Rater Reliability and Concurrent Validity of Single and Dual Bubble Inclinometry to Assess Cervical Lateral Flexion

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Abstract

Objective: The purpose of this study was to assess interrater and intrarater reliability and validity for single inclinometry (SI) and dual inclinometry (DI) assessment of cervical lateral flexion (CLF) range of motion and compare reliability in a practicing physical therapist (PT) and student PTs (SPTs).

Methods: Twenty-four subjects performed right and left CLF while SI, DI, and 3-dimensional kinematics were concurrently recorded. Subjects were reassessed by 2 SPTs and 1 PT using both SI and DI. Each subject was measured twice per rater in round-robin fashion.

Results: There were significant positive relationships between DI and motion capture for both right ($r = 0.841$; $P < .01$) and left lateral flexion ($r = 0.838$; $P < .01$). Single inclinometry also had a significant correlation with motion capture for right ($r = 0.927$, $P < .01$) and left ($r = 0.834$, $P < .01$) lateral flexion. Interrater reliability was good for both SI and DI methods. For SI, intraclass correlation coefficient (ICC) (3,1) was 0.905 and 0.870 for right and left CLF, respectively. For DI, ICC(3,1) was 0.803 and 0.757 for right and left CLF, respectively. Intrarater reliability was good for both methods. Average SI values were ICC(2,1) of 0.928 and 0.897 for right and left CLF, respectively. Average DI values were ICC(2,1) of 0.882 and 0.851 for left and right, respectively. Although not significant, the PT had slightly higher reliability in all measures (range, 0.881-0.935) compared to the SPTs (range, 0.880-0.925).

Conclusions: Both SI and DI are acceptable for clinical use and both are reliable measurement methods for CLF between raters and for repeated measures. There are minimal differences in reliability between a PT with experience and SPTs with minimal experience. (J Manipulative Physiol Ther 2015;38:572-580)

Key Indexing Terms: *Range of Motion; Spinal Column; Physical Examination; Reliability and Validity*

Range of motion (ROM) measurements are routinely performed during the rehabilitation clinician's initial examination of patients seeking care for a host of musculoskeletal conditions.[1] Often times, these measurements are used to document cervical impairment and can be used as intervention outcome measures.[2,3]

For the peripheral joints, the universal goniometer tool is most frequently used for the assessment of active ROM (AROM) and passive ROM. For the spinal regions, bubble inclinometers are widely used as alternatives to the universal goniometer as they are less cumbersome than the universal goniometer. In addition, universal goniometry has relatively poor interrater reliability in the cervical spine (intraclass correlation coefficients [ICCs] ranging from 0.54 to 0.79).[4] A host of other tools have been outlined in the literature as possible options for clinicians when choosing an appropriate method to assess cervical ROM (CROM), but there is no clear agreement as to which is the "gold standard" method of measurement. Intricate devices such as electrogoniometers and digital inclinometers have been shown to be valid for measuring CROM and scaption motion in the shoulder complex in research settings, but their practicality and cost make their feasibility for use in clinical and educational settings highly questionable.[5-7] Visual estimation of cervical AROM and passive ROM is a technique used commonly in clinical settings because of its ease of performance; however, the interrater reliability of this technique has been shown in some studies to be quite poor ($\kappa = 0.16$).[8,9] In addition, a CROM device has been used to assess a variety of cervical motions and postures including CROM,[10] forward head posture,[11] and upper

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cervical angle,[12] but the device is more costly than other methods of assessment including goniometers and bubble inclinometers.[10] Very recent studies have even presented evidence that states that using an iPhone with an inclinometric application can be considered a reliable (ICC, 0.85-0.65) option for clinicians measuring spinal ROM.[13]

The use of the bubble inclinometer has become a quite common clinical practice, and the tool has been shown reliable for use in several areas of the body, specifically the lumbar spine.[14] In addition, this tool has also been shown to provide clinically similar CROM values to more technical, expensive measurement devices such as the aforementioned electrogoniometers.[15] This being said, the literature is relatively scarce in reporting validity and reliability values for these devices, with only 3 studies identified that addressed either validity or rater reliability of these tools for CROM measurement.[16-20] Although these studies were generally rated as poor to fair methodologically (quality scores ranging from 3 to 7 of 13 possible) by Williams et al,[16] single inclinometers were still recommended by these authors as being suitable for CROM measurements, with the caveat that further research is required. A 2008 systematic review looked at the limited literature on measurement tools available for measuring cervical AROM in people with nonspecific neck pain.[21] They too concluded that the bubble inclinometer was a reliable and valid tool for measuring cervical AROM but felt that significant gaps were still present within the literature.[21]

One or 2 bubble inclinometers can be used for assessment of cervical lateral flexion (CLF) ROM. With the single-inclinometry (SI) technique, the patient is positioned in sitting, and the device is placed on the crown of the head in frontal plane for lateral flexion measurement. When using the dual-inclinometry (DI) technique, 1 device is placed on the crown of the head with the second device positioned in the frontal plane over the spinous process of T1. Range of motion is calculated as the difference in measurement between the 2 devices and is thought to isolate the measurement to the cervical spinal segments only by subtracting the motion contribution from the upper thoracic spine. Single inclinometry and DI can also be used to assess ROM in the sagittal and transverse planes by changing patient positioning and orienting the inclinometers in either the sagittal or transverse planes.

There has been little discussion regarding whether SI or DI is most appropriate for examination of patients with or without cervical dysfunction, and furthermore, these 2 approaches are often treated clinically as providing similar CROM information. Previous studies have shown significant disagreement between lumbar flexion values obtained using a single and dual inclinometer, but to the best of our knowledge, no studies have been performed exploring this relationship in the cervical spine.[14] In addition, a recent article by Johnson et al[22] found that reliability of SI and goniometry to measure thoracic ROM was poorer in some testing positions than others. They hypothesized that this was because, in some testing positions, motion from other segments of the spine and body may contribute to the measured thoracic motion.[22] However, the authors were unable to confirm with the tools they used that the motion they assessed originated solely in the thoracic spine.[22] The authors of the current study wished to investigate whether this accessory motion, which may skew single inclinometric measures of CROM, may be accounted for using DI techniques. To resolve this question, it must first be determined whether single and dual inclinometers provide the same information when used to measure ROM in the cervical spine.

To our knowledge, there have been no studies conducted that have investigated the concurrent validity of SI and DI in the cervical spine. Therefore, the primary purpose of this study was to assess the concurrent validity with a gold standard motion capture (MC) system of SI and DI when used to assess CLF ROM in individuals without neck dysfunction. A secondary purpose was to investigate the interrater and intrarater reliabilities of the dual inclinometer and the single inclinometer to measure CLF ROM in healthy subjects as well as the relative reliabilities of these measures in novice vs experienced clinicians.

Methods

Subjects

A total of 24 participants were recruited for this observational, cross-sectional research design. Participants were obtained through convenience sampling by poster advertisement and word of mouth from Regis University and the surrounding community. Inclusion criteria for participation included ability to (1) understand and follow written directions in English; (2) perform pain-free cervical ROM multiple times in multiple directions; (3) remain sitting for up to 10 minutes during a 1-hour session for testing; and (4) tolerate the placement of an inclinometer and skin markers on the upper thoracic, cervical spine and cranium. Exclusion criteria consisted of (1) cervical or shoulder dysfunction that required treatment by any health care provider or limited activities for more than 3 days within the previous 6 months; (2) current dizziness due to vertigo or other conditions; (3) history of cervical, thoracic or shoulder surgery; (4) major scoliosis; (5) latex allergy and/or skin sensitivity to adhesives; and (6) severe systemic diseases.

Study Protocol

All data were collected in the physical therapy research lab at Regis University. This study was approved by the Regis University Institutional Review Board for human subject research. The research protocol and purpose were explained to participants, and informed consent was obtained before all data collection. Participants were included only if they self-reported no symptoms of current neck pain or dysfunction requiring medical attention. In