to assess the extent of correlation.

Results

We found no statistical differences in ANT or RNT between patients with right and left vestibular lesions. Thus, the data from each side were averaged for comparison with controls. We found a negative correlation between ANT and LNG under EC conditions only in affected patients ($r = -0.44$, $p < 0.05$) (Table I). We found a positive correlation between RNT and LNG under EC conditions in both controls ($r = 0.44$, $p < 0.05$) and patients with unilateral vestibular deficits ($r = 0.52$, $p < 0.05$) (Table I).

Discussion

Control over human posture is exerted by a multisensory system consisting of visual, proprioceptive, auditory, and vestibular subsystems, allowing three-dimensional space perception [11]. Posture and

Table I. ANT, RNT, and their correlation with LNG (EC).

Group	ANT	ANT and LNG (EC)	RNT	RNT and LNG (EC)
Control (n = 24)	27.4 ± 3.5 (NS)	NS	1.1 ± 0.2 (NS)	r = 0.44 (p < 0.05)
Chronic dizziness (n = 26)	29.7 ± 5.4	r = −0.44 (p < 0.05)	1.1 ± 0.1	r = 0.52 (p < 0.01)

ANT, average of bilateral neck tension; EC, eyes closed; LNG, total length of path; NS, statistically not significant; RNT, ratio of bilateral neck tension. We found a negative correlation between ANT and LNG under EC conditions only in affected patients.

purposive motion are adjusted by the interplay of these systems. Their coordination is subject to control by central nervous centers [12]. Vestibulo-ocular, optokinetic, and cervico-ocular reflexes, as well as proprioceptive receptors of the cervical spine in the facet joints and in the paravertebral muscular system, are vital components of posture control. Effects of neck vibration on postural stability have been reported previously. In patients with peripheral vestibular lesions, average deviation of body position was moderately increased compared with normal subjects, when the neck muscles were exposed to vibration under EC conditions [13]. This result strongly suggests that neck proprioceptive input is important for postural control.

We found a negative correlation between ANT and LNG under EC conditions only in affected subjects (Table I). We propose that this negative correlation results from vestibular compensation for increased proprioceptive inputs to vestibular nuclei from neck muscles. We found a positive correlation between RNT and LNG under EC conditions in controls and in patients with unilateral vestibular deficits (Table I). We hypothesize that the neck muscle asymmetry reflects asymmetry in vestibular function. Tension is increased to compensate for postural stabilization, but tension asymmetry is not completely compensated. Unfortunately, in this experiment, we could not obtain quantitative data of vestibular asymmetry. This hypothesis should be investigated in a future study.

In addition, we assume that the lack of a significant difference in LNG between patients and controls under EO conditions indicates a shift of perceptual weighting magnitude from the vestibular system to the visual system.

In a previous investigation of the role of proprioceptors of different skeletal muscles in postural control, in patients with unilateral labyrinthine dysfunction (ULD), the effect of vibration on the trapezius muscles was studied by posturography. Vibration of the dorsal neck muscles caused a postural deviation toward the dysfunctional side. The data suggest that the upper dorsal neck muscle plays an important role in maintaining body balance in the frontal plane in patients with ULD [14]. In subjects with unilateral vestibular dysfunction, the application of a vibratory stimulation (100 Hz) to the right and left dorsal neck muscles produces a nystagmus directed towards the good ear in 85% of patients. In healthy subjects, nystagmus occurs in 6% of the cases [15]. These results indicate that manipulation of the neck afferents causes decompensation in subjects whose vestibular dysfunction has already been compensated for by multisensory inputs including neck afferents. Moreover, in a study of three human subjects with absent labyrinthine function, the passively induced COR was moderately potentiated, accounting for about 25% of compensation for head motion during active target seeking [16].

Conversely, in healthy subjects, fixation of the cervical spine leads to stabilization of postural balance. This fixation seems to be helpful in compensating for malfunction of other components of the balance system. This effect results from increased activity of the COR. There was no evidence of a COR in any of the healthy subjects in a recent study [17]. However, the reflex is increased in acquired vestibular loss, thereby partially compensating for the vestibular deficit [18].

The somatosensory system is composed of muscle spindles, Golgi tendon organs, and joint receptors, all of which are proprioceptive, and the exteroceptive receptors, such as mechanoreceptors in subcutaneous tissues. The muscle spindles are essential for sensing muscle length and the velocity of length change, and the Golgi tendon organs monitor muscle tension. Mechanical joint receptors register movements in the joint capsule [19]. The interaction between neck proprioceptors and the vestibular system has been investigated by application of neck vibration. Neck vibration can increase afferent activity from stimulated muscles [20]. Observation of the nystagmus provoked by stimulation of the neck can reveal the possible interactions or interference with cervical afferents [15]. The results show that afferent cervical somatosensory input can substitute for absent vestibular information as part of the central vestibular compensation in the presence of unilateral peripheral vestibular deficit.

In summary, the negative correlation of ANT and LNG (EC) observed in patients with chronic dizziness probably results from vestibular compensation for increased proprioceptive inputs to vestibular nuclei from neck muscles. This is the first report demonstrating a relationship between trapezius muscle tension and static balance.

Conclusion

Affected subjects with increased neck muscle tension had decreased LNG, as indicated by posturography. We conclude that in patients with chronic dizziness, neck muscle tension may increase to stabilize static posture resulting from vestibular compensation.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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