Test-retest reliability of assessing cervical proprioception using cervical range of motion device

Ravi Shankar Reddy, Khalid A. Alahmari, Paul S. Silvian
Department of Medical Rehabilitation Sciences, College of Applied Medical Sciences, King Khalid University, Abha, Kingdom of Saudi Arabia

Address for correspondence: Dr. Ravi Shankar Reddy, Department of Medical Rehabilitation Sciences, College of Applied Medical Sciences, King Khalid University, P. O. Box No. 3665, Guraiger, Abha, Kingdom of Saudi Arabia. E-mail: ravsreddy@gmail.com

ABSTRACT

Background: Cervical proprioception plays an important role in the stability and optimal functional of the cervical spine and assessment of cervical proprioception is integral in the assessment and management of cervical spine dysfunction. Cervical range of motion (CROM) device is an effective tool, simple and cost effective tool to assess cervical proprioception. The objective of the study was to establish the test-retest reliability of a CROM in assessing cervical proprioception in asymptomatic individuals. Methods: Twenty healthy adults (mean age 37.8 years) were recruited and test retest reliability of CROM device in assessing cervical proprioception was assessed. Cervico-cephalic kinaesthetic sensibility tests - Neutral Head Positioning (NHP) and Target head Positioning (THP) tests were used to assess cervical proprioception. The test retest reliability was assessed in 2 sessions each session is separated with the other by 48 hours. Results: The test-retest reliability of measurements made with the CROM was verified with ICC values for all cervical measurements ranging between 0.66 (CI: 0.1, 0.8) for Target Head Position – rotation right to 0.93 (0.8, 0.9) (CI: 0.8‑0.9) for THP – Rotation right. The correlation analysis found there are high and significant correlations between the test and retest results indicating that the reliability of the test can be established (positive correlation coefficients ranging from 0.524 – 0.863). Conclusion: CROM device can be used to quantify cervical proprioception errors with acceptable level of reliability in asymptomatic individuals.

Key words: Clinical tool, neck, proprioception, spine
INTRODUCTION

Proprioception process plays an integral role by occurring along the afferent pathways of the sensorimotor system. Sensorimotor system encompasses the whole process from providing a sensory stimulus to muscle activation; in other words, the acquisition of sensory stimulus, the conversion of stimulus into a neural signal, the transmission of the neural signal via afferent pathways to the central nervous system (CNS), the processing and integration of the signal by the various centers of the CNS, and thus eliciting motor response resulting in muscle activation for the performance of various tasks and joint stabilization. The imperative role of sensory information from mechanoreceptors in the skin, muscles, tendons, and joint structures plays in joint stability.

Any joint injury or joint diseases such as cervical spine injury or cervical spondylosis can lead to a disturbance in the sensory system. This disturbance can be measured by proprioceptive acuity. Several studies have concluded that subjects with a cervical spine injury, for example, a whiplash injury or acute or chronic neck pain have impaired or altered proprioception.

Two common measures of cervical proprioception are neutral head reposition sense, neutral head position (NHP), and target head position sense (THP). The THP is the most established test and is regarded as reliable, and more sensitive in detecting differences between groups, such as between patients with a neck injury, neck pain, and uninjured (control group). A relation between impaired kinesthesia, measured by THP, and poor functional performance (measured by Neck Disability Index) and poor subjective outcome (measured by disease-specific questionnaires or subjective estimation of neck function on a visual analog scale) has been found in patients with neck pain, whiplash injury, and spondylosis. Thus, one may imply that kinesthesia is an important indicator of the result of neck pain or neck injury.

As cervical proprioception is frequently evaluated in physical therapy practice, it is important to ensure that therapists have access to an objective tool for its measure. The cervical range of motion (CROM) device is one of the tools available clinically to measure cervical proprioception. The ability to reposition the head in a neutral position after active head movements have also been used to indirectly assess impairment in sensorimotor function originating from the neck.

From a clinical point of view, the CROM is easy to use, and requires minimal palpation to locate landmarks, can be installed quickly and can be used to test cervical proprioception in all directions without changing the position of the inclinometer. Furthermore, it is an affordable tool for clinics when compared to more sophisticated motion analysis systems. Though the major criteria of any product usage are affordability, accessibility, availability, and appropriateness, for an instrument to be clinically significant, it must have good reliability. Reliance on standardized tools places demands on clinicians to understand their properties, strengths, and weaknesses, to interpret results and make clinical decisions. The aim of the study was to assess the test-retest reliability of a CROM, in uninjured men and women.

METHODS

Twenty healthy adults, 10 men and 10 women between ages 21 and 62 years (mean ± standard deviation [SD], 37 ± 8 years), were recruited as respondent volunteers among the surrounding Community of the Research Center at Manipal University, India. Subjects with cervical or thoracic conditions were excluded. The study protocol was approved by the Manipal University Ethics Committee, Manipal. Informed consent was obtained from all participants before the experimental procedure, and their rights were protected.

Instrumentation

Cervical range of motion device

The CROM device is a type of goniometer designed specifically for the cervical spine and was used to measure CROM. The CROM device has been evaluated most often, with 7 studies assessing its reliability, both on healthy volunteers and on symptomatic patients. The CROM has 3 inclinometers, one to measure in each
plane, and is strapped to the head. One gravity dial meter measures flexion and extension, another gravity dial meter measures lateral flexion, and a compass meter measure rotation with its accuracy reinforced by 2 magnets placed over the subject’s shoulders. CROM device is effectively used in clinical setup, easy to apply, and cost-effective. CROM device indicated good criterion validity \((r = 0.89–0.99)\) and reliability (intra-class correlation coefficients [ICC] =0.92–0.96), which are considered to be acceptable.  

**Experimental procedures**

Cervical proprioception was measured with the CROM device which was placed on the subject’s head, and a magnetic collar, also part of the CROM device, was placed on the shoulders to take into account any rotation of the trunk. The collar was kept in the same position with respect to the magnetic pole and the chair on which the subjects sat was kept in the same position for all the respondents. Cervical proprioception was measured during 2 sessions, separated by 48 h, to assess test-retest reliability of measurements. The 2 sessions were scheduled during the same period of the day on each day (morning and in the early evening).

For the measurement of cervical proprioception, cervicocephalic kinesthetic sensibility tests were used. [1,9] The subjects were asked to sit upright in a comfortable position and look straight ahead, which can be described as the NHP. The CROM unit was placed on top of the head and attached posterior held in place using the Velcro strap. The magnetic part of the unit was then placed so that it sat squarely over the shoulders. The investigators calibrated the CROM device to an NHP.

For the cervicocephalic kinesthetic sensibility tests, subjects were required to keep the head in the NHP and were told to close their eyes throughout the subsequent tests. The first test was head-to-NHP repositioning test. [1,8] The subjects were then instructed to turn the head, completely to their left and reposition back, (considered the starting point in a controlled fashion) without opening their eyes. When the subjects reached the reference position, their relocation accuracy was measured in degrees with respect to the magnetic pole and the chair on which the subjects sat was kept in the same position for all the respondents. Cervical proprioception was measured during 2 sessions, separated by 48 h, to assess test-retest reliability of measurements. The 2 sessions were scheduled during the same period of the day on each day (morning and in the early evening).

Data analysis

To determine the test-retest reliability of the CROM measurements, ICC with 95% confidence intervals (CIs) were obtained from the measures taken with the CROM on day 1 and day 2. Furthermore, the standard error of measure (SEM) for each movement, as measured with the CROM, with the corresponding 95% CI was calculated using the following formula: \[
SEM = SD \times \sqrt{1-ICC}.
\]

Where SD is the average of the SDs of the test (day 1) and retest (day 2) values. The statistical analysis was done using the SPSS Inc. Released 2007. SPSS for Windows, Version 16.0. Chicago, SPSS Inc. The statistical significance value was set at 0.05 with 95% CI and \(P \leq 0.05\) were considered as significant. Alternately, a product moment correlation analysis was performed to assess the test-retest reliability and validate the SEM significance.

**RESULTS**

Cervical proprioception values obtained on day 1 using the CROM were very similar to those obtained on day 2 [Table 1]. The test-retest reliability of measurements made with the CROM was verified, with ICC values for all cervical measurements ranging between 0.66 (CI: 0.1, 0.8) for THP – rotation right (RR) to 0.93 (0.8, 0.9) (CI: 0.8–0.9), for THP – RR [Table 2]. The SEM was small for all CROM directions [Table 2], ranging from 0.10° (THP – side bending right) to 0.27° (THP – RR).

The correlation analysis [Table 3] also found that there are high and significant correlations between the test and retest results indicating that the reliability of the test can be established (positive correlation coefficients ranging from 0.524 to 0.863).

**DISCUSSION**

The present results reveal that the head-to-NHP test, and the majority of head-to-target tests in the three cardinal planes are reliable. The repositioning errors were expressed in degrees which are the standard way of representing.
Table 1: Cervical proprioception

<table>
<thead>
<tr>
<th>Cervical proprioception movement</th>
<th>Day 1</th>
<th>Day 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head-to-NHP</td>
<td>2.0±1.4 (1.3, 2.6)</td>
<td>1.6±0.9 (1.1, 2.0)</td>
</tr>
<tr>
<td>Head-to-THP: Flexion</td>
<td>2.5±0.9 (2.1, 2.9)</td>
<td>2.4±0.9 (2.0, 2.8)</td>
</tr>
<tr>
<td>Head-to-THP: Extension</td>
<td>4.0±0.8 (3.6, 4.4)</td>
<td>3.8±0.8 (3.4, 4.2)</td>
</tr>
<tr>
<td>Head-to-THP: SBL</td>
<td>1.1±0.8 (0.2, 1.0)</td>
<td>1.1±0.8 (0.2, 1.0)</td>
</tr>
<tr>
<td>Head-to-THP: SBR</td>
<td>1.5±1.1 (0.9, 1.9)</td>
<td>1.1±1.1 (0.6, 1.6)</td>
</tr>
<tr>
<td>Head-to-THP: RL</td>
<td>2.4±1.5 (1.7, 3.1)</td>
<td>2.4±0.9 (1.3, 2.8)</td>
</tr>
<tr>
<td>Head-to-THP: RR</td>
<td>2.1±1.4 (0.7, 2.0)</td>
<td>2.1±1.2 (1.1, 2.1)</td>
</tr>
</tbody>
</table>

Values are mean±SD (95% CI) in degrees. SD = Standard deviation, CI = Confidence interval, NHP = Neutral head position, THP = Target head position, SBL = Side bending left, SBR = Side bending right, RL = Rotation left, RR = Rotation right

Table 2: Measurement properties of CROM device

<table>
<thead>
<tr>
<th>Cervical proprioception movement</th>
<th>ICC (95% CI)</th>
<th>SEM (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Head-to-NHP</td>
<td>0.63 (0.5, 0.9)</td>
<td>0.19 (−0.01, 0.81)</td>
</tr>
<tr>
<td>Head-to-THP: Flexion</td>
<td>0.75 (0.3, 0.9)</td>
<td>0.19 (−0.29, 0.49)</td>
</tr>
<tr>
<td>Head-to-THP: Extension</td>
<td>0.89 (0.7, 0.9)</td>
<td>0.11 (−0.4, 0.44)</td>
</tr>
<tr>
<td>Head-to-THP: SBL</td>
<td>0.93 (0.8, 0.9)</td>
<td>0.10 (−0.21, 0.21)</td>
</tr>
<tr>
<td>Head-to-THP: SBR</td>
<td>0.86 (0.6, 0.9)</td>
<td>0.16 (0.04, 0.75)</td>
</tr>
<tr>
<td>Head-to-THP: RL</td>
<td>0.71 (0.2, 0.8)</td>
<td>0.26 (−0.50, 0.60)</td>
</tr>
<tr>
<td>Head-to-THP: RR</td>
<td>0.66 (0.1, 0.8)</td>
<td>0.27 (−0.83, 0.33)</td>
</tr>
</tbody>
</table>

CI = Confidence interval, ICC = Intra-class correlation coefficient, SEM = Standard error of measure, THP = Target head position, NHP = Neutral head position, SBL = Side bending left, SBR = Side bending right, RL = Rotation left, RR = Rotation right

Table 3: Correlation analysis and significance levels

<table>
<thead>
<tr>
<th>Cervical proprioception correlation for Day 1 and Day 2</th>
<th>Correlation Coefficient “r”</th>
</tr>
</thead>
<tbody>
<tr>
<td>NHP (day 1 × day 2)</td>
<td>0.802**</td>
</tr>
<tr>
<td>Flexion (day 1 × day 2)</td>
<td>0.593*</td>
</tr>
<tr>
<td>Extension (day 1 × day 2)</td>
<td>0.812**</td>
</tr>
<tr>
<td>SBL (day 1 × day 2)</td>
<td>0.863***</td>
</tr>
<tr>
<td>SBR (day 1 × day 2)</td>
<td>0.791**</td>
</tr>
<tr>
<td>RL (day 1 × day 2)</td>
<td>0.611*</td>
</tr>
<tr>
<td>RR (day 1 × day 2)</td>
<td>0.524*</td>
</tr>
</tbody>
</table>

*Significant at 0.05. **Significant at 0.01. NHP = Neutral head position, SBL = Side bending left, SBR = Side bending right, RL = Rotation left, RR = Rotation right

Our results with the CROM device in neck healthy individuals are consistent with those of other studies, for example, Demaile-Wlodyka et al. The contribution of cervical muscles to sensorimotor function has been emphasized with regards to the density of muscle spindles that reflect a well-developed proprioceptive system and cervical muscles play a major role in the motor control of the head and neck. [2,3,27]

Our head repositioning tests showed asymmetry in the variability of repositioning errors between the right and left. In this study, the variability of the repositioning errors among trials was high during neck motion toward left side bending. Lack of consistency during repeated repositioning toward the left/right sides in the frontal plane was also found by others in related studies of the cervical and lumbar repositioning test. [29,30] Such phenomenon according to them was due to the effect related to side dominance. Further studies are required to investigate the relationship between hand dominance and the head repositioning test.

The level of reliability considered acceptable varies widely in literature, with lower limits for “good” reliability ranging from ICC 0.61 to 0.81 holds that relocation from full cervical rotation ICC = 0.35/0.44 (R/L), from 30° of cervical rotation ICC = 0.62/0.82 (R/L) shows poor to adequate test-retest reliability. [15,16] There was relatively reduced reliability (as shown in Pearson’s correlation r = 0.611, 0.524) for the repositioning errors in the transverse planes (rotation left and RR) during head-to-target tests might be attributed to the increased coupling movements, which introduced variation during action in the transverse plane. [31,32] Higher reliability was found for the head-to-target tests in the frontal plane (ICC 0.93–0.86) and sagittal plane (ICC 0.88–0.73) in comparison to those in the transverse plane (ICC 0.66–0.71, r = 0.593) in this study. Our results were in accordance with the studies done by Gill and Callaghan, 1998; Swinkels and Dolan, 1998, Allison and Fukushima, 2003 though their studies were construed in lumbar spine. [33-37]

Based on the assumption that repositioning ability can be determined by the function of muscle spindles of the contracting muscles, one could interpret the difference in the test-retest reliability of the head-to-NHP and head-to-target repositioning tests as different repositioning ability of muscle groups that were used to perform these two repositioning tests. [39] For example, by calculating the force generation capacity of cervical muscles during different motions, Vasavada et al. [40] found that some muscles (the semispinalis capitis and the longissimus capitis) might participate more for the head motion toward NHP in the transverse plane, but less for the head motion away from NHP. Authors demonstrated that longus colli was activated during rotation to the NHP, whereas both longus colli and SCM were co-activated during rotation from NHP toward the maximal range. [20] Further investigation is required to determine whether the poor repositioning reliability from different position indicates various movement strategies adapted by individual or proprioceptive changes of neck muscles in asymptomatic young adults.

CONCLUSION

Since this study has elicited a repositioning...
error in normal, healthy student volunteers, it helps to understand whether patients with neck problems, especially of nontraumatic origin, express repositioning errors different from nonsymptomatic controls. This finding may be used to show the mechanism behind repositioning errors seen in people with neck pain. This study would be very useful for physiotherapists in private clinics, who can now confidently use the CROM device to measure proprioception changes, in affordable costs, reliably. Our results suggest that the CROM device can be used to quantify impairment in HRA with an acceptable level of reliability in asymptomatic individuals. Further studies are required to see the level of reliability in patients with different neck disorders.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

REFERENCES


