Repeatability of Cervical Joint Flexion and Extension Within and Between Days

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Abstract

Objective: The purpose of this study was to investigate within- and between-day repeatability of free and unrestricted healthy cervical flexion and extension motion when assessing dynamic cervical spine motion.

Methods: Fluoroscopy videos of 2 repeated cervical flexion and 2 repeated extension motions were examined for within-day repeatability (20-second interval) for 18 participants (6 females) and between-day repeatability (1-week interval) for 15 participants (6 females). The dynamic cervical motions were free and unrestricted from neutral to end range. The flexion videos and extension videos were evenly divided into 10% epochs of the C0-to-C7 range of motion. Within-day and between-day repeatability of joint motion angles (all 7 joints and epochs, respectively) was tested in a repeated-measures analysis of variance. Joint motion angle differences between repetitions were calculated for each epoch and joint (7 joints), and these joint motion angle differences between within-day and between-day repetitions were tested in mixed-model analysis of variance.

Results: For all joints and epochs, respectively, no significant differences were found in joint motion angle between within-day or between-day repetitions. There were no significant effects of joint motion angle differences between within-day and between-day repetitions. The average within-day joint motion angle differences across all joints and epochs were 0.00° ± 2.98° and 0.00° ± 3.05° for flexion and extension, respectively. The average between-day joint motion angle differences were 0.02° ± 2.56° and 0.05° ± 2.40° for flexion and extension, respectively.

Conclusions: This is the first study to report the within-day and between-day joint motion angle differences of repeated cervical flexion and extension. This study supports the idea that cervical joints repeat their motion accurately. (J Manipulative Physiol Ther 2018;41:10-18)

Key Indexing Terms: *Spine; Cervical Vertebrae; Range of Motion, Articular; Fluoroscopy*

Introduction

Dynamic cervical joint motion is an important part of cervical biomechanics. Clinical examination of cervical joints and neck motion is an important diagnostic tool in continued diagnostic assessment of intervention and surgery.[1-5] Repeated examination of cervical motion is common in clinical practice[6-10]; however, the repeatability of dynamic cervical motion has not been investigated. Diagnosis presumes a repeatable cervical motion pattern or at least repeatable cervical joint motion. The descriptive evidence for free and unrestricted cervical motion is weak, even though biomechanical assessments of cervical joint motions are important for surgery, treatment, and ergonomics.[11-15] A better understanding of cervical joint motion may provide new methods to assess cervical dysfunctions.[13-17]

Previous normative studies of cervical joint motion have documented cervical joint motion from 3 to 5 static roentgen images,[15,18] which does not allow a detailed understanding of natural dynamic joint motion. Real-time video fluoroscopy studies with analysis of dynamic motion provide the means to a new and detailed understanding of cervical flexion and extension joint motion.[14,16,19]

Healthy cervical motion has previously been described and modeled as a "spring like" structure with continuous

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joint motion contributions.[20] In these models, cervical motor control is exerted through deep and superficial muscles, where the deep muscles contribute to stability of the cervical spine, and the superficial muscles move the head and neck.[21-23] New research suggests that a free and unrestricted cervical joint moves with irregular motion speed.[11,14,17,24] Furthermore, the maximum joint motion has previously been documented before end range; thus cervical joints with maximum motion occurring before end range move, at least in part, antidirectionally or opposite to the intended cervical motion direction from the maximum joint motion to end range.[14,25] Such movement patterns do not support the "spring-like" model, and suggest the motion patterns are more convoluted and require more joint specific muscle activity of the deep muscles compared with the "spring-like" model, as superficial muscles have little capacity for control of specific joint motion.[11,13-17]

The finding of maximum cervical joint motion before end range implies that cervical joints can move in excess of the motion measured at end range.[14] The excess motion capacity is unknown; however, the excess motion opens up the possibility of multiple motion pattern solutions, with varying joint motion contributions to end-range motion or cervical range of motion (ROM). Dynamic joint contributions can be expressed in degrees or in percentages of total cervical ROM,[11,13-15,26] and the contributions have in the past been assessed as free and unrestricted motion or as controlled motion with the head and neck controlled by a pivot arm.[14-17,26,27]

The aim of this study was to assess the within-day and between-day repeatability of free and unrestricted cervical flexion and extension joint motion. Cervical flexion and extension joint motion was hypothesized to be repeatable within day (20-second interval) and between days (1-week interval).

Methods

Participants

Thirty-six healthy participants were recruited in this study. Eighteen participants were examined for within-day repeatability, and 15 participants, for between-day repeatability. The within-day data were extracted and reanalyzed from another data set focusing on morphology of movements and not repeatability.[24] Participants were university colleagues and students (Table 1). The exclusion criteria were neck pain within the last 3 months, pain during the experiment, and possible pregnancy. Participants signed written informed consent forms. The study was executed in accordance with Declaration of Helsinki. The North Denmark Region ethics committee approved the study (N20140004).

Experimental Procedures

In the first experiment, participants conducted 2 cervical flexion motions and 2 extension motions with 20 seconds between repetitions. In the second experiment, participants engaged in 2 sessions with 1 week between sessions.

Table 1. *Participant Characteristics*

N	Within-Day Group 18 (6 women)	Between-Day Group 15 (6 women)	*P* Value
Age (y)	26.5 ± 5.1	25.1 ± 4.6	.104
Height (cm)	173.9 ± 9.8	173.9 ± 12.1	.941
Weight (kg)	68.3 ± 11.5	70.4 ± 13.3	.889
Body mass index (kg/m^2)	22.4 ± 2.0	23.1 ± 2.4	.396

Except for N, values are expressed as mean ± standard deviation. *P* values are for comparisons between groups made with an unpaired *t* test.

Participants were asked to sit in a chair with hips, knees, and ankles at 90° fixed by straps. The instruction was to flex/extend the head following a vertical line on wall, ceiling, and floor, and the line was used to control out-of-plane motion. A cross marked at eye height on the line assisted reposition of neutral position. Flexion or extension motions were recorded by fluoroscopy from neutral position to end range, and the motions were free and unrestricted. Participants wore a pair of glasses on which lead balls were attached via steel wires for better identification of the C0 joint. Participants were asked to hold neutral position and end range for 2 seconds. In the second repetition (20 seconds or 1 week later), participants repeated the flexion and extension. Compliance with experimental procedures was practiced several times before acquisition and timed to approximately 16 seconds.

Fluoroscopic Recordings

Fluoroscopy images were acquired at 25 frames per second (BV Libra, Philips, Netherlands) with an average source-to-participant (C7 spinous process) distance of 76 cm. Average exposure of 45-kV, 208-mA, 6.0-ms x-ray pulses during complete cervical motion recordings yielded 0.48 mSv (PCXMC software, STUK, Helsinki, Finland).

Image Analysis

After video fluoroscopy acquisition of cervical flexions and extensions, the images (frames) were digitalized, clipped (Honestech VHS to DVD 3.0 SE, Honestech Inc, Austin, Texas), and stored on a computer. On a high-resolution monitor, 26 marking points (4 external points for C0 and 22 bony points) were placed manually for each image in a MATLAB-based program. The anatomical points were based on radiographic analysis.[15,16,28] The 4 external markers improved analysis of C0.

The marking points were 2 anterior and 2 posterior external markers for occiput (C0), 2 points at the centers of