

INFLUENCE OF LUMBAR SPINE KINEMATICS ON FEET PRESSURE DISTRIBUTION

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Abstract

Determining the center of pressure trajectories, as an indicator of postural stability or lumbar pathology, has been a challenging issue for researchers during the last decades. The paper advances an investigational method in order to determine a correlation between lumbar spine movements and feet center of pressure distribution. Five young healthy volunteers were simultaneously tested using an ultrasound based motion analyzing system and a force platform, while performing imposed tasks. Results showed specific patterns described by the center of pressure trajectories and a good coordination of angular amplitudes during lumbar spine movement.

1. Introduction

Over the last decades, quantifying human postural stability represented a valuable asset in the investigation of certain disorders, from osteoporosis, to low back pain and neuro-sensorial [1-4]. All experiments involved groups of subjects, divided with respect to sex, age, pathology or task.

One of the most significant stabilometric indicators used in clinical practice is the feet center of pressure (COP) and the corresponding excursions recorded on different measuring systems. A recent study revealed that there is insufficient data to suggest a relationship between the level of perceived disability, pain intensity and the magnitude of COP excursions, emphasizing the need of future research in this direction [5-6]. Thus, the present paper underlines the influence of lumbar spine kinematics on feet COP trajectories, quantified as fundamental patterns for anatomically normal movements.

2. Method and samples

The study was conducted in Motion Analysis Laboratory of “Politehnica” University of Timisoara. Five young healthy subjects, aged (23 ± 1.3), having no medical history of low back pain, volunteered for the experiment.

Two non-invasive measuring systems were used in this study, both branded by Zebris Medical GmbH Company (Germany). The first equipment (Zebris CMS-HS) is a motion analysis system, based on the ultrasound emission-reception process, between a set of special markers, attached to the subjects’ lumbar region with Velcro bands, and a measuring sensors tripod, which detects the spatial-temporal diagram of the ultrasound signal [7]. The second equipment (Zebris FDM) represents a force platform which uses high quality capacitive sensors, in order to record the feet pressure distribution. All sensors are arranged in a 216 x 56 matrix, each cell measuring 100 mm².

The imposed tasks were common lumbar spine movements: flexion-extension (FE), lateral flexion (LF) and axial rotation (RO), a combination of the three representing a trial. In order to obtain reliable results, a specific experimental protocol has been thoroughly followed by each subject, the tasks execution being strictly supervised by an authorized physiotherapist.

Prior beginning, a set of warming exercises was performed, preparing the subjects for their tasks. All types of movements were executed with free chosen speed, maintaining a constant rhythm during the investigational period. Data acquisition was recorded at a frequency of 10 Hz for both measuring systems.

3. Results and Discussions

A parallel view of the feet mean COP distribution is presented for each movement independently. During lumbar flexion-extension, one can observe almost vertical, symmetrical COP trajectories, covering a 35 mm maximum sagittal excursion for the right foot (RFT), while the left foot exhibits only a 30 mm displacement (Figure 1).

Figure 2 reveals some differences in COP distribution for lumbar lateral flexion movement, in comparison to flexion-extension. Both trajectories are no longer vertical, but bent with respect to the direction determined by the line which intersects the heel and the toe of each foot. In addition, the COP excursion lengths increased to 55 mm for the right foot and 70 mm for the left foot. The only resemblance between the two feet is the line shape of the trajectories.

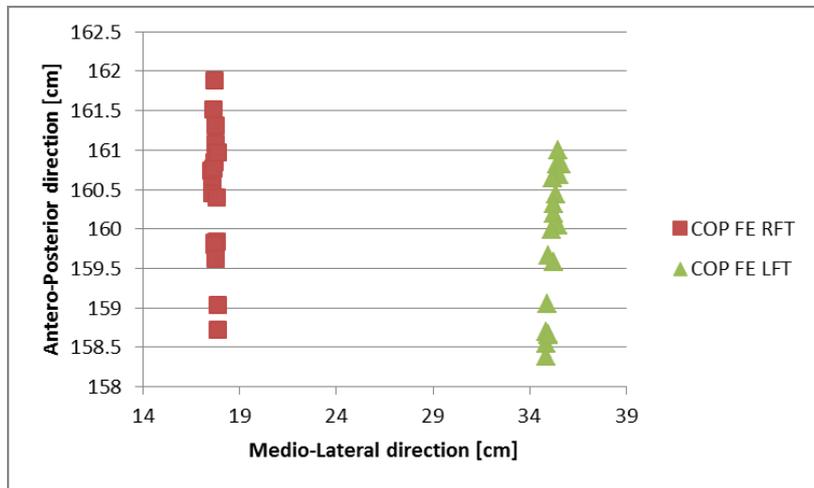


Fig.1. COP trajectories during flexion-extension movement

During lumbar axial rotation, an interesting aspect occurs, as shown in figure 3. The COP trajectories described by the left foot presents an opposite distribution than the right foot. In other words, the geometric locus of the right foot COP covers the superior half of the platform, while for the left foot the inferior half. The shape of both trajectories changed from lines to polynomials.

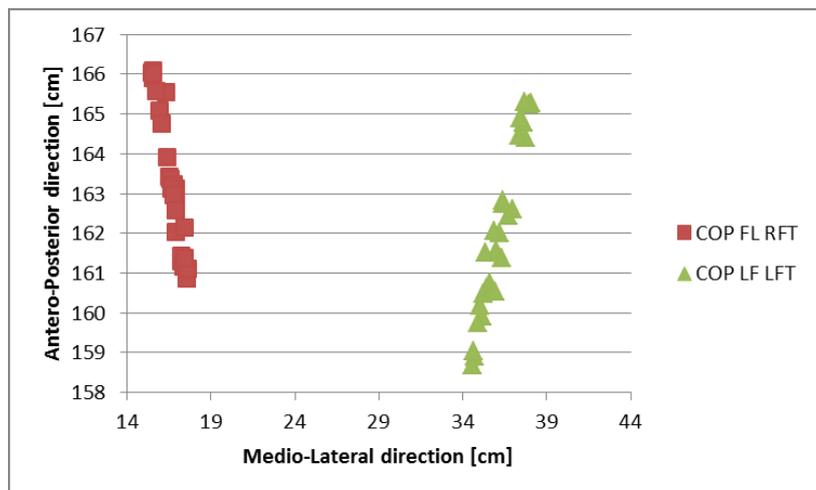


Fig.2. COP trajectories during lateral flexion movement

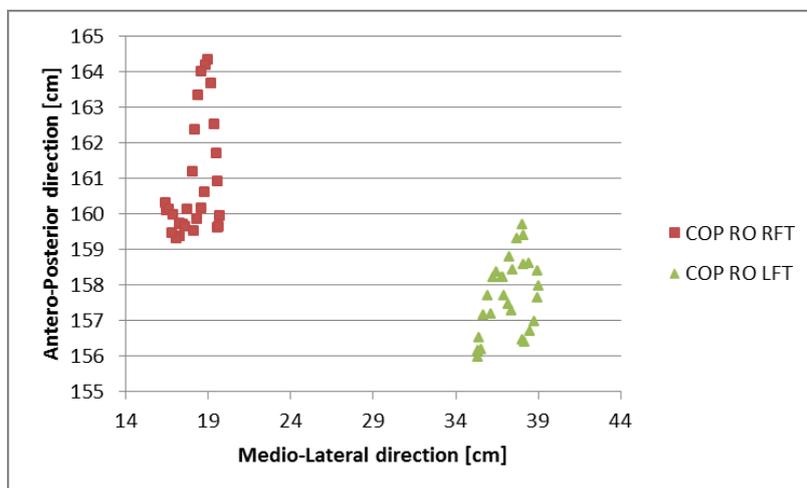


Fig.3. COP trajectories during rotation movement

The COP coordinates have been calculated using the classical mechanics method of determining the center of parallel forces. Applying one-way ANOVA at an alpha level of 0.05 on inter- and intra- trial lumbar angular amplitudes, high p values ($p > 0.5$) were obtained, showing no significant difference between lumbar homologue movements. The inter correlation coefficient values velocity variations in all exercise (0.92 FE, 0.95 RO and 0.91 LF) did not influence the experimental study. Future work will focus on continuing the study on subjects having different lumbar disorders, in order to achieve certain patterns of parameters variation, based on the subject specific pathology.

4. Conclusions

The experimental study has established a preliminary normative database containing the feet COP trajectories during normal lumbar movements of healthy subjects. The database could represent an important asset in the diagnosis and rehabilitation process of patients having lumbar disorders.

The investigation protocol uses non-invasive measuring systems, thus it would be easily applied in medical practice. In order to sustain the reliability of the results, statistical coefficients were determined, and shown a good correlation, both inter- and intra- group.

Acknowledgements

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