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Assessment of postural stability in women with hip osteoarthritis: A case–control study

Bartosz Slomka [a,b], Witold Rongies [a,c], Janusz Sierdzinski [d,*], Wlodzimierz Dolecki [c], Marta Worwag [e], Ewa Trzepla [f]

[a] Department of Rehabilitation of Physiotherapy Division, 2nd Faculty of Medicine, Medical University of Warsaw, Poland
[b] PhD Program Medical University of Warsaw, Poland
[c] Department of Rehabilitation, Independent Public Central Clinical Hospital in Warsaw, Poland
[d] Department of Medical Information Technology and Telemedicine Medical University of Warsaw, Poland
[e] Medical University of Warsaw, 2nd Faculty of Medicine, Poland
[f] Medical Center, Medical University of Warsaw, Poland

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ABSTRACT

Objective: The aim of the study was to assessment the impact of hip osteoarthritis on postural stability.
Methods: One hundred and twenty-five randomly selected women 20–85 years old (mean age of 49 ± 24.4 years) were assigned to three groups based on age, health status and activity level. Group 1 (cases) – elderly women with diagnosed hip osteoarthritis, group 2 (control) - women without hip osteoarthritis, and group 3 (control) - healthy young women. Assessment of postural stability were measured using a WIN-POD Pel 38 electronic podometer. Statistica 10 software was used to perform t-test resulting in significance level of $p < 0.05$.
Results: Significant differences in pedobarographic balance measurements were observed between the study groups with eyes opened or closed (deviation length eyes open: group 1–3 and 2–3 $p < 0.0001$; eyes closed group 1–2 $p = 0.19$; 1–3 and 2–3 $p < 0.0001$; deviation area eyes open: group 1-3 and 2–3 $p < 0.0001$; eyes closed group 1–3 and 2–3 $p < 0.0001$; deviation velocity eyes open: group1-3 and 2–3 $p < 0.0001$; eyes closed group 1–2 $p < 0.010$, 1–3 and 2–3 $p < 0.0001$). The poorest postural stability was observed in patients with hip osteoarthritis (deviation length eyes open vs eyes closed 180.8/201.7 $p = 0.028$, deviation area 128.7/145.7 $p = 0.771$, deviation velocity 5.1/6.1 $p < 0.0001$), and the best postural stability was observed in young women (deviation length 111.3/137.5 $p < 0.0001$, deviation area 57/76.9 $p = 0.003$, deviation velocity 3.4/4.2 $p < 0.0001$).
Conclusion: (1) Osteoarthritic degeneration of the hip joint results in a significant disturbance in proprioception. This finding was reflected by the inferior stability parameters collected from subjects with hip osteoarthritis when asked to stand with their eyes closed. These finding were not observed in the other groups. (2) The disorder of the body stability of people with osteoarthritis may be a relative indication for the implantation of hip arthroplasty.
Level of evidence: Level III Diagnostic study.

Introduction

Degenerative joint disease is one of the most common joint pathologies. Sixty percent of these pathologies involve the hip (hip osteoarthritis (HOA)) and/or knee (gonarthrosis).

The etiopathogenesis of HOA is not fully understood. Since HOA is usually secondary to a process such as obesity, trauma, the onset of clinical symptoms may occur at virtually any adult age. The less common primary or "wear and tear" HOA is usually observed men and women in their 6th through 8th decades of life. The

Abbreviations: HOA, hip osteoarthritis; EBM, evidence based medicine; COG, center of gravity; COP, center of pressure; EO, eyes open; EC, eyes closed; OA, osteoarthritis.

* Corresponding author. Department of Medical Informatics and Telemedicine, Medical University of Warsaw, Banacha 1a, Warsaw, 02-097, Poland. Tel.: +48 22 6582997.

E-mail address: jsierdzinski@wum.edu.pl (J. Sierdzinski).

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progressing HOA leads to a significant restriction in functional capabilities resulting in reduced mobility, social activity, and overall quality of life.[1–4] Many authors highlight the essential role of the biomechanical characteristics of this joint that predispose it to degeneration.[1–6] The abnormal distribution of load within the hip promotes fast progression of degenerative changes. Therefore, biomechanical analysis of the lower limbs is an important element in the assessment of the pathomechanism behind hip dysfunction.[7] The population particularly prone to falls includes individuals with hip osteoarthritis. Our study was an attempt to interpret the sway of the body's center of gravity via pedobarography in women with advanced osteoarthritis of the hip. The careful interpretation of COG projections in pedobarographic examinations could aid in the development of these methods and potentially decrease the incidence of falls in this subgroup. The purpose of this study was to assessment the impact of hip osteoarthritis on postural stability.

Patients and methods

This a case–control design was conducted between September 2014 and April 2016, in a group of female ranging in age from 20 to 85 years. Participants were chosen based on the following inclusion criteria: above years old, with and without hip osteoarthritis confirmed by standard clinical, different physical activity, and the ability to walk without any aid or physical assistance. Exclusion criteria were the same for all groups and included musculoskeletal pain, advanced foot deformities, intake of analgesic drugs, functional shortening of more than 15 mm of a lower limb, overall poor well-being, declared consumption of alcohol within 24 h of the test and less than 6 h of sleep, single total hip or knee arthroplasty, visual or vestibular impairments or any disease that could potentially worsen their condition or balance, such as cerebrovascular disease, Parkinson's syndrome, polyneuropathy, or a neuromuscular disorder. Out of 160 recruited females, 125 met the eligibility criteria. Ten males were initially included in the study. However, due to the overwhelming number of female participants and a desire to keep the study group homogeneous, we decided to exclude them from analysis.

We've added a second control group included young females to serve as the “benchmark standard”. These women were assumed to have the best body stability due various health factors such as higher bone density, healthy blood pressure and more.

125 participants in aged between 20 and 85 were assigned to three groups based on age, health status and activity level. The cases in this study were inactive elderly polish females with diagnosed hip osteoarthritis (group 1) and the controls were active elderly polish females without hip osteoarthritis (group 2) and young inactive polish females (group 3). Active polish elderly females were chosen as one of the control groups to demonstrate the effects of hip osteoarthritis on body stability. Women of similar ages were assumed to demonstrate similar stability. Young polish females were chosen as the second control group to serve as the “benchmark standard”. These women were assumed to have the best body stability due various health factors such as higher bone density, healthy blood pressure and more. The number of participants in each group was determined randomly. The case group consisted of 37 female cases, 55–85 years old, with diagnosed bilateral HOA declaring no systematic recreational activity. Degenerative changes in the both hips joint had been confirmed in all patients on the basis of patient history physical examination and radiographic evidence (grade 2 according to Altman). The first control group consisted of 30 randomly selected female controls, 60–83 years old without degenerative diseases of the lower limb joints, systematically engaging in organized physical exercises. These women participated in moderate physical activities such as walking 2–3 times per week for around 30–60 min from a minimum 24 months. The absence of degenerative joint disease was confirmed by standard clinical tests and criteria developed by the American College of Rheumatology. The second control group consisted of 58 randomly selected young female controls, 20–28 years old, not engaging in regular physical activity. All subjects in group 3 were students. A summary of their baseline characteristics is presented in Table 1. The study protocol was approved by the Bioethics Committee (KB/137/2012). All participants gave written informed consent before data collection began. All participants gave written informed consent before data collection began. Assessment of postural stability were measured using a WIN-POD Pel 38 electronic podometer and WIN-POD 3.81 (Medicapteurs, France) software at a frequency (f) of 100 Hz per 30 s. The length (mm), area (mm^2) and mean velocity (mm/s) of COG deviations were analyzed. The examination consisted of four 30-s tests with 60-s intermissions in the sitting position. The participants were asked to remove their shoes and stand upright on the forceplate (barefoot) with the head erect and their arms hanging loosely by their sides. Each participant only get tested one time. The first two pedobarographic tests were performed with eyes open (EO) in freestanding posture, whereas the third and fourth tests were performed with eyes closed (EC). For the duration of the recording, the participants were further instructed to “stand as still as possible”. To ensure uniform data collection and reliable results, examiners were asked to adhere to a strict study protocol that included asking participants a series of questions prior to the test about conditions that could adversely affect postural stability. The questions were designed to assess overall well-being, medication intake, number of hours of sleep, alcohol consumption, history of excessive physical exercise, and current pain or discomfort. All tests were conducted in a quiet room with normal temperature and the same illumination. WIN-POD electronic podometer was calibrated prior to the recordings and further underwent an automatic calibration check before each trial. Each participant underwent a single pedobarographic reading.

In statistical analyses, Statistica software (version 10.0, StatSof Inc., Poland) was used. Normalization of the distribution was evaluated by Kolmogorov–Smirnov test. The *t*-test was used for independent groups and dependent variables to compare the individual variables within the study groups. P values less than 0.05 were considered statistically significant.

Results

The study groups differed in number and age. The analysis revealed significant differences in BMI between groups 1 and 3 and 2 and 3. The patients were assigned to three groups based on age, health status and activity level. Group 1 consisted of 53 women with bilateral HOA declaring no systematic recreational activity. Degenerative changes in the both hips joint had been confirmed in all patients on the basis of patient history physical examination and radiographic evidence (Altman's grade 2). Sixteen participants dropped out from this group (eight participants reported co-exist pain in other locations in the musculoskeletal system. five

Table 1
Baseline demographic characteristics of subjects[a].

	Exp (n = 37)	Con 1 (n = 30)	Con 3 (n = 58)
Age (y),	71 (7.2)	71 (6.5)	23.6 (2.5)
BMI (kg/m^2)	27.8 (5.1)	26 (4.3)	21 (2.1)

Abbreviation: Exp 1,experimental group 1; Con 2, control group 2; Con 3, control group 3; BMI, body mass index.
[a] Data are mean (SD).

patients had advanced foot pathologies. and three had recently taken an analgesic). Group 2 consisted of 41 randomly selected women without degenerative diseases of the lower limb joints, systematically engaging in organized physical exercises. These women participated in moderate physical activities such as walking 2–3 times per week for around 30–60 min for a minimum 24 months. The absence of degenerative joint disease was confirmed by standard clinical tests and criteria developed by the American College of Rheumatology. Eleven participants dropped out from this group (two patients had functional shortening of more than 15 mm of a lower limb, and four reported overall poor well-being and five others reported co-exist pain). Group 3 consisted of 66 randomly selected young women not engaging in regular physical activity. Eight participants in this group dropped out from the study (four patients declared less than 6 h of sleep, three had balance disorders and one had functional shortening of more than 15 mm of a lower limb).The flow of participants through the trial are presented in Fig. 1.

The main outcomes measured in this study were length (mm), area (mm^2) and mean velocity (mm/s) of COG deviations. The first pedobarographic parameter subjected to statistical analysis was COG deviation *length* (mm). In EO tests, significant statistical correlations were observed between groups 1–3 and 2–3. The shortest mean value of COG deviation length were in group 3 and the longest in group 1. When comparing the results of the EC tests, there was a statistically significant difference in length of COG deviations between groups 1–2, 1–3 and 2–3. The shortest mean deviation was observed in group 3, while the longest mean deviation was observed in group 1.

The next parameter analyzed was COG deviation *area* (mm^2). In EO tests, significant statistical correlations were observed between groups 1–3 and 2–3. The largest deviation area was measured in group 2 while the smallest deviation area was measured in group 3. The smallest mean areas were observed in group 3 while the largest mean areas were observed in group 1. In the EC tests statistically significant deviation area was observed between groups 1 and 3 and between groups 2 and 3. The largest mean areas were observed in group 1 while the smallest mean areas were observed in group 3. Analysis of results revealed statistical significance between study groups in EO and EC tests.

The last parameter to be analyzed was the average COG deviation *velocity* (mm/s). In EO tests correlations were observed between groups 1–3 and 2–3 while in the EC tests the significant correlation was observed between groups 1–2, 1–3 and 2–3. In EO tests the smallest mean deviation velocity was measured in group 3 while the largest velocity was measured in group 2. In EC tests the largest mean deviations overall were observed in group 1 while the smallest mean deviations were observed in group 3. Comparative analyses of pedobarographic parameters between the three groups were also conducted. Only groups 1 and 3 showed significant worsening of postural stability during the EC tests. A summary of characteristics assessment parameters are presented in Table 2.

Discussion

There are a number of studies on balance disorders in patients with osteoarthritis (OA).[8–16] However, only a few studies, with controversing results, are available on the changes in postural control when the hip joint is affected.[17–19] Arthritic joint damage leads to capsular and other joint structure pathologies, which impairs proprioception and postural stability.[15,16,20] Postural control is a very complex function that combines sensory input, central processing, and neuromuscular responses. Its sensory components include the vestibular, visual and different somatosensory signals,

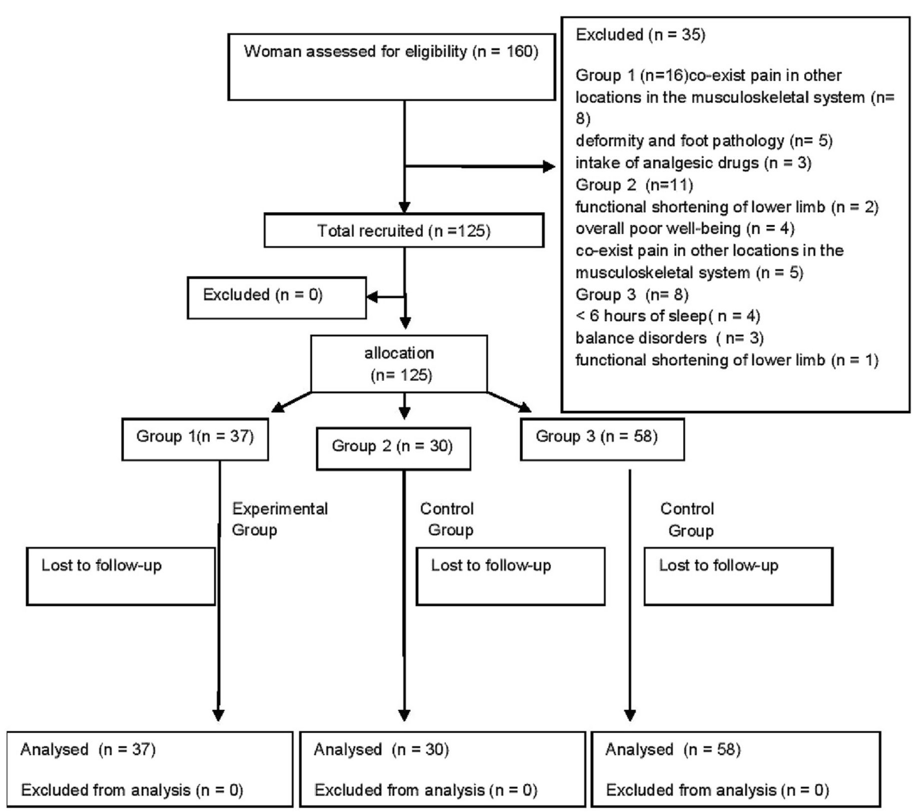

Fig. 1. Design and flow of participants through the study.

Table 2
Mean (SD) for COG deviation for each group, mean (SD) difference within group[a].

Outcome	GROUPS			Within-group differences between eyes open and eyes closed (95% CI)					
	Exp 1 (n = 37)	Con 2 (n = 30)	Con 3 (n = 58)	Exp 1 (n = 37)	*P*	Con 2 (n = 30)	*P*	Con 3 (n = 58)	*P*
Deviation length (mm)	180.8 (50.6)	158.9 (43.7)	111.3 (31.5)	−20.9 (−39.5 to −2.35)	0.028[b]	−5.4 (−20.4 to 9.7)	0.470	−26.1 (−33.2 to −19.1)	0.001[b]
EO/Deviation length (mm) EC	201.7 (42.3)	178.4 (35.7)	137.5 (28.6)						
Deviation area (mm^2)	128.7 (46.5)	118.5 (75.5)	57 (35.4)	−17 (36.1–2.0)	0.077	−21.4 (−49.1 to 6.3)	0.125	−19.8 (−32.6 to −7.0)	0.003[b]
EO/Deviation area (mm^2) EC	145.7 (58.7)	139.9 (59.8)	76.9 (44)						
Deviation velocity (mm/s)	5.1 (1.3)	5.3 (1.3)	3.4 (0.9)	−1.0 (−1.3 to −0.7)	0.001[b]	−0.1 (−0.7 to 0.6)	0.851	−0.8 (−1.0 to −0.6)	0.001[b]
EO/Deviation velocity (mm/s) EC	6.1 (1.2)	5.3 (1.2)	4.2 (0.9)						

Abbreviations: Exp 1,experimental group 1; Con 2, control group 2; Con 3, control group 3; CI, confidence interval; EO, eyes open; EC, eyes closed.
[a] Data are mean (SD).
[b] Statistically significant difference ($P < 0.05$.).

provided by receptors in joint capsules, ligaments, surrounding muscles and in the skin.[15,16,21] Patients with OA are known to frequently suffer from pain. Thus, pain should also be considered to be an important factor in functional impairments.[10,19]

The generalized sensomotor deficit, a lack of proprioceptive information, and loss of neuromuscular control due to the degenerative process may lead to balance problems in OA patients, which renders this issue worthy of study. Our studies as well as studies by other authors demonstrate that both posture and balance are markedly affected by hip OA. Observed postural stability disturbances in patients with OA convey a certain warning, or maybe even compel us to perform total hip replacement procedures earlier than suggested by current guidelines. Total hip replacement is a much easier and safer procedure when it is elective.

Rasch et al evaluated 20 elderly patients with unilateral coxarthrosis prior to, as well as six and 24 months after the surgery. Parameters of gait and postural stability were also analyzed, and a clinical evaluation was performed. The balance measured while standing on the sick leg before the surgery differed significantly from the results of the measurements taken while the patients were standing on the healthy limb during sways in the sagittal and frontal planes. After the operation, there was a gradual improvement in both.[22] Wykman and Goldie evaluated 21 patients before and 1 year after hip replacement surgery. They reported an improved postural stability and a corrected pattern of sway.[23] However, Jarnlo and Thorngren showed that approximately 2 years after a hip fracture, the patients still perceived an impaired balance and exhibited more postural sway than healthy controls.[24] Nallegowda et al showed that patients after total hip replacement had no proprioceptive difficult when compared with healthy age- and sex-matched controls.[25] Nantel et al observed that six months after hip resurfacing, patients had better postural stability than the patients who underwent traditional arthroplasty.[26] Cichy et al analyzed the effects of total hip replacement on podometric measurements. A static podometric examination conducted prior to the surgery revealed no significant differences in maximum plantar pressures between limbs. However, one month after surgery, the operated limb displayed significantly reduced plantar pressures.[27] Similar findings were observed by Merle et al,[28] Belaid et al[29] and Pethe-Kania K et al.[30] Szymanski et al compared the postural stability outcomes of a group of 20 patients after hip resurfacing surgery to 20 after total hip replacement surgery. The control group consisted of 20 healthy individuals. Postural stability was assessed while standing on one foot, both feet, with eyes opened and with eyes closed. Statistically significant differences were demonstrated between the study groups. Individuals after hip resurfacing surgery demonstrated better postural stability in every position described above. Additionally, no significant differences in balance were observed between patients after hip resurfacing and healthy controls.[31] Also, Truszczynska et al observe improved postural stability in patients after hip alloplasty.[32]

Joint-related pathologies may affect the quality of sensory information, leading to diminished proprioception and disrupted automatic postural responses to sensory stimuli which may increase the risk of falls and fractures in patients with HOA.[15,16,19] Therefore, patients with osteoarthritis should be encouraged to have a total hip arthroplasty because these patients have high risks for having trochanteric region (intertrochanteric and subtrochanteric) fractures which makes their treatment more complex. It is challenging to do arthroplasty or firstly fixing fracture and then doing the arthroplasty in a future time is very difficult for these elderly patients for receiving anesthesia in different times.[33,34]

The results of this study may lay the groundwork for future studies in the field of HOA and the prevention of its devastating consequences. This study attempts to interpret pedobarographic deviations in center of gravity of women with hip osteoarthritis and the results will serve as an initial data set from which future studies can build.

Conclusions

(1) Osteoarthritic degeneration of the hip joint results in a significant disturbance in proprioception. This finding was reflected by the inferior stability parameters collected from subjects with hip osteoarthritis when asked to stand with their eyes closed. These finding were not observed in the other groups. (2) The disorder of the body stability of people with osteoarthritis may be a relative indication for the implantation of hip arthroplasty.

Conflicts of interest

No conflicts declared.

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