15th International Symposium on Computer Methods in Biomechanics and Biomedical Engineering
and
3rd Conference on Imaging and Visualization
CMBBE 2018
P. R. Fernandes and J. M. Tavares (Editors)

Abstract ID-185

NON-IONIZING THREE-DIMENSIONAL ESTIMATION OF AXIAL VERTEBRAL ROTATIONS IN ADOLESCENTS SUFFERING FROM IDIOPATHIC SCOLIOSIS

Saša Ćuković[(1)], William Taylor[(1)], Michele Fiorentino[(2)], Vanja Luković[(3)], Goran Devedžić[(4)], Subburaj Karupppasamy[(5)], Silvio Lorenzetti[(1)]

[(1)]**Swiss Federal Institute of Technology ETH, Department of Health Sciences and Technology, Institute for Biomechanics, Switzerland**
sasa.cukovic@hest.ethz.ch, taylorb@eth.ch, sl@ethz.ch

[(2)]**Politehnico di Bari, Politecnico di Bari, DMMM, Italy**
michele.fiorentino@poliba.it

[(3)]**University of Kragujevac, Faculty of Technical Sciences, Serbia**
vanja.lukovic@ftn.kg.ac.rs

[(4)]**University of Kragujevac, Faculty of Engineering, Serbia**
devedzic@kg.ac.rs

[(5)]**Singapore University of Technology and Design - SUTD, Singapore**
subburaj@sutd.edu.sg

Keywords: Axial Vertebral Rotation - AVR, Non-ionizing Diagnosis of AIS, Surface Topography, Patient-Specific CAD Models

Summary: Three-dimensional deformity and axial rotation of vertebrae or a section of the vertebral column are considered risk factors for scoliosis development, but also predictors of curve progression, prognosis, and treatment outcomes. Clinically, measurement of axial rotation of vertebrae is performed manually from 2D anterior-posterior radiographs by estimating the relative positions of vertebral pedicles from the vertebral symmetry line. However, an inability to measure the 3D Euclidean distance between anatomical features of the vertebrae and the asymmetric nature of the vertebral column due to rotational deformity, leads to poor accuracy and reproducibility of the measurement. In this article, we investigate the use of an integrated method, by combining a 3D non-invasive optical method with a surface topography (ST) technique, to measure 3D absolute vertebral axial rotations (VAR) of three sections of the vertebral column: lumbar (L1-L5), thoracic (T1-T12), and cervical (C5-C7) in a patient with adolescent idiopathic scoliosis (AIS), and quantify standing posture in terms of extracting clinically meaningful 3D anatomical measures. The steps involved in this method are: 3D digitalization of the dorsal surface of the patient, patient-specific 3D CAD model of the spine, and ontology-based knowledge-aided system (KAx) to map and quantify VAR and other measures. We conducted a retrospective analysis of 372 subjects (141 males and 231 females) with major thoracic AIS who were optically scanned using a 3D digitizer between 2009 and 2015. We evaluated axial rotations and processed them statistically, with the primary aim of studying apical (most dislocated) vertebral rotation in the primary curve of the deformity. The thoracic primary curve with apical vertebra occurred mostly between T1 and T11. The T1 apical vertebra was identified as the most prevalent and found in 272 patients with axial rotations between 3.08 and 21.93 degrees. Due to its non-ionizing nature, the integrated method of data acquisition and analysis has enormous potential to be safely used in clinical settings, for monitoring AIS, and to predict important indicators of the underlying structures and the associations between the vertebral rotations and other spinal deformity variables.