ISB 2013 BRAZIL
XXIV CONGRESS OF THE INTERNATIONAL SOCIETY OF BIOMECHANICS
XV BRAZILIAN CONGRESS OF BIOMECHANICS

RELIABILITY OF FINITE HELICAL AXIS PARAMETERS IN CERVICAL KINEMATICS

Ron Clijsen[1,2], Erik Cattrysse[3], Claudia Jehle[1,2], Marco Barbero[4], Corrado Cescon[4]
[1]University of Applied Sciences and Arts of Southern Switzerland, Department of Health Sciences, Landquart, Switzerland. [2]University College Physiotherapy, Thim Van Der Laan AG, Landquart, Switzerland.3Arthrokinematics research group, Faculty of Medicine and Pharmacy, Department of Experimental Anatomy, Vrije Universiteit Brussel, Belgium. 4Department of Health Sciences, University of Applied Sciences and Arts of Southern Switzerland, SUPSI, Manno, Switzerland. e-mail: ron.clijsen@supsi.ch

SUMMARY

The objective of the present study is the evaluation of the reliability of Finite Helical Axis (FHA) parameters for the functional analysis of cervical movements. The reliability of FHA parameters was analyzed with the intraclass correlation coefficient (ICC) as shown in the table. The parameters investigated showed different values of ICC with angular velocity, ROM and convex hull area resulting more reliable than the others.

INTRODUCTION

The use of FHA is a stable approach and very common in spacecraft dynamics and graphic imaging, nevertheless it is still little used in clinical context and among medical professionals. The dispersion of the 3D-motion axis has been used previously to express the stability of the motion in cervical kinematics for whiplash patients (Osterbauer et al. 1992; Panjabi 1979; Woltring et al. 1985). Beside quantitative aspects of joint kinematics, like absolute and relative ranges of main and coupled motion components derived from a 6Dof analysis, more quantitative kinematic aspects may be more relevant from a clinical perspective. The present study investigates the reliability of the FHA method to represent cervical kinematics.

METHODS

Thirty-eight healthy subjects (age: 23.5 ± 2.6) participated to the study. Cervical movements were registered with the Polhemus-G4, a non-invasive electromagnetic device, which tracks the positions of sensors relative to a source in three dimensions. One sensor was positioned on the subjects' forehead and one on the chest. The sensors were connected to a PC, which recorded the position of the sensors at 120Hz. A custom made software was used to format and store the data for 3D analyzis of the neck movements. The subjects were asked to perform three series of movements of the head (flexion-extension, left-right rotation, left-right lateral bending) at a natural spontaneous speed (Cattrysse et al., 2012) during five different sessions in three days.

Data analysis was performed off-line using Matlab® (the MathWorks Inc., Natick MA, USA). The coordinate data were filtered with an anticausal low-pass Butterworth filter (2nd order) using a cut-off frequency at 6 Hz.

For the analysis, an orthogonal dextral coordinate system was used with anterior, superior and right being positive (x,y and z-directions, respectively), as recommended by the International Society of Biomechanics.

Seven parameters were evaluated: range of movement (ROM, degrees), angular velocity (rad/s), angular acceleration (rad/s2), angular jerk (rad/s3), energy of the first harmonic of the Fourier transform of the angular position (%), minimum area of the convex hull of the intersection of the FHAs with a plane (cm2) during a movement, and mean value of the distribution of angles between the FHAs during a movement.

Subjects were not considered if they had a history of headache or neck surgery or had received treatment for neck or shoulder conditions within the past three months. The study was approved from the Ethical Committee of Southern Switzerland and subjects signed informed consent forms.

RESULTS AND DISCUSSION

Table 1 shows the intraclass correlation coefficient (ICC) of the seven parameters investigated. The ICCs represent the inter-session reliability of the seven parameters and are shown for the three movements and the 38 subjects.

CONCLUSIONS

The parameters investigated showed different values of ICC with angular velocity, ROM and convex hull area resulting more reliable than the others.

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Table 1. Intraclass correlation coefficient (ICC) and the relative confidence interval for the finite helical axis parameters during three cervical movements.

	flexion-extension **ICC (Conf. Interv.)**	left-right rotation **ICC (Conf. Interv.)**	left-right lateral bending **ICC (Conf. Interv.)**
ROM	0.88 (0.80-0.93)	0.83 (0.71-0.90)	0.93 (0.88-0.96)
Ang vel.	0.88 (0.80-0.93)	0.90 (0.83-0.94)	0.92 (0.87-0.96)
Ang accel.	0.74 (0.56-0.85)	0.67 (0.44-0.82)	0.59 (0.31-0.77)
Ang jerk	0.75 (0.54-0.86)	0.71 (0.51-0.84)	0.55 (0.24-0.75)
Perc 1st harm	0.65 (0.40-0.80)	0.48 (0.12-0.71)	0.67 (0.45-0.82)
Area CH	0.80 (0.67-0.89)	0.79 (0.65-0.88)	0.76 (0.59-0.86)
Mean Angle	0.67 (0.44-0.81)	0.55 (0.23-0.75)	0.47 (0.09-0.70)