Cervical Spine Assessment Using Passive and Active Mobilization Recorded Through an Optical Motion Capture

Alejandro J. Moreno, MS, Gonzalo Utrilla, MS, Javier Marin, MS, Jose J. Marin, PhD, Maria B. Sanchez-Valverde, PhD, and Ana C. Royo, PhD

Abstract

Objective: The purpose of this study was to develop and measure a protocol for evaluation of cervical range of motion (ROM), based on passive mobilization (PM) combined with active mobilization (AM) and recorded through an optical motion capture system.

Methods: Passive and active mobilization were applied to 24 asymptomatic participants. Cervical ROM was recorded in 3 anatomic planes (transversal, frontal, and sagittal) using a precision optical system and a set of rigid bodies placed on the sacrum, spinous processes of the C7-T1 vertebrae, and the head. Three captures were made for each participant, distributed over 2 days. The characteristics of the PM, the interaction with the AM, and the coherence patterns between tests were analyzed. Reliability was studied for these procedures.

Results: The reliability results of the PM were high in all analyzed indices; only flexion showed low values. Reliability of AM was greater than PM for flexion, extension, and lateralization because of the similarity to rotation. No statistically significant differences were found comparing PM and AM techniques.

Conclusion: The authors present a cervical ROM assessment based on combined PM and AM protocols at different sessions. This model demonstrated high reliability, individually and combined, and no differences were detected between PM and AM ROMs. Because the evaluator, instrumentation, and the patient are factors that could influence outcomes, the authors suggest that they be combined in protocols. These protocols could be used to evaluate the functional and structural capacity of patients and inform clinical outcomes. (J Chiropr Med 2018;17:167-181)

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

Introduction

Musculoskeletal disorders of the cervical spine have a high incidence and prevalence and are considered a public health problem, especially in developed countries.[1,2] Although there have been significant contributions in different fields to access cervical spine injury, such as whiplash associated disorder (WAD), several diagnostic tests that assess cervical-area alterations, "whiplash severity grading systems," diagnostic imaging tools, and scales such as the Quebec Task Force, seem to be insufficient for predicting possible complications of symptomatology.[3,4]

IDERGO Research Group, I3A, Department of Design and Manufacturing Engineering, University of Zaragoza, Spain.

Corresponding author: Jose J. Marin, PhD, IDERGO Research Group, I3A, Department of Design and Manufacturing Engineering, University of Zaragoza, Edificio Torres Quevedo, María de Luna 3, 50018 Zaragoza, Spain. Tel.: +34 976761978. (e-mail: *jjmarin@unizar.es*, *alexMor1993@hotmail.com*).

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The diagnostic difficulty is because traumatic cervical spine injuries and their associated symptoms are diverse. Variables that have been measured to quantify the degree of dysfunction are isometric muscle strength,[5] motion velocity, smoothness,[6] and cervical range of motion (ROM).[7-14] Because of the relationship between joint dynamics and the dysfunction location,[9-11] the ROM is often used to quantify severity and treatment.[7] This index is also used by the American Medical Association[4,15] to assess physical damage; it also is used in specific legislation in countries, such as Spain (Law 35/2015)[16] for the assessment of damage caused by traffic accidents.

One method to evaluate cervical ROM uses voluntary patient movements under the instructions of an evaluator, called active mobilization (AM). This type of mobilization does not require physical interaction between the patient and the evaluator[17] and provides relevant functional information.[18] However, application of AM as an isolated technique is questioned.[17-19] Because of the influence of the patient's subjectivity motivated by psychosocial factors,[2,20-22] different types of errors may be observed, and the AM technique has high variability of results and a low capacity to predict chronic symptoms.[7,8,18] Likewise, it does not provide clinical information to determine structural function.[20,22]

Another method is passive mobilization (PM).[11,23] In this case, an external force is induced by the examiner to move specific body parts up to the joint limits while the participant relaxes the joint that is being explored.[18,24] Passive mobilization allows the examiner to assess the "physiological barrier," the structural information of the joint under assessment, which is useful in clinical decision making for treatments.[25-27] It is assumed that this range is not influenced by psychosocial factors, as in AM, because the captured ROM mainly depends on action and perception of the examiner during the test.[22,28] Therefore, authors have reported a lower variability in the results in applying PM techniques.[10,18]

Most PM techniques use subjective analyses based on the examiner's perception,[17] so is not considered the gold standard.[7,17,18] Consequently, the challenge associated with PM is to provide studies that analyze its properties and characteristics through objective kinematic measurements, enabling its validation as a diagnostic technique.

To validate methodologies based on PM, it is necessary to apply criteria related to accuracy and reliability.[29,30] The criteria involve some standards satisfying reliability, which require that the measurement must be repeatable and invariant to external factors (ie, the subjectivity of the evaluator, technical-system commitment, and others).

In a systematic review[7] of 46 reliability studies and 21 validation studies where PM and AM techniques were applied, 8 PM studies were found, which described the passive technique used.[31] There is a problem when explaining the characteristics and properties using PM combined with objective measures. In general, PM reliability has not been analyzed in depth,[7,8,32] and only a few have used objective measurements for the analysis of PM techniques.[12,17]

If AM and PM were combined for assessment, they could possibly provide greater sensitivity and specific diagnostic information in the clinical-care setting. In addition, the problem concerning the subjectivity of both, which is derived from the evaluator in the PM and is derived from the psychosocial factors of the participant in the AM, might be mitigated by their combination.

Motion capture (MoCap) systems provide precision; however, they are not exempt from sources of errors, such as those derived from the marker placement on particular anatomic areas that move with respect to the underlying bones and those due to the conditions of application in a specific area or use conditions in a specific field.[33] The evaluator's ability to perform a correct grip on the patient is a critical aspect in the measurement of the ROM movements during PM, where the reflective markers can be hidden or even moved by the evaluator if he or she is not sufficiently trained. Consequently, the variability of the system depends on the design of the set and its degree of integration, that is, the placement of markers, the checks, the understanding of the movements by the participant, the instructions to the patient, or the training of the evaluator in the use of the system. Therefore, the added value provided by MoCap technologies can be diminished in the clinical setting if the possible sources of error are studied in their practical application, which is the general purpose of this study.

Therefore, the objectives of this study were the following: (1) to develop a cervical ROM assessment protocol based on PM; (2) to check the system reliability using the PM and AM, individually and combined; (3) to perform a comparison of both techniques, PM and AM; and (4) to understand the influence and interactions between tests when applied together.

Methods

Instrumentation

Cervical mobility was recorded through a MoCap system composed of the following components: (1) set of 8 OptiTrack cameras (Flex 13, 1.3 PM, 56° field of view, and 120 frames per second) and the OptiTrack Motive 1.9 application (NaturalPoint Inc, 2016), and (2) software motion characterization Move-Human Sensors (University of Zaragoza, Aragon, Spain),[34] implemented in Vizard VR Toolkit[35] (WorldViz, Santa Barbara, California) virtual reality platform and the intellectual property of the University of Zaragoza.

OptiTrack Motive controls the cameras and processes the movement data of certain rigid bodies (RBs), providing 6 degrees of freedom for each of them. The RBs information is read in real time by Move-Human Sensors through a peripheral network communication protocol, and is transferred to a 3D digital human model. At the beginning of each capture, an anatomic calibration process to adjust the digital model to the anthropometry of the participant and associate the position and orientation of each RB with the corresponding body segment is completed by matrix transformation. The software allows visualizing and recording cervical movements in real time while applying the PM or AM techniques.

The RBs correspond to groups of 3 markers (reflective spheres) placed on a rigid support. Each RB was individually designed for an appropriate fit adjustment to its corresponding body part. Three RBs were used to record the cervical kinematics: 1 on the sacrum, another on the spinous processes of vertebrae C7-D1, and another on the head (Fig 1).

Participants

Twenty-four asymptomatic participants (16 men and 8 women) aged 32 ± 11.35 years participated in the study. Anthropometric characteristics from the population are shown in Table 1. The inclusion criteria were the absence of the following: a history of neck or head pain; cervical trauma; vestibular, visual, or nervous problems; or surgeries in the cervical region. These data were collected by interview, which was guided by the same evaluator.