STUDY OF CENTER OF PRESSURE (COP) IN GAIT ANALYSIS OF ELDERLY WOMEN IN ROMANIA

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The purpose of this study is to analyze the differences in the trajectory of the center of pressure, COP, in a group of 100 female volunteers aged 55 to 87, using the BioAnalysis software version 2.3.0 for data processing provided by AMTI's AccuGait System force plate. The trajectory of the COP during gait provides an additional tool in the assessment of foot pathology. Research has clarified the differences in trajectories of COP generated and controlled during locomotion, depending on the intensity of disturbances while walking. The aging process leads to a reduction of the movement capacity and the loss of balance, implicitly to a deviation of the center of pressure trajectory, leading to the clarification of a particular pathology. Evaluations of the centers of pressure trajectories of subjects participating in the study showed significant differences between normal and pathological gait. Research on the trajectory of the center of pressure is useful for human gait analysis and for a good understanding of the stability of subjects. In biomechanical evaluation by means of the inverse dynamics method, the force plate is a tool for assessing the interaction between the foot and the support surface, being an indispensable element. In the design of orthopedic footwear, biomechanical analysis is an essential element, so as to ensure a more efficient gait.

Keywords: center of pressure, gait, biomechanics

INTRODUCTION

According to the National Institute of Statistics of Romania (www.insee.ro), on January 1st, 2018 the demographic ageing phenomenon in Romania aggravated, the elderly population aged 65 and over exceeded the young population aged 0-14 by 350 thousand (3614 thousand compared to 3264 thousand persons). The demographic aging process deepened, compared with 2017, with an increase of 0.3 percentage points in the share of the elderly population (aged 65 and over) (Figure 1).

Figure 1. Structure of population per age groups, January 1st, 2018

As the body ages, it becomes less biomechanically active and the prevalence of gait dysfunction and postural balance is increased among the geriatric population. The

importance of the phenomenon results from its association with the increased risk of falling, immobilization, increased degree of dependency and lowered quality of life (Jahn, Zwergal and Schniepp, 2010; Stolze *et al.*, 2004).

For many elderly subjects, the aging process is inevitably accompanied by a reduction in motion capacity and loss of balance (Woollacott, 1993), so the muscles responsible for movement become weaker by decreasing muscle mass and muscle volume, etc. The purpose of this study is to analyze the differences in the trajectory of the center of pressure, COP, in the gait of elderly women in Romania.

The center of pressure (COP) is the point where the resultant of all the ground reaction forces acts. For a normal subject, the center of pressure (COP) trajectory is shown in Figure 2 (Horak, 2006; Serban, 2011), which has the following characteristics in relation to the axis of the plantar surface:

- initial point situated center-lateral corresponding to the contact phase of the gait;
- the trajectory roughly parallel to the axis of the plantar surface for the unilateral support phase;
- medial deflection to the distal end of the hallux in the toe-off phase.

Figure 2. Normal trajectory of the COP (Horak, 2006; Serban, 2011)

Any deviation from this trajectory leads to the classification of a particular pathology or to a certain disturbance of the stable dynamic balance (Serban, 2011).

RESEARCH METHODOLOGY

The study followed biomechanical gait analysis by measuring ground reaction and, implicitly, the center of pressure (COP).

Data Collection

The trajectory of the center of pressure was determined using the BioAnalysis software version 2.3.0 for data processing provided by AMTI's AccuGait System (www.amti.biz).

The study included 100 elderly female volunteers, aged 55 to 87. The structure of the sample by age group is shown in Figure 3, most subjects were aged over 71 (34%), followed by subjects in the 60-64 age group (27%), then those aged 55-59 (26%), while the 65-70 age group consisted of only 13% (Vasilescu *et al.*, 2016). They have given their prior consent to the participation of this experiment. The subjects walked on the track where the force plate was incorporated, and only the trials in which the right foot landed entirely on the plate were deemed valid.

Figure 3. Structure of the age sample

Data Analysis and Interpretation

Normalized parameters provided by the force plate on the center of pressure are the following:

- COP:Heel Strike X (cm) - The X coordinate of the COP at Heel Strike, cm;
- COP:Heel Strike Y (cm) - The Y coordinate of the COP at Heel Strike, cm;
- COP: Toe Off X (cm) - The X coordinate of the COP at Toe Off, cm;
- COP: Toe Off Y (cm) - The Y coordinate of the COP at Toe Off, cm;
- COP: Excursion Along X-Axis,(cm) - The X coordinate of the COP at the maximum point along the X-Axis, cm;
- COP: Excursion along Y-Axis, (cm)- The Y coordinate of the COP at the maximum point along the Y-Axis, (cm);
- COP: Avg X (cm) - The COP's average distance in the X direction;
- COP: Avg Y (cm) - The COP's average distance in the Y direction;
- COP: Length (cm) - The length of the total distance traveled by the COP, (cm);
- COP: Max Velocity (cm/sec) - The maximum velocity traveled by the COP.

Determinations show significant differences between trajectories of the center of pressure of a normal foot and a pathological foot. Unlike the normal foot (Figure 4), the trajectory of the center of pressure for a pathological foot (Figure 5) shows the following characteristics:

- initial point situated center-medial corresponding to the contact phase of the gait;
- the trajectory curved outward during the unilateral support phase;
- lateral deflection to the end of the metatarsophalangeal joint, as a result of the inability to perform toe-off.

Figure 4. Graphical representation of the trajectory of the center of pressure, COP, for a normal foot (right foot)

Figure 5. Graphical representation of the trajectory of the center of pressure, COP, for a pathological foot (right foot)

Each person responds to a task in different ways. For example, Figure 6 shows the comparative time variations of the center of pressure for several subjects participating in the study. There is a different evolution of biomechanical parameters depending on the walking style of each subject.

Figure 6. Evolution of the trajectory of the center of pressure over time for subjects participating in the study

CONCLUSIONS

The analysis of center of pressure trajectory is an essential element in designing and making orthopedic footwear so as to ensure a more efficient gait and so that the footwear functions would facilitate normal foot functions while walking for the purpose of successful day-to-day activities. The design of orthopedic footwear requires a good understanding of the normal and pathological gait biomechanics.

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REFERENCES

- Horak, F.B. (2006), “Postural orientation and equilibrium: what do we need to know about neural control of balance to prevent falls”, *Age Ageing*, vol. 35, ii7- ii11
- Jahn, K., Zwergal, A., Schniepp, R. (2010), “Gait Disturbances in Old Age, Classification, Diagnosis, and treatment From a Neurological Perspective”, *Dtsch Arztebl Int*, 107(17), 306–316, published online 30 Apr 2010, <https://doi.org/10.3238/arztebl.2010.0306>.
- Serban, I.I. (2011), “Studies and research on environmental influence on the stability and human locomotion”, PhD thesis, Transilvania University of Brasov.
- Stolze, H., Klebe, S., Zechlin, C. *et al.* (2004), “Falls in frequent neurological diseases - prevalence, risk factors and aetiology”, *J Neurol*, 251, 79–84, <https://doi.org/10.1007/s00415-004-0276-8>.

Vasilescu, A.M., Deselnicu, D., Pantazi, M. *et al.* (2016), "Analysis of selected anthropometric parameters of elderly women", Proceedings of the 6th International Conference on Advanced Materials and Systems - ICAMS 2016, 429-434, <https://doi.org/10.24264/icams-2016.III.19>.

Woollacott, M.H. (1993), "Age-related changes in posture and movement", *J Gerontol*, 48, 56-60.

*** www.insec.ro