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Original Article

Assessment of the cervical range of motion over time, differences between results of the Flock of Birds and the EDI-320: A comparison between an electromagnetic tracking system and an electronic inclinometer

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Abstract

The objective of this study was to analyse cervical range of motion, assessed over time by means of a digital inclinometer (EDI-320) and a three-dimensional electromagnetic tracking device (Flock of Birds).

The maximum active cervical range of motion was assessed with two measurement devices in three sessions over time, with 6-week intervals. In total, 26 women and 24 men (mean age: 44.4, SD: 9.9) without known pathology of the cervical spine participated. Four movements were measured axial rotation with the cervical spine in a flexed and in an extended position, flexion–extension, and lateral bending.

The results showed that the factor time was significant for rotation in extension and rotation in flexion. The factor device was significant for all movements measured, and the interaction term between time and device was significant for all movements except rotation in extension.

The Flock of Birds measured significantly higher ranges of motion on all motions except for lateral bending. A substantial variation in cervical range of motion was observed over time (ranging from −5.6 to 8.1) as well as between devices (ranging from −13.1 to 29.9).

Substantial and significant differences in cervical range of motion were found over time as well as differences between the Flock of Birds and the EDI-320.

Keywords: Range of motion; Assessment; Natural variation; Reliability

1. Introduction

Measuring the range of motion of the cervical spine is an important clinical issue, since it is used to measure impairments and treatment effects. Because of its complex anatomical structure the cervical spine range of motion is difficult to assess (Bogduk and Mercer, 2000). Although there is a substantial amount of evidence for the validity and reliability of different measurement devices, there is no gold standard for measuring cervical range of motion (Chen et al., 1999; Antonaci et al., 2000; Lantz et al., 2003). Each measurement device has its own advantages and disadvantages. Simple devices, such as goniometers, are easy to handle and are mostly used in clinical

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practice. More sophisticated devices, which are mostly used in laboratories, require extensive training, sophisticated software and are usually more time-consuming. However, few comparisons of simple and sophisticated devices have been performed. One study, showed good agreement between a three-dimensional ultrasound motion device (Zebris) and a gravity goniometer (Myrin) (Malmstrom et al., 2003).

In a clinical setting, usually the range of motion is assessed over time; we therefore conducted a longitudinal study comparing the EDI-320 with the Flock of Birds (FOB). The EDI-320 is an electronic inclinometer, a small and mobile device, which is easy to handle. Studies demonstrate that the EDI-320 has a good intraobserver (ICC: 0.93 and higher) and interobserver reliability (ICC: 0.89 and higher) (Chiarello and Savidge, 1993; Tousignant et al., 2001; Pool et al., 2004; de Winter et al., 2004). The Flock of Birds is a sophisticated electromagnetic tracking device, but is not easy to use in a clinical setting, because of an extensive calibration procedure and is not portable (Meskers et al., 1999). Previous studies indicated that this system has a high precision and a good intraobserver (SD: between 2° and 4°) and an acceptable to good interobserver reliability (ICC: 0.66 and higher) in measuring active cervical range of motion (Koerhuis et al., 2003; Assink et al., 2005; Bergman et al., 2005). Because natural variation in neck mobility over time is an important factor in cervical range of motion measurement (Bergman et al., 2005), we performed measurements in three sessions, with a 6-week interval. The natural variation represents the variation in the range of motion which occurs over time naturally. This variation is not the result of an intervention.

The aim of this study is to analyse cervical range of motion, assessed over time by means of a digital inclinometer (EDI-320) and a three-dimensional electromagnetic tracking device (Flock of Birds).

2. Materials and methods

2.1. Subjects

Fifty healthy volunteers, 26 women and 24 men (mean age: 44.4, SD: 9.9) without known pathology in the neck and shoulder region were invited to participate. The subjects were mostly employees of the Centre for Rehabilitation at the University Medical Centre Groningen. Informed consent was obtained from all the volunteers.

2.2. Measuring devices

The Flock of Birds (Ascension Technology Corporation, Burlington, USA) is a 6-degrees-of-freedom electromagnetic tracking device, consisting of a standard range transmitter and three receivers. One receiver is mounted on the head, one on the thorax and the third receiver is mounted on a palpation stylus. The receivers on head and thorax are used to measure the range of motion. The receiver with the palpation stylus is used for locating seven bony landmarks on the head and the thorax (nose bridge, chin midpoint, processus xiphoideus, incisura jugularis, protuberantia occipitalis externa, processus spinosus C7 and processus spinosus T8) (Koerhuis et al., 2003). These landmarks are used for constructing a coordinate system which defines the posture of the patient and the position of the receivers on head and thorax. These data are used to calculate the position and orientation of the head relative to the thorax. This position will be recorded and translated into a range of motion. For details, the reader is referred to Koerhuis et al. (2003) and Meskers et al. (1999).

A position calibration procedure was performed prior to the measurements, since the influence of metals in the environment, e.g., iron-strengthened concrete, on data outcome is quite large (Meskers et al., 1999).

The Cybex Electronic Inclinometer-320 (EDI-320) is an electronic inclinometer consisting of a display and a hand-held unit that is used to take the range of motion readings of various joints of the body. The hand-held unit contains an incremental encoder, which converts rotatory displacement into a digital pulse. The encoder should be held vertically because of its gravity-dependency. Differences between the starting and ending positions are converted to degrees in range of motion. Thus, the encoder provides relative values compared to the starting position. The display device indicates range of motion on a 360° scale. Because the EDI-320 must be held against the subjects' head by the observer, it is not possible to measure passive range of motion. Measurements were performed while the subject was seated in an upright position. Axial rotation with the cervical spine in a neutral position while sitting upright could not be measured by the EDI-320, because it cannot measure range of motion in the horizontal plain.

2.3. Measurements

All the measurements were performed by one observer (BK) with equal experience with the EDI-320 and the Flock of Birds. Prior to the study, measurements were standardised and information about the aim of the study and the measurement procedure was given to all the participants. All measurements started with a measurement by the Flock of Birds. The subjects were invited to take place in a chair with armrests facing a mirror and were asked to assume a comfortable and upright position, looking at their own reflection in the mirror. The subjects conducted four movements actively in a fixed sequence: axial rotation with the cervical spine in a flexed and in an extended position, flexion–extension, and lateral bending.