Kinematic Measurement of the Lumbar Spine and Pelvis in the Normal Population

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ABSTRACT

Spinal and pelvis motion has been studied by a variety of different methods, the majority of which have a number of limitations. The present study investigated motion characteristics of the lumbar spine and pelvis using a three-dimensional optoelectronic system. The aim of our study was to determine kinematic parameters of spine and pelvis during trunk flexion, extension and lateral bending in normal, healthy subjects. Kinematic motion analysis was performed on 63 asymptomatic volunteers for four different trunk motions. This study has shown that the pelvis range of motion is affected by the gender. Contribution of pelvic movement to trunk flexion was 50%, while pelvic angle was significantly higher in women. During lateral bending female subjects had statistically significant higher values of vertebral arc with respect to male subjects. During extension the contribution of pelvic movement was 45%. There was no significant difference found in total angle, pelvic angle and vertebral arc.

Key words: kinematic, spine, pelvis

Introduction

Mobility of the spine and pelvis depends on physical and anatomical characteristics of lumbar and pelvic regions and leg. For measuring spine mobility several non-invasive methods are in use: skin markers for external photo- or videography, electromagnetic devices, ultrasonic digitizers, electrogoniometers and others, more or less sophisticated devices. Kinematic measurements enable us to measure mobility during the whole motion of all body parts we wish to examine. During the last few years, three-dimensional motion measuring techniques have been developed with skin markers which enable accurate and user friendly measurement of the whole motion range and motion characteristics. Considering that kinematic assessment of motions and spine and pelvis coordination are used for the assessment and follow-up during the course of rehabilitation for patients with low back pain, it is important to identify the range of motion (ROM) in asymptomatic, healthy subjects.

Loebel et al. used goniometer to measure spine flexion and extension analyzing mobility according to gender and age. Results of the study showed that total mobility of the spine decreased with age on average 8 degrees per decade. They found no significant differences between men and women. Measuring trunk’s mobility in healthy subjects using the kinematic system, McGill et al. concluded that flexion and lateral flexion mobility decreased with age. Einkauf et al. measured flexion, extension and lateral flexion trunk motions in healthy women of 20 to 84 years of age using Schober method and goniometer. Results indicated the decrease in mobility with age for all motions examined. Macrae et al., by using modified Schober method, conducted measurements and compared lumbar spine flexion and extension values in healthy subjects according to gender and age. Results of this study showed higher flexion in men and significant decrease of lumbar flexion with age. Measurements on healthy subjects showed that mobility decreased with age. There were no differences found in mobility according to gender except in the study by Macrae et al. who showed greater flexion in men. Lateral flexion in relation to the dominant side of the body showed no statistically significant difference.

The aim of the present study is to determine relationship between the movements of the lumbar spine and hips during trunk motion. The range of trunk extension and flexion and lateral bending (both right and left) was
examined in normal, healthy population. Moreover, differences in motion range in regard to gender were investigated.

**Materials and Methods**

This study included 63 examinees in good health with no history of low back pain in the lumbar spine within the last three years. Subjects sample included 40 male (63%) and 23 women (37%) with the mean age of 35 years.

All subjects were informed about the details of the procedure and that the measurement is performed for scientific research purposes. Subjects willfully participated in the research study and signed an inform consent. Subjects could have refused further participation at any stage of the research.

Kinematic measurements were performed with 3D optoelectronic device (Smart, BTS, Padua, Italy) with 9 CCD cameras of 50Hz (version 1.10, Build 2.39). Infrared sensitive markers of 10 mm in diameter were fastened to 15 anatomical points: left and right lateral part of the ankle, left and right lateral part of the knee in the middle part height relating to the joint fissure, left and right greater trochanter, 2 markers left and right symmetrically on the belt that crosses anterior superior iliac spine left and right, posterior superior iliac spine left and right, spinous processes of S1, L3, Th12, Th6, C7 and acromion left and right (Figure 1).

Measurements were performed during the period from 9.00–13.00 hours in order to lessen the influence of daily activities on measuring results. Measurements were performed in a biomechanical laboratory at room temperature. Movement measuring protocol required from the subjects to perform trunk flexion/extension in a standing position and a lateral trunk flexion in a standing position. Each measurement was repeated five times. Measurement began from vertical neutral position and followed with continuous movements.

Using calculation protocol called Vertebral Kinematic Analysis (VKA) developed for functional spine examination, kinematic values were singled out for further statistical analysis. VKA calculations (Figure 1) enabled us statistical analysis of following kinematic variables: total angle (TA pelvic angle (PA)_p), lower lumbar segment angle (Ls2), upper lumbar segment angle (Ls1), lower thoracic segment angle (Ts2), upper thoracic segment angle (Ts1) and vertebral arc (VA). VA actually consists of sum of four spinal segment angles: Ts1+Ts2+Ls1+Ls2.

In addition, for each subject arithmetic mean of measured values and variation coefficient CV (defined as ratio of standard deviation and arithmetic mean, all multiplied by hundred) were recorded.

Measuring results were entered into the relational table formed in MS Excel. Statistical analysis was done by computer program STATISTICA version 6. (StatSoft Inc., Tulsa, OK, USA).

**Results**

The values of total angle, pelvic angle and vertebral arc in flexion, extension and lateral flexion are presented in Figure 2.

**Flexion**

Contribution of pelvic mobility to trunk flexion was 50%. Total angle, pelvic angle and vertebral arc were compared according to gender. Pelvic angle was significantly higher with women (ANOVA, F=4.88, p=0.029). Total angle and vertebral arc were higher with women but not statistically significant.

**Extension**

Contribution of pelvic mobility during trunk extension was 45%. Total angle, pelvic angle and vertebral arc were also compared according to gender and there was no significant difference found.

**Lateral flexion**

Gender comparison regarding vertebral arc discovered that female subjects had statistically significant higher values (right: p=0.012, left: p=0.002) in contrast to comparison of total angle and pelvic angle values where no statistically significant differences were found.
Discussion and Conclusion

Kinematic spine measurement aims to determine biomechanical characteristics of the spine and pelvis during different trunk movements. The purpose of kinematic spine measurement in healthy subjects is determining levels of mobility according to age, gender, dominant side of the body and daily changes in mobility. There were no differences in mobility found according to gender except in the study by Macre who determined a greater range of trunk flexion motion in men. For the success in rehabilitation and treatment of patients with low back pain (LBP), remission of neurological symptoms are equally important as the recovery of functional features such as mobility, flexibility, strength and endurance of the musculature as well as the recovery of neuro-motor control. Wong et al. points out the importance of mobility measurements in clinical practice with the purpose of functional assessment of patients with back pain and rehabilitation efficiency evaluation.

Practical significance of kinematic measurement lies in planning and programming of rehabilitation processes. Namely, the obtained results represent a starting point for programming and conducting the rehabilitation procedure adjusted to individual functional features of the patient with LBP. In case of persistent functional deficit there is a higher probability of recurrence of LBP episodes. In comparison between groups of subjects according to gender, angle values during flexion indicated statistically significant higher pelvic angle value in women. Although with no statistical significance, higher value of the total angle was also determined in women of all ages.

REFERENCES


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