Reliability of the Cervical Spine Device for the Assessment of Cervical Spine Range of Motion in Asymptomatic Participants

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Abstract

Objective: The purpose of this study was to assess the inter- and intra-assessor reliability of the cervical spine device (Formetric, DIERS International GmbH, Schlangenbad, Germany) in measuring cervical range of motion.

Methods: The cervical spine device was used to measure the cervical range of motion of 65 asymptomatic participants. Flexion-extension, right and left rotation, and right and left lateral flexion were analyzed. Two different assessors performed the measurements on the same day to estimate inter-assessor reliability and 2 days later to examine intra-assessor reliability. Intra-assessor and inter-assessor reliability was assessed using the intraclass correlation coefficient (ICC). The standard error of measurement (SEM) and the smallest detectable difference (SDD) were also estimated.

Results: Inter-assessor reliability ICCs for flexion + extension and total lateral flexion movements were >0.90. The ICCs for rotation movements and for left lateral flexion were >0.70. The ICCs for flexion (0.64), extension (0.58), and right lateral flexion (0.56) indicated moderate correlation. Mean SEMs ranged from 2.28° (SDD = 6.31°) for left rotation to 8.08° (SDD = 22.38°) for total rotation. As for intra-assessor test-retest reliability, all ICCs were >0.70. Mean SEMs ranged from 3.14° (SDD = 8.70°) for total lateral flexion to 7.50° (SDD = 20.77°) for extension.

Conclusion: Both inter- and intra-observer reproducibility correlation values are moderate to high for measurements obtained using the cervical spine device. (J Manipulative Physiol Ther 2018;41:342-349)

Key Indexing Terms: *Range of Motion; Spine*

Introduction

Cervical spine disorders are common and have a significant impact on individuals, communities, and health care systems.[1,2] Patients with cervical spine disorders usually complain of pain and reduced active and passive cervical ranges of motion (ROMs). Restoring physiological ROM is crucial in the management of cervical spine disorders, and, therefore, its proper assessment is extremely important in quantifying the physical disability, determining the best therapeutic interventions, and evaluating their effectiveness.[3] Several tools have been developed to evaluate cervical ROM (CROM), ranging from simple visual estimation to complex 3-dimensional (3-D) motion analysis.[3,4] Selecting a measurement tool requires taking into consideration the purpose for the testing and the very tool's own psychometric properties such as reliability and validity.[5] Both visual estimation[6] and goniometric measurements are often used in clinical practice because of their versatility and simplicity. However, these methods cannot quantify combined movements (eg, lateral flexion and rotation), require experienced training, and are affected by the use of standardized methods of application. For research, the use of more accurate measuring systems may be necessary.[7]

Dynamic radiographic intervertebral motion has long been considered a "gold" standard for studying CROM, but today, the use of this invasive measurement system is limited by the small number of radiographs that may be obtained so as to minimize a patient's exposure to radiation.[8] Three-dimensional kinematic analysis is accurate in calculating CROM, but it is expensive and restricted to a laboratory environment that requires experienced staff.[7] These drawbacks limit its applicability in clinical settings.

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Paper submitted September 10, 2016; in revised form December 1, 2017; accepted January 9, 2018.

0161-4754
https://doi.org/10.1016/j.jmpt.2018.01.003

The Formetric (DIERS International GmbH, Schlangenbad, Germany) is a radiation-free analysis system used in assessing spinal posture and pelvic position, both of which are often evaluated in research and clinical settings.[9-11] It has been reported to have a high correlation with radiographic assessments of the anatomy of spine and pelvis, as well as high accuracy and reliability in static and dynamic conditions.[12,13] The cervical spine device is an opto-electronic infrared device, conceived as an additional module for the Formetric, that assesses cervical motion on 3 planes of space and the associated coupled movements. The introduction of a reliable ROM cervical measuring system as an additional module to raster stereography could provide parameters additional to those obtained with the Formetric and could make it possible to measure cervical kinematic data.

To be clinically useful on a daily basis, a measurement system needs to be accurate, easy to use, and able to generate reliable results.[14] Reliability must present both absolute and relative consistency that may be quantified using the standard error of measurement (SEM) and the intraclass correlation coefficient (ICC), respectively.[15] Absolute consistency refers to the consistency of scores of individuals, whereas relative consistency is the consistency of the position or rank of individuals in the group with respect to others. More specifically, the SEM evaluates the precision of a score, thereby allowing the construction of confidence intervals (CIs) for scores.[16]

The aim of the present study was to evaluate the reliability of the cervical-spine device in the measurements of neck movements on 3 planes of space in a sample of assymptomatic participants in terms of absolute and relative consistency.

Methods

Participants

From January 2014 to June 2014, 65 assymptomatic participants of both sexes were recruited from staff and postgraduate students from the Department of Physical Medicine and Rehabilitation.

To be included, participants had to be aged 25 to 45 years. They were excluded if they had reported or complained of neck, shoulder, and/or head pain in the preceding month. Those with a history of neck and/or shoulder disorders, including traumas and fractures, and a history of neurologic and/or rheumatologic disorders were also excluded.

A blinded physician ascertained the eligibility of participants through a screening questionnaire that evaluated demographic data and overall health.

All procedures were in accordance with the Declaration of Helsinki on human experimentation. The ethics committee of the University of Rome approved the experimental protocol. All participants provided written consent.

Instrumentation

The cervical spine device uses 2 infrared cameras to detect the position of 18 passive reflective markers. Sixteen are placed on a very light cylindrical helmet with a known radius and a known fixed set of reflecting markers, worn by the participant during the exam; one is placed on the spinous process of the seventh cervical vertebra and the other on the mastoid process of the temporal bone.

During movement, the system tracks the markers in the stereographic set of images and thus reconstructs the spatial coordinates of the head piece in the reference coordinate system with a frequency of 40 frames/s. The resulting trajectory curves are projected onto the 3 standard planes, and the angles are calculated with respect to the initial positions.

The system is calibrated with 2 cameras spaced approximately 100 cm apart. The 3-D reconstruction is accurate to 1 mm within the patient's ROM. The *x-y* reference plane is perpendicular to the optical axis of the system. The *z* axis goes straight out from the system, with the positive axis pointing toward the operator (Fig 1). The C7 marker is used to reference the spatial position of C7 within the fixed calibration space of the system (as determined by the system calibration). The device calculates cervical movements on the 3 planes as follows:

1. Flexion-extension in sagittal plane: The trajectory is projected on a reference plane going through C7 and the extrema on the helmet. It corresponds to the pitch angle in the Euler system.
2. Rotation of head in transversal plane: Angles are calculated with respect to the initial (start) angle. The start angle is defined as zero. The trajectory of the movement is projected on the axial *x-z* plane going through the midpoints of the helmet. This angle corresponds to the yaw angle in a Euler system.
3. Lateral flexion in coronal plane: The trajectory of the movement is projected on the plane going through the left and right points of the crown. This angle corresponds to the roll angle in a Euler system.

The mastoid marker and the C7 marker represent real anatomical landmarks. Thus, distances, angles, and positions (in the calibrated reference space) can be calculated between the 2 "systems": (i) trunk (spine, C7) and (ii) head (skull, mastoid). This is used in some of the 3-D visualizations as well as in specific data analysis of the extension-flexion movements, where anatomical and physiological accuracy are significant for the operator.

Procedure

Prior to this study, 2 physicians (assessor 1 and assessor 2) with 5 years of clinical experience and knowledge of CROM measurements received a training course on understanding the conceptual framework, application, and