

INFLUENCE OF SUBCLINICAL NECK PAIN ON THE ABILITY TO PERFORM A MENTAL ROTATION TASK: A 4-WEEK LONGITUDINAL STUDY WITH A HEALTHY CONTROL GROUP COMPARISON



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ABSTRACT

Objective: Mental rotation of objects and the frame of reference of those objects are critical for executing correct and skillful movements and are important for object recognition, spatial navigation, and movement planning. The purpose of this longitudinal study was to compare the mental rotation ability of those with subclinical neck pain (SCNP) to healthy controls at baseline and after 4 weeks.

Methods: Twenty-six volunteers (13 SCNP and 12 healthy controls) were recruited from a university student population. Subclinical neck pain participants had scores of mild to moderate on the Chronic Pain Grade Scale, and controls had minimal or no pain. For the mental rotation task, participants were presented with an object (letter “R”) on a computer screen presented randomly in either normal or backwards parity at various orientations (0°, 45°, 90°, 135°, 180°, 225°, 270°, and 315°). Participants indicated the object’s parity by pressing “N” for normal or “B” for backwards. Each orientation for normal and backward parities was presented 5 times, and the average response time for all letter presentations was calculated for each participant, at baseline and 4 weeks later.

Results: Both groups had overall improved response times from baseline to 4 weeks. Healthy participants had significantly improved response times compared to SCNP, both at baseline ($P < .05$) and 4 weeks ($P < .05$).

Conclusions: Healthy participants performed better than the SCNP group at both time points. Subclinical neck pain may impair the ability to perform a complex mental rotation task involving cerebellar connections, possibly due to altered body schema. (*J Manipulative Physiol Ther* 2016;39:23-30)

Key Indexing Terms: *Cerebellum; Adult; Body Schema; Humans; Neuropsychological Tests; Space Perception; Visual Perception; Mental Processes*

The concept of an altered body schema in individuals with chronic pain has become a recent area of interest, with the altered schema extending to peripersonal space.¹ Mental rotation is the ability to rotate mental representations of 2 or 3 dimensional figures rapidly and accurately. Mental rotation is a complex task requiring

prediction and cerebellar involvement,^{2,3} and 1 past study showed that ability to mentally rotate an object improved with a single session of neck manipulation.⁴ Neck pain has been shown to impact upper limb proprioception,⁵ and recent neurophysiologic studies suggest that individuals with neck pain may have altered cerebellar processing.^{6,7}

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Subclinical neck pain (SCNP)⁸⁻¹⁰ refers to mild-to-moderate recurrent neck pain for which participants have not yet sought treatment. Individuals with SCNP show decreased neck range of motion, cervical kinesthesia, and muscle endurance.⁸⁻¹⁰ Individuals with SCNP may have days when they do not experience pain. Therefore, they provide an opportunity to explore the neurophysiologic impact of chronic changes in sensory input from the neck¹¹ without the confounding effect of current pain, which has been shown in previous studies to affect measures of sensorimotor integration and motor control.¹²⁻¹⁴

Recent work using transcranial magnetic stimulation⁷ showed that cerebellar function is altered in individuals with SCNP in comparison to healthy controls. Normally, the cerebellum disinhibits to allow learning of new motor skills. This ability is impaired in individuals with low-level neck pain. This influence raises the possibility that altered cerebellar processing of afferent input may contribute to alterations in other cerebellar dependent functions such as kinesthesia and spatial awareness.

The cerebellum is important in both feedback and feedforward models of motor control, using afferent feedback to update body schema to maintain accuracy of feedforward control of movement.³ The cerebellum also plays a critical role in spatial processing and object recognition.¹⁵ The study by Picazio et al¹⁵ used continuous theta burst stimulation (cTBS) to decrease cerebellar hemispheric excitability in healthy adult participants performing a mental rotation task. Mental rotation ability is important for a number of abilities such as acquiring spatially complex skills, object recognition, problem solving, and action planning.² Mental rotation is used in flight navigation¹⁶ as well as sport performance.¹⁷ In the study by Picazio et al,¹⁵ decreasing the input from the left cerebellar hemisphere using cTBS led to slower mental rotation response times for both an embodied mental rotation task requiring an egocentric mental rotation strategy and an abstract mental rotation task, which required an allocentric strategy, as compared to sham cTBS.

The involvement of the cerebellum in mental rotation is intriguing in light of 1 previous study that showed that upper cervical manipulation enhanced mental rotation ability in individuals with neck joint dysfunction compared to a group receiving a sham treatment.⁴ Altered kinesthetic awareness is known to occur in SCNP participants,^{5,9,10} and it seems likely that this may extend to altered spatial awareness of objects. If mental rotation ability is impaired in individuals with recurrent neck pain relative to healthy controls, it would suggest that the altered cerebellar processing could be contributing to not only a disrupted body schema but also disruptions in spatial recognition of objects.

Therefore, the aim of the current study was to compare mental rotation in a group of individuals with recurrent neck pain to a healthy control group and to follow up this

comparison at 4 weeks in the absence of any treatment for the neck pain group. We hypothesized that those in the SCNP group would have slower response times when performing mental rotation and that this would not be explained by changes in movement time (indicated by response time when the object was presented in normal orientation at 0° of rotation). Furthermore, we hypothesized that although both groups would improve over time due to task familiarity, the SCNP group would still show decreased mental rotation ability relative to the control group after 4 weeks.

METHODS

Participants

Thirteen participants (age, 21.2 ± 1.9 years; 8 females and 5 males) with self-reported neck pain but minimal acute pain on the day of testing participated in the study. Participants were shown a continuous 10-cm line and were asked to indicate their average pain in the experimental week from minimal pain severity on the far left of the line to maximal pain severity on the far right, also known as the visual analog scale. These participants additionally were classified as grades I to III on the Chronic Pain Grading Scale which categorizes pain intensity and disability between a grade of 0, meaning the participant had minimal pain in the previous 6 months, and a grade of IV, meaning very severe pain intensity and disability in the previous 6 months.^{18,19} The Chronic Pain Grade Scale indicates the average pain over 6 months, so the scores indicate the amount of pain of the participant on average over 6 months, but on the day of the experiment, they had no pain. Participants had to be free of pain on the day of the experiment or else they could not participate in the study. All participants were right handed with a mean score (\pm SD) of 71.6 ± 18.2 on the Edinburgh Handedness Inventory.²⁰

Data were also collected from a healthy control group of 12 participants (21.9 ± 2.1 years; 3 females and 9 males) without neck pain or a history of neck pain/injury. These participants had an Edinburgh Handedness Inventory score (\pm SD) of 73.0 ± 30.5 and very low grading on the Chronic Pain Grade Scale (0 disability points and characteristic pain intensity score ≤ 23).

Exclusion to participate included major structural injuries or anomalies to the cervical spine including disk herniation or fracture. As well, participants were excluded if they had received care for their neck condition in the past 3 months. Other exclusion items included inflammatory or system conditions (eg, rheumatoid arthritis or infection), trauma or other severe injury to the spine, radicular arm pain, hypermobility, intake of anticoagulant medication or bleeding disorders, history of stroke or cancer in the past 5 years, and vertigo or dizziness. Neck pain participants had to provide the history, frequency, duration, location, and

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