Principal Component Analysis between perceptions and kinematics of the subject. An ergonomic case study at office work

A. Picarda,b,c, M. Mahea,b,c, J. M. Barbierb, C. Grangeb, M. Lefebvreb, S. Duc, W. Bertucci and N. Houela

aeso – Parisc Recherche, Ecole Supérieure d’Ostéopathie – Paris; bInstitut Technologique Forêt Cellulose Bois-construction Ameublement; cGRESPI, EA4694/UFRSTAPS, Université de Reims Champagne-Ardenne

KEYWORDS Ergonomics; PCA; comfort; questionnaire; accelerometer

1. Introduction

Nowadays, musculoskeletal disorders (MD) account for 80% of professional pathologies (INRS 2008).

MD contains the peri-articular pathologies that affect muscles, articulations and nerves (INRS 2008). World Health Organization published a report in 2004 that showed prevalence of lumbar back pain was about 60%.

The main risks factors of MD are repeatability of a task, bad posture maintaining and static muscle activity (INRS 2008). Videman et al. (1990) showed a relationship between back pain and office working according to their low activity. Identification and prevention of risk of MD are usually based on ergonomic studies. Ergonomics focuses on comfort and discomfort, especially with sitting workers. However, few studies have been carried out in order to connect the cognitive approach and biomechanics, aiming to better evaluate the links between the biomechanics of comfort and its perception by a subject (Baucher and Leborgne 2006). These studies interested only on the subjective comfort’s parameters and postural balance of the subject regardless of the upper joint or spine kinematics.

The aim of this study is to show the relationships between comfort’s perception and biomechanics. This approach presents through a case study.

2. Methods

A female subject (size = 169 cm, weight = 85 kg, age = 44 years) practicing as an office assistant with administrative and secretary tasks voluntarily participated to this study. This subject presented scapular pain following a tendinitis. The study was carried out in respect of subject working conditions and workstation environment and complied with Helsinki declaration.

Eight triaxial accelerometers of Trigno Delsys system (sampling rate = 148 Hz) were attached on the subject. The sensors were placed on upper limbs and spine: forearm (2), arm (2), C4 (1), T5 (1), L1 (1), sacrum (1). Each sensor’s signals were filtered with second order butterworth filter at a cut-off frequency between 0 to 2 Hz. Joint’s kinematics of lumbar, thoracic and cervical were computed from Newton-Euler matrix associated with the anthropometric model of Vette et al. (2012). Joint’s kinematics of upper limbs and head were computed from Newton-Euler matrix associated with the anthropometric model of De Leva (1996). Joint’s active range of motion (AROM) and mean angles were defined for flexion and side bending of spine and left and right shoulders motions (flexion, abduction). Postural parameters: area of center of mass (CoM), length of CoM path sway, mean position of CoM on antero-posterior (CoMy) and medio-lateral (CoMx) axis were computed. The recordings were made during ten minutes and three times a day (morning, midday, evening) during one week. These recordings moments were previously chosen by subject’s typical working day observation.

At the same time of acquisition, the subject was submitted to three questionnaires: the Siegrist questionnaire which measures the effort’s perception and rewards attempts; the Karasek questionnaire which reveals the mental requirements and social support in working environment; and the final chair evaluation check-list (CEC) which provides information on seat’s comfort. Effort and reward scores were retained for the Siegrist questionnaire. Mental requirements and the two scores of social support were used for the Karasek questionnaire. Comfort score was used for the final CEC.

The normality of each variable (kinematics and questionnaires) was tested using asymmetry and kurtosis coefficients. All data were submitted to a principal component
Table 1. Mean and standard deviation of joint kinematics (in degrees) at office.

| Items                  | Mean   | Standard Deviation |
|------------------------|--------|--------------------|
| L1 sacrum flexion Y    | 26.13  | (12.18)            |
| L1 sacrum side-bending Z| 4.81   | (6.04)             |
| T5 L1 flexion Y        | -28.81 | (15.49)            |
| T5 L1 side-bending Z    | 0.04   | (8.38)             |
| C4 T5 flexion Y        | -22.58 | (15.46)            |
| C4 T5 side-bending Z    | -4.55  | (10.04)            |
| Left shoulder flexion Y| 14.30  | (11.08)            |
| Left shoulder side-bending Z| 18.32  | (9.87)             |
| Right shoulder flexion Y| 22.10  | (13.19)            |
| Right shoulder side-bending Z| -24.75 | (14.46)            |

3. Results and discussion

The PCA highlighted two principal component coefficients (Table 2). The first coefficient had a correlation index equal to 36.4%. The first principal component coefficient presented essentially the Siegrist and Karasek questionnaires, the spine's angles and postural fluctuations (Table 2). The second principal component coefficients had a correlation index equal to 18.66%. The second principal component coefficient presented the comfort and postural stability.

The joints kinematics of the subject are in agreement with the current studies. The PCA results showed that perception associated to the Siegrist evaluation and social support of Karasek evaluation were correlated with CoMx, CoMy, mean lumbar, thoracic and cervical angles. These results are in agreement with Stins et al. (2015) that showed the influence of anxiety and negatives emotions on postural fluctuations in gait initiation. Grateful and social support could influence postural fluctuations and could impact spinal curves. Moreover, the present study showed a correlation between the perception of comfort, mean velocity, length and area of path sway and shoulders AROM. On a similar point of view, Moseley et al. (2004), showed pain anticipation induce a postural change in order to preserve the damaged area. In the case of the present study, the subject's shoulders pain could influence his postural balance and perception of comfort.

4. Conclusion

This study showed links between stress, social support in work environment and postural balance and upper body kinematics. This study also shows the relationships between postural stability and comfort. This study highlighted the benefits of using both accelerometers and questionnaires in order to evaluate the integrality of a subject in working situation at office. This methodology allows to show the relationship between personal feeling, angular kinematics and postural balance. This methodology is easily to use in many works environments.

Acknowledgements

The authors wish to thanks the management of ESO R. Caporossi, C. Caporossi et O. Caporossi, and S. Pin, J. Sanchez and L. Stubbe for their confidence and support.

References

INRS. 2008. Prévention des risqué liés aux positions de travail statique. Fiche pratique de sécurité ED131.
Videman T, Nurminen M, Troup JDG. 1990. Lumbar spine pathology in cadaveric material in relation to history of back pain, occupation, and physical loading. Spine. 15(8):728–740.
Baucher J, Leborgne P. 2006. Application d’une approche transversale de l’appareil locomoteur au confort siege. ITBM-RBM. 27:133–140.
Stins J, van Gelder L, Oudenhoven L, Beek P. 2015. Biomechanical organization of gait initiation depends on the timing of affective processing. Gait Posture. 41:159–163.
Moseley G, Nicholas M, Hodges P. 2004. Does anticipation of back pain predispose to back trouble? Brain. 127:2339–2347.
Vette AH, Yoshida T, Thrasher TA, Masani K, Popovic MR. 2012. A complet, non-lumped, and very fiable set of upper body segment parameters for three dimentional dynamic modelling. Med. Eng. Phys. 33:70–79.
De Leva P. 1996. Adjustment to Zatsiorky-Seluyanov’s segment inertia parameters. J. Biomech. 29:1223–1230.