

MEASUREMENT OF RANGE OF MOTION FOR THE SPINE IN NORMAL INDIVIDUALS USING ELECTROMAGNETIC TRACKING DEVICE

Yi-Wen Chang¹, Chien-Jen Hsu², Hong-Wen Wu³, Wei-Ning Chang², Wen-Ying Chou⁴

¹Department of Physical Therapy, Foo-Yin Institute of Technology, Taiwan

²Orthopedic Section, Veterans General Hospital - Kaohsiung, Taiwan

³School of Physical Therapy, China Medical College, Taiwan

⁴Second Section of Anesthesia, Chang Gang Memorial Hospital - Kaohsiung, Taiwan

Email: sc092@mail.fy.edu.tw

INTRODUCTION

The spine may be considered as a structure composed of multiple motion segments connected in series. The movements of thoracic spine, lumbar spine and pelvis basically constitute the trunk motion. The measurement of range of motion (ROM) for the spine is common in clinics as a basis of the evaluation for the impairment of the spine. The tape measure and inclinometer are typically utilized in the noninvasive assessment. However, the traditional methods may not be easy to distinguish the hip from spinal motion and thoracic from lumbar motion. The electromagnetic tracking device can derive the movement pattern of multiple segments with simple sensor placement. Therefore, the purposes of this study were to measure the ROM of the spine for the normal subjects using the electromagnetic tracking device, and to analyze the relative contribution of thoracic spine, lumbar spine and pelvis to the trunk motion during the forward/backward bending, side bending and axial rotation.

MATERIALS AND METHODS

A three-dimensional kinematic model of trunk was established in this study. There were four coordinate systems, including thoracic spine, lumbar spine, pelvis and thigh. Since the standing position was chosen to measure the ROM of spine, a close chain exercise was investigated in this study. Thus, the relationship of a proximal

coordinate system relative to a distal coordinate system was used to define the segmental movement of the spine. Euler angles were used to describe the movement of a proximal segment relative to a distal segment (An et al, 1984).

Eighteen normal male subjects participated in the study. The Flock of Birds electromagnetic tracking device (1999 Ascension Technology Corporation, Burlington, VT, USA) with four sensor units was used in this study. The locations of these sensors were on the spinous processes of the 7th cervical spine, the 12th thoracic spine and the 5th lumbar spine, and on the middle area of the right posterior thigh. After having obtained the subjects' informed consent, the anatomical position was first collected with the static standing, as a reference of the segmental movement computed from Euler angle. Then the trials of forward/backward bending, bilateral side bending and axial rotation of the trunk were performed for each subject. Three repetitions for each movement were collected in this study.

RESULTS

The ROM for different functions of trunk was shown in Table 1. Thoracic spine generated the greatest angle in axial rotation and the least angle in backward bending. Lumbar spine generated the greatest angle in forward bending and the least angle in axial

rotation. Pelvis generated the greatest angle in forward bending and the least angle in backward bending.

The contribution of each movement segment was computed as a percentage of total trunk motion (Figure 1). 40% of forward bending motion occurred at lumbar spine and 40% at pelvis. 60% of backward bending occurred at lumbar spine. 60% of axial rotation occurred at thoracic spine. 45% of side bending occurred at thoracic spine. The contribution of lumbar spine was substantial for forward and backward bending, but the thoracic spine was significant in the motion at the frontal and horizontal planes.

Table 1: ROM (mean ± standard deviation) for the trunk motion. (F: flexion; E: extension; LB: left bending; RB: right bending; LR: left rotation; RR: right rotation)

| Degrees | Thoracic | Lumbar | Pelvis | Sum |
|---------|----------|---------|---------|----------|
| F | 26 ± 9 | 51 ± 12 | 58 ± 17 | 131 ± 23 |
| E | 17 ± 10 | 25 ± 15 | 8 ± 7 | 45 ± 13 |
| LR | 49 ± 9 | 7 ± 3 | 15 ± 5 | 56 ± 9 |
| RR | 42 ± 9 | 9 ± 4 | 25 ± 8 | 59 ± 8 |
| LB | 27 ± 6 | 19 ± 5 | 12 ± 4 | 66 ± 10 |
| RB | 26 ± 4 | 20 ± 5 | 16 ± 7 | 71 ± 12 |

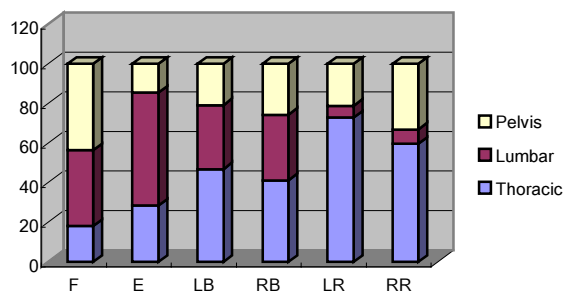


Figure 1: Contribution (%) for different spinal segments (F: flexion; E: extension; LB: left bending; RB: right bending; LR: left rotation; RR: right rotation)

DISCUSSION

A three-dimensional kinematic model of the spine has been developed in this study. Although the real movement unit of the spine is between two vertebrae connected in series, it is currently impractical to define the three-dimensional coordinate system in vivo for each vertebra using the motion analysis system. To minimize this difficulty, three movement segments of the spine were defined in this study, to evaluate the angle change for the different spine region.

Several noninvasive methods have been used in clinics to measure the ROM of the trunk, including the inclinometer and tape measure. However, these approaches can only measure static positions. Radiographic goniometry has also been used in vertebral measurement. However, it might have errors caused by the x-ray beam not rectangular to the plane of the spinal movement (Tulley et al, 1997). With the technique in this study, the dynamic pattern of the spine motion could be quantitatively evaluated. The model of the receiver placement isolated the pelvic motion from the lumbar motion, and lumbar motion from thoracic motion, and provided the in vivo information regarding the relationship between the movements of the adjacent spinal segments.

REFERENCES

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