Coll. Antropol. **31** (2007) 4: 1039–1042
Original scientific paper

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

Stanislav Peharec[1], Romana Jerković[2], Petar Bačić[1], Josip Azman[2] and Dragica Bobinac[2]

[1] Polyclinic of Physical Medicine and Rehabilitation, Pula, Croatia
[2] Department of Anatomy, School of Medicine, University of Rijeka, Croatia

A B S T R A C T

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[1–4] 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[5]. Measuring trunk's mobility in healthy subjects using the kinematic system, McGill et al. concluded that flexion and lateral flexion mobility decreased with age[6]. 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[7]. 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[8]. 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

Received for publication October 20, 2006

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).

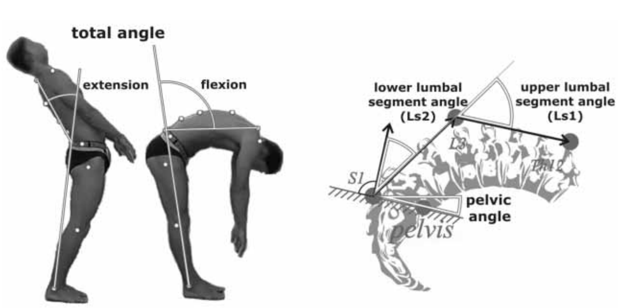

Fig. 1. Kinematic analysis model and main variables definitions.

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),), 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.

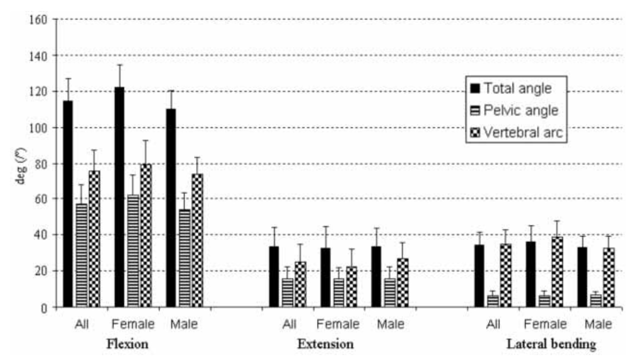

Fig. 2. Total, pelvic and vertebral arc during flexion, extension and lateral bending in healthy persons. All values are expressed in degrees.

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[1,5–13]. 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[8]. 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 neuromotor control[14–19]. 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[20].

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 comparation 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. Obtained results are in accordance with already published studies in which there were no statistically significant differences found in flexion and extension angles according to gender[1,5,13].

Total flexion angle in average healthy subjects was 114,4°±12,5° which is close to values from the study by Esola et al. where flexion value was 111[02]. Moreover, in a healthy subjects VA values are in negative correlation with age, meaning that with age VA values are decreasing (data not shown). Mobility of the pelvis compared to the total angle was around 50% movements for both groups of subjects compared to 37%[21], 61,1%[3,22] and 62,5%[2]. We can assume that significant differences in pelvic mobility probably arise from different measuring methods.

Total extension angle in average healthy subjects was 33,7°±10,4°. A female subjects show no significant differences to male subjects in all kinematics values. Moreover, there were no differences according to the age in all examined subjects.

Lateral flexion angle value in Lariviere study resulted to be 38° for both sides and in our study around 35[03,22]. According to gender, there were no significant differences found which is in accordance with the results by McGregor et al.[13,23]. Lateral flexion according to the left/right side of bending showed no significant difference which is in concord with the results of previous studies[1,12].

Kinematic analysis conducted in this study contributes to the functional assessment of lumbopelvic region.

REFERENCES

1. GRACOVETSKY S, NEWMAN N, PAWLOWSKY M, LANZO V, Spine, 20 (1995) 1036. — 2. ESOLA MA, MCCLURE PW, FITZGERALD GK, SIEGLER S, Spine, 21 (1996) 71. — 3. LARIVIERE C, GAGNON D, LOISEL P, Clin Biomech, 15 (2000) 407. — 4. FITZGERALD GK, WYNVEEN KJ, RHEAULT W, ROTHSCHILD B, Phys Ther, 63 (1983) 1776. — 5. LOEBL WY, Ann Phys Med, 9 (1967) 103. — 6. MCGILL SM, YINGLING WR, PEACH JP, Clin Biomech, 14 (1999) 389. — 7. EINKAUF DK, GOHDES ML, JENSEN GM, JEWELL MJ, Phys Ther, 67 (1987) 370. — 8. MACRAE IF, WRIGHT V, Diseases, 28 (1969) 584. — 9. ENSINK FB, SAUR PM, FRESE K, SEEGER D, HILDEBRANDT J, Spine 21 (1996) 1339. — 10. MELLIN G, Spine, 13 (1988) 668. — 11. MELLIN G, KIISKI R, WECKSTROM A, Spine, 16 (1991) 1108. — 12. NG JKF, KIPPERS V, RICHARDSON CA, PARNIANPOUR M, Spine, 26 (2001) 53. — 13. MCGREGOR AH, MCCARTHY ID, HUGHES SP, Spine, 20 (1995) 2421. — 14. SNOOK SH, WEBSTER BS, MCGORRY RW, FOGLEMAN MT, MCCANN KB, Spine, 23 (1998) 2601. — 15. MAGNUSSON ML, BISHOP JB, HASSELQUIST L, SPRATT K, SZPALSKI M, POPE MH, Spine, 23 (1998) 2631. — 16. SHIRADO O, ITO T, KIKUMOTO T, TAKEDA N, MINAMI A, STRAX TE, Spine, 30 (2005) 1219. — 17. JUKER D, MCGILL S, KROPF P, STEFFEN T, Med Sci Sports Exerc, 30 (1998) 301. — 18. NELSON, BW, CARPENTER DM, DREISINGER TE, MITCHELL M, KELLY CE, WEGNER JA, Arch Phys Med Rehabil, 80 (1999) 20. — 19. HIROMICHI K, KENICHI S, OSAMU N, ISAKICHI Y, SYUICHI T, KOHTARO F, Spine, 21 (1996) 225. — 20. WONG TKT, LEE RYW, Hum Mov Sci, 23 (2004) 21. — 21. MAYER TG, TENCER AF, KRISTOFERSON S, Spine, 9 (1984) 588. — 22. LARIVIERE CD, GAGNON P, LOISEL J, Electromyogr Kinesiol, 10 (2000) 79. — 23. MCGREGOR AH, CATTERMOLE HR, HUGHES SPF, J Bone Joint Surg, 80 (1998) 1009.

R. Jerković

Department of Anatomy, Rijeka University School of Medicine, Braće Branchetta 20, 51000 Rijeka-HR, Croatia
e-mail: romana@medri.hr

KINEMATSKA MJERENJA LUMBALNE KRALJEŽNICE I ZDJELICE U ZDRAVIH ISPITANIKA

S A Ž E T A K

Gibanje kralježnice i zdjelice moguće je mjeriti pomoću različitih metoda od kojih većina ima određene nedostatke. U našem istraživanju s ciljem mjerenja pokretljivosti lumbalne kralježnice i zdjelice korišten je trodimenzionalni optoelektronički kinematski sustav. Cilj istraživanja bio je utvrditi kinematska obilježja kralježnice i zdjelice tijekom pokreta fleksije, ekstenzije i lateralne fleksije trupa u 63 zdrava ispitanika. Rezultati istraživanja dokazali su utjecaj spola na opseg pokreta zdjelice. Pokret zdjelice u fleksiji trupa iznosio je 50% od ukupnog pokreta fleksije. Kut fleksije zdjelice statistički je značajno veći u žena. Kut laterofleksije u žena statistički je značajno veći u odnosu na muške ispitanike. Kut zdjelice prilikom pokreta ekstenzije trupa iznosi 45% od ukupnog kuta ekstenzije. Nije utvrđena statistički značajna razlika u ukupnom kutu, kutu zdjelice i vertebralnom kutu između muških i ženskih ispitanika.