Validation of the Spin-T Goniometer, a Cervical Range of Motion Device

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Abstract

Objective: To test the validity of the Spin-T goniometer for the assessment of cervical range of movement.

Methods: A linear regression analysis for paired neck movements using first a foam head model and then human subjects was performed to quantify the differences between the measurements obtained from the MotionStar, a movement-tracking device, and the Spin-T. A within-subject repeated measures design using simultaneous data acquisition was completed.

Results: The coefficient of determination (R^2) for all planes of cervical range of motion for both model and human data sets was higher than 0.99. The regression equations for the model data showed no significant ($P > .05$) intercept for flexion-extension and lateral rotation. Human data showed statistically significant intercept for flexion-extension (mean, -0.52°) and lateral flexion (mean, 0.81°) at $P < .05$.

Conclusion: This study quantifies the difference between the MotionStar and the Spin-T goniometer and documents the systematic error between the measures. Where the error reached statistical significance, the magnitude of the error was very small ($<1.5^\circ$). The results of this study suggest that the Spin-T goniometer may be used as a valid measuring instrument for cervical range of movement. (J Manipulative Physiol Ther 2005;28:604-609)

Key Indexing Terms: *Reproducibility of Results; Cervical Vertebrae; Range of Motion; Articular; Validity*

The classic spinal motions are flexion, extension, lateral rotation, and lateral flexion. Cervical spine movement is difficult to investigate accurately because of its anatomic structure and individual compensatory movements that may be associated with habit, posture, or pain. Motion in the cervical spine may be divided into the upper cervical spine (occiput to C2) and the lower cervical spine (C3 through T1). Movements of the upper cervical spine include flexion-extension and lateral rotation with minimal lateral flexion, whereas in the lower cervical spine, all 4 movements occur.[1] Movements in the cervical spine are determined by the orientation of the facets, passive tension of the ligaments, muscles, joint capsule, and fibers of the anulus fibrosus.[1]

Normal variation of the cervical range of motion (CROM) is influenced by age and sex,[2-4] degeneration, pathology, surgery, or trauma, as well as factors such as pain,[5,6] muscle spasm, and whether the movement is performed actively or passively.

A subjective, qualitative observation of the range and path of motion is normally performed by clinicians to analyze passive and active movements. Lack of convenient, valid, and reliable instruments may be a reason why measuring instruments are not used in routine clinical practice. Measuring instruments may be time-consuming for the operator and cumbersome for the patient. Decisions regarding intervention and treatment are often based partly on joint motion, and clinicians need to justify their choice of treatment modality based on an objective assessment of the CROM. Many different methods and instruments have been used to assess CROM. Validity of measuring equipment has been reported less frequently than reliability.[7-10]

Concurrent validity is established by comparing test scores with a recognized gold standard, the criterion. If a high concurrent validity is established, then clinical utility is related to the measurement sensitivity and the ease and logistics of the clinical tool in the normal physiotherapy, and rehabilitation setting is considered.

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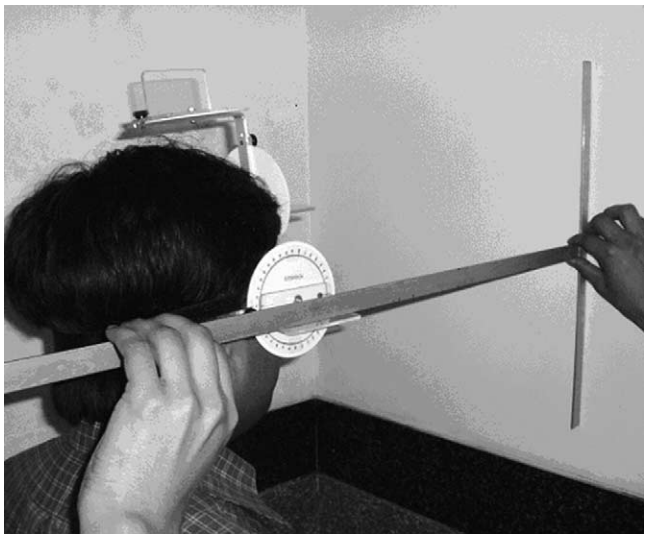

Fig 1. *The Spin-T goniometer strapped on the subject's head. The T square is positioned along the spindle of the flexion-extension dial to provide a perpendicular reference to the wall.*

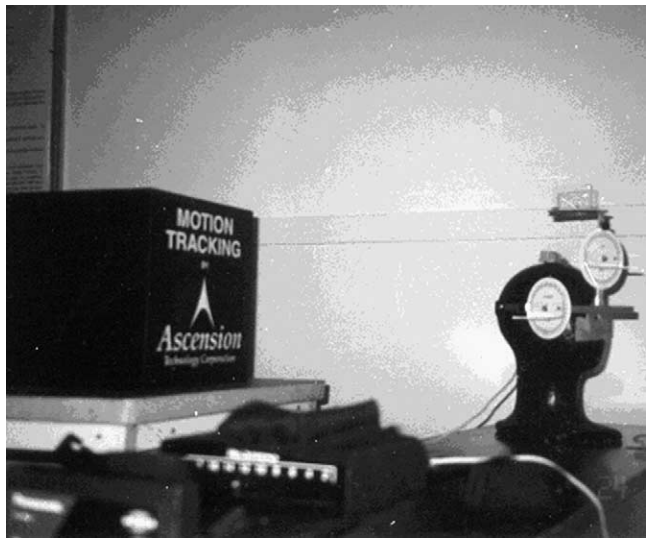

Fig 2. *The Spin-T on a foam head model placed in front of a wall. One sensor of the MotionStar can be seen on top of the foam head, whereas the other is placed parallel to it, in front of the foam head. The MotionStar is placed to enable it to track movements of its sensors.*

The CROM device has been used to report concurrent validity of a single inclinometer.[11] The inclinometer was validated for flexion-extension (ICC = 0.80) and lateral flexion (ICC = 0.79), but not for rotation (ICC = −0.18). A study by Haynes and Edmondston[12] showed that the CROM device could not accurately measure natural composite rotation movements. The aim was to establish if the Spin-T and the CROM device could accurately measure natural rotation movement. The devices were placed on a testing instrument which could be positioned at preset angles of rotation with/without a tilt to mimic the lateral flexion that occurs ipsilaterally to and concomitantly with cervical rotation. The Spin-T correlated positively with the testing instrument for rotation with accompanied tilt up to 15° (ICC > 0.99), whereas the CROM device showed a poor concordance (ICC = 0.50) at rotation with 10° tilt. The concurrent validity of the CROM device has been evaluated against radiographs[13] in the sagittal plane. In flexion, the coefficient of determination was $R^2 = 0.94$, $r = 0.97$ at $P < .001$. The slope value was 0.98 with a y-axis intercept of −0.08. In extension, $R^2 = 0.97$, $r = 0.98$ at $P < .001$ with a slope value of 1 and intercept of −2.1. Radiographs in the flexion-extension view have also been used as a gold standard for a pendulum goniometer.[14] The pendulum goniometer showed a positive correlation ($r = 0.97$) with the radiographs for the entire head on neck motion.

Ultrasound-based motion analyzers have been validated against a precision goniometer[15] and a digital inclinometer.[16] A maximum measurement difference of 0.6° was calculated between the CMS 3D real-time motion analyzer (Zebris Medizintechnik GmbH, Isny, Germany) and the precision goniometer.[15] In clinical terms, a 1° error is acceptable. The CMS 70P ultrasound system (Zebris Medizintechnik GmbH) was found to be accurate in comparison with the digital inclinometer.[16]

Christensen[17] validated the CA 6000 Spine Motion Analyzer (Orthopedic Systems Inc, Union City, Calif) electrogoniometer with two manual protractors. Neck movements in all 6 directions were tested with 4 to 5 recordings measured in each tested direction. The electrogoniometer was not found accurate with the mean difference ranging from 2% to 11.5%. The CA 6000 Spine Motion Analyser is expensive and ideally suited for research laboratories.

Studies that establish concurrent validity between clinical tests of CROM and gold standard criteria determine the degree of concordance between the two measurements. It is the clinician who then uses this information to consider if the magnitude of the variance between the two systems is small enough to justify the use of the clinical tool.

The Spin-T goniometer has been devised to measure composite cervical spine movements. The purpose of this study was to compare measurements of the simple, clinical cervical spine Spin-T goniometer with that of a high-resolution motion tracking system (MotionStar; Ascension Technology Corporation, Burlington, Vt) for CROM in different planes.

Methods

Subjects

Four male subjects (age range, 28-45 years) with no history of head or neck pain volunteered to take part in this