© Med Sci Monit, 2006; 12(12): CR507-513
PMID: 17136006

Received: 2006.11.09
Accepted: 2006.11.10
Published: 2006.12.01

Gait analysis in osteoarthritis of the hip

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Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

This study was carried out with financial support from the Polish Scientific Research Commission (KBN), grant no. 3 P05 D 070 23

Source of support: Departmental sources

Summary

Background: Several characteristic groups of changes can be observed during full instrumental evaluation of gait in patients with osteoarthritis of the hip. However, this procedure is expensive and causes patient discomfort. We attempted to determine the most clinically useful parameters of gait changes in patients with osteoarthritis of the hip measured by pedobarography, a simple and non-invasive technique.

Material/Methods: 30 patients of both genders, 51–78 years of age, were included in the study. Each patient was tested for static and dynamic gait parameters using an EMED SF-4 force platform (Novel, Germany), with a grid of force transducers registering the pattern of forces exerted by the sole of the foot on ground contact.

Results: Significant differences were observed in step length. Small but statistically significant differences were observed for total ground contact area between the results obtained for the affected and helthy leg. Maximum ground reaction measured for the whole foot and ground contact time was not significantly different between the limbs. Statistically significant differences were observed for maximum pressure and area under the pressure/contact time curve. In evaluating the gaitline (a line representing the maximum dynamic force from initial contact to push-off), 25 of 30 patients had an abnormal result for the affected leg, whereas the healthy leg was abnormal in 16 of 30 patients.

Conclusions: Gait abnormalities in patients with hip osteoarthritis are mainly observable in asymmetry of weight-bearing and asymmetry of step length. Pedobarography is a clinically suitable diagnostic tool.

key words: **pedobarography • hip osteoarthritis • gait parameters**

Full-text PDF: http://www.medscimonit.com/abstract/index/idArt/469536

Word count: 3980
Tables: 2
Figures: 3
References: 24

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BACKGROUND

An unequivocal and universally accepted definition of osteoarthritis has yet to be developed. Clinically, this disease entity is characterized by joint pain, occurring mainly on joint motion, and by progressive loss of joint function. Radiographic studies typically reveal destruction of articular cartilage and the subchondral bone layer, coexistent with signs of reparative processes, such as subchondral bone condensation and osteophytes in the bone-cartilage interface. The morphological features of the disease include joint cartilage and periarticular bone defects with coexistent inflammatory changes, usually of low intensity, involving the articular capsule and surrounding tissues, resulting in cicatrization [1]. One of the most frequent locations of osteoarthritis is the hip joint [2].

The etiology of primary hip osteoarthritis remains unknown. According to some authors, a specific causative factor can be identified in approximately 75% to 80% of cases of hip osteoarthritis, on the basis of clinical history and additional tests, which may reveal, for example, developmental dysplasia of the hip or epiphysiolysis of the femoral head, resulting in various degrees of abnormalities in the anatomy and pattern of force distribution in the hip joint. In these patients, the diagnosis is secondary osteoarthritis [2]. In cases where no such abnormalities can be detected or where no other specific causes can be identified, primary osteoarthritis of the hip is diagnosed upon exclusion of other factors [2].

The prevalence of hip osteoarthritis in the Caucasian population is approximately 10-20%; degenerative changes of the hip are found in no more than 4% of the 18- to 34-year-old population, but occur in 85% of persons over 75 years of age [2].

The clinical symptoms of hip osteoarthritis include joint pain, progressive loss of range of motion, sometimes effusion and other features of inflammatory process, not accompanied by systemic inflammatory reactions. Clinical examination almost invariably demonstrates pain on movement and weight-bearing on the affected extremity, usually most pronounced upon initial movement after a period of inactivity ("start-up pain"); the patients usually localize the pain anywhere from the groin to the knee, most commonly in the antero-lateral and anterior aspects of the thigh [3]. A physical examination will reveal a reduced range of motion in the affected joint and pain on terminal range of motion. The highest diagnostic sensitivity is observed for internal rotation (the normal range in adults is 40°), hyperextension (normal value 15°) and external rotation (normal range 60°).

Radiographic imaging usually determines the diagnosis. The presence of osteophytes in the acetabular rim or around the femoral head, coexistent with reduced joint space, confirms the diagnosis of osteoarthritis. In most cases, a plain AP X-ray is sufficient to make the diagnosis. The pain and decreased range of motion caused by hip osteoarthritis usually cause patients to seek medical attention only at a late stage of the disease, when anatomical changes are advanced and well visible in radiographic studies. Therefore, in any case of suspected hip osteoarthritis not confirmed by radiography, other possible causative factors should be sought to explain the patient's symptoms.

Osteoarthritis of the hip significantly impairs gait efficiency, progressively lowering the patient's quality of life. In gait analysis of patients with osteoarthritis of the hip, several characteristic groups of abnormalities can be observed. These result from the principal symptoms of osteoarthritis. The most characteristic change is reduced gait speed [4]. This results in ineffective usage of momentum and increased fluctuation of the center of gravity in the sagittal plane. Pain in one of the lower limbs, along with reduced range of motion in the affected hip joint, disturb the isometric gait determinant. The resulting anisometric gait is characterized by impaired coordination, reduced support phase and reduced step length in the affected leg, and prolonged duration of the whole gait cycle. An extreme form of the anisometric gait pattern is the "dragging" pattern, where only one of the lower limbs (usually the affected leg) is swung forward, whereas the healthy leg is only pulled forward and does not cross the coronal plane.

Pathological gait in hip osteoarthritis also includes disturbances of the isochronic gait determinant, resulting in the so-called antalgic gait pattern. This is characterized by prolonged stance phase in the healthy lower extremity, when the patient prepares the affected leg for ground contact, followed by "leaping" over the affected leg in order to regain the ground contact of the healthy lower extremity as quickly as possible, thus reducing the period of weight-bearing on the painful affected hip joint. Uncoordinated arm movements also impair equilibrium and cause an irregular pattern of weight-bearing. This gait pattern includes anisometry [5].

Gait can be analyzed objectively using instrumentation, usually involving five cameras and a system of electrodes attached to the patient's body. However, this procedure is expensive, cumbersome, time-consuming, and very uncomfortable for the patient. Accordingly, we attempted to develop a simple and reliable method to analyze the changes observed in the support gait phase, using a device capable of recording dynamic patterns of ground reaction forces. We focused primarily on the comparison of parameters such as step length, foot-ground contact area, maximum ground reaction force, maximum force per area unit (maximum pressure), and foot-ground contact time, as well as two calculated integrals: area under the force/time curve and area under the pressure/time curve. Considerable inter-individual variability is observed in healthy subjects in most of these parameters. However, the most important and practically definitive feature of normal gait, required for its energy efficiency, is symmetry; therefore, in our study we focused our analysis on the symmetry or asymmetry of these gait parameters.

MATERIAL AND METHODS

Our study was carried out in the years 2002–2004 at the Traumatology, Orthopedics and Rehabilitation Clinic of the Jagiellonian University's College of Medicine in Cracow, and at the Central Research Laboratory of the Footwear Industry (Centralne Laboratorium Przemysłu Obuwniczego), also located in Cracow. The study group consisted of 30 patients, 19 females and 11 males, ranging in age from 51 to 78 years ($x=63.6\pm8.9$ years).

The inclusion criteria were as follows:
– a diagnosis of primary unilateral osteoarthritis of the hip;

– ability to ambulate without the use of crutches, walking sticks or walking aids.

The exclusion criteria for our study were as follows:
– clinical changes in more than one limb or in the spine (clinically overt degenerative changes, limitation of range of motion, posttraumatic changes);
– obesity (defined as body mass index above 30);
– diabetes mellitus;
– documented disorders of arterial or venous circulation in the lower extremities;
– implanted endoprosthesis of the contralateral hip or any of the knee joints;
– structural or apparent shortening of one of the lower extremities exceeding 2.5 centimeters;
– deformities or diseases affecting the feet;
– history of amputation at any level of the lower extremities.

All 30 patients were evaluated for the same gait parameters. The test procedures examined the static and dynamic pattern of ground reaction forces, using an EMED SF-4 force platform (manufactured by Novel, Munich, Germany). This system consists of a fixed running track 5 meters long and 1 meter wide, with a built-in force plate at approximately 2/3 of the length, 360 mm long and 190 mm wide, containing an array of 2,736 transducers (4 sensors/cm^2), able to measure ground reaction forces dynamically (sampling frequency 50 Hz) in the range of 0 to 127 N [6]. The force plate is automatically calibrated every time the device is turned on. Due to the high sensitivity of the transducer array, the test procedure is always carried out with the subject barefoot, in order to eliminate errors caused by clothing, such as seams in hosiery.

The static phase of the test included the recording of total pressure (the entire foot-ground reaction force calculated for the contact area) and the distribution of forces exerted by the plantar surface of the foot. The procedure was carried out individually for each leg.

Dynamic testing was performed at the normal gait speed of each individual patient, since the gait pattern is known to be consistent in its physical characteristics when the patient is allowed to walk at his/her usual speed [7–9]. The second step along the track was recorded, in order to eliminate errors resulting from momentary loss of equilibrium at start-up. The tests were carried out three times for each leg. The method we adopted has been described in the literature as the mid-gait measurement method [7,10,11].

The data obtained for foot-ground reaction force patterns were digitalized and analyzed in a dedicated workstation equipped with proprietary EMED software. The individual footprint images were manually superimposed with so-called masks, which are standardized grids of anatomical areas, allowing us to calculate standardized forces for each individual area of the foot [7,11]. A total of seven such masks were superimposed on the footprint images (Figure 1):
– mask 1: big toe;
– mask 2: remaining toes;
– mask 3: head of the 1st metatarsal;
– mask 4: heads of the 2nd and 3rd metatarsals;
– mask 5: heads of the 4th and 5th metatarsals;
– mask 6: midfoot;
– mask 7: heel.

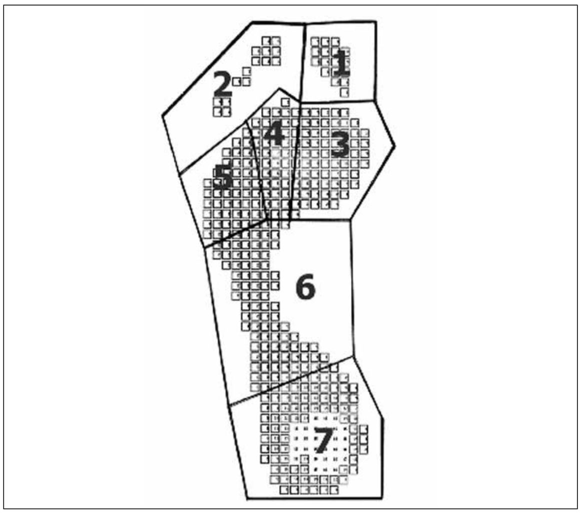

Figure 1. Mask grids superimposed on the footprint image for the analysis of parameters in specific anatomical areas. Mask 1 – big toe; Mask 2 – remaining toes; Mask 3 – head of 1st metatarsal; Mask 4 – heads of 2nd and 3rd metatarsals; Mask 5 – heads of 4th and 5th metatarsals; Mask 6 – midfoot; Mask 7 – heel.

This system has been described in the literature by Kernozek et al. [12].

The following parameters were subsequently analyzed:
– total foot-ground contact area (expressed in cm^2);
– maximum ground reaction force, with a record of the mask where the maximum force was observed (expressed in N);
– maximum pressure in individual masks (in N/cm^2);
– total foot-ground contact time and contact time in individual masks (in milliseconds);
– ground contact time in individual masks, expressed as a percentage of total foot-ground contact time;
– moment of initial ground contact for each mask (expressed as a percentage of the total ground contact time);
– moment of last ground contact for each mask (expressed as a percentage of total ground contact time);
– the integral (area under the curve) of the pressure/time curve for the whole foot and for individual masks [in (N/cm^2)×s)].
– moment of maximum force for the whole foot and in individual masks, expressed as a percentage of total ground contact time.

We also examined the shape of the so-called gaitline, which is a geometrical description of the course of the calculated mean ground reaction force during the propulsion phase when the foot is in contact with the ground, plotted by the EMED system computer. For the sake of simplicity this parameter was assumed to have one of two different values:
– "normal gaitline," i.e. approximating a straight line, starting at the heel and directed towards the toes, free of loops or indentations;
– "abnormal gaitline," i.e. containing loops or indentations, or originating anywhere other than at the heel.

A gaitline with any shape other than normal may indicate disturbances of equilibrium, loss of motion smoothness, and

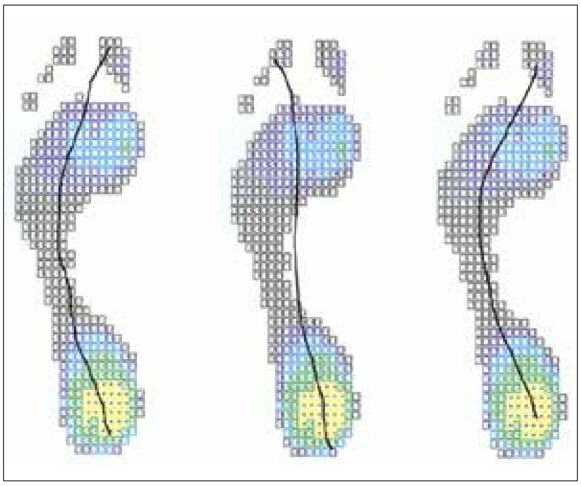

Figure 2. Typical variants of normal gaitline.

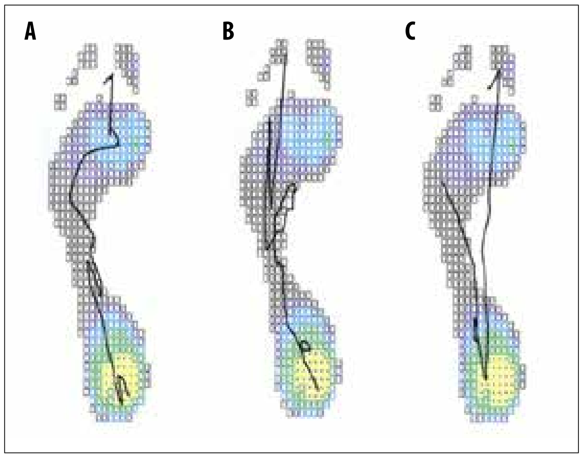

Figure 3. Three commonly observed shapes of abnormal gaitline: (**A**) "indented" line; (**B**) "looped" line, (**C**) starting point other than the heel.

insecurity of gait [13,14]. Figure 2 demonstrates some typical variations of normal gaitline; Figure 3 illustrates three frequently observed abnormal gaitlines.

Three sets of data were obtained for each foot. Parameters from these three tests for each leg were used to calculate the means for all parameters. This method has been generally accepted in the literature, and is aimed at eliminating errors caused by the variability of the results observed between tests carried out in individuals. Most authors recommend accepting the arithmetic means from three to five parameters as the final results for a given patient [15].

The range of motion in both hip joints was assessed in all patients using a manual goniometer. The results were recorded to the nearest 5 degrees.

Step length was measured for each leg, and the arithmetic mean was taken from three separate tests. The measurements were carried out manually with a rigid measuring line; the accuracy was assumed to be 1 cm, and mean values were rounded to the nearest centimeter. In addition, the length of the lower extremities were measured for all patients, as well as height and weight.

The results of static, dynamic and clinical data were subjected to statistical analysis. The data we obtained were used to calculate the statistical parameters, where the measure of the central tendency was the arithmetic mean (x) and the measure of dispersion (variability) was standard deviation (SD) and range (minimum-maximum).

RESULTS

Analysis of step length

In healthy subjects at freely selected gait speed, step length is equal for both legs, and the value averages 75 centimeters in the adult population. In our study group, significant deviances from the norms were observed, with step length ranging from 21 to 70 cm in the affected limb, and from 21 to 74 cm in the healthy limb. The means were significantly lower than normal (x=42.6±13.1 cm for the affected leg, x=44.1±13.7 cm for the healthy leg).

Analysis of static testing

The maximum pressure for the affected leg averaged 14.4±7.9 N/cm^2 (min=4.0 N/cm^2, max=47.0 N/cm^2). For the healthy leg, the mean values were 17.2±7.8 N/cm^2, with minimum and maximum values of 6.0 N/cm^2 and 40.0 N/cm^2, respectively.

Analysis of dynamic testing

Table 1 summarizes the results of parameters obtained in dynamic testing of both affected and healthy legs.

Statistically significant differences were observed between the affected and healthy legs in the area of foot-ground contact. (Statistically significant differences were also observed for this parameter between genders; however, this difference is of no importance for the purposes of this study, as it obviously results from the statistically greater values of body weight and foot size observed in males). The difference between legs in terms of maximum ground reaction force also proved to be statistically significant (Wilcoxon's test, assuming $p<0.05$ as the upper limit of statistical significance). The maximum ground reaction force likewise differed significantly, with lower maximum pressure values recorded for the affected leg.

The differences in mean foot-ground contact time between the values for the healthy and affected legs were not statistically significant ($p>0.05$, Wilcoxon's test). For the area under the pressure/time curve, however, these values differed significantly, with lower values observed for the affected leg ($p<0.05$), while the area under the force/time curve did not differ significantly.

The moment of maximum pressure is presented in absolute values (milliseconds elapsed from initial foot-ground contact to the instant of maximum pressure) and as a percentage of the entire foot-ground contact time (propulsion phase). No statistically significant differences were observed between the mean values obtained for the affected and healthy legs. The moment of maximum force is also presented in absolute values (milliseconds elapsed from initial foot-ground contact

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Table 1. Summary of results of measurements of gait parameters in 30 patients (19 females and 11 males) for the affected and healthy lower extremity. Results have been presented for whole study group collectively.

Parameter	Results of measurements			
	Affected leg		Healthy leg	
	X±SD	Range	XS±D	Range
Total contact area [cm^2]	128.1±14.3	99.0–159.3	**132.8±17.7***	97.0–165.0
Maximum force [n]	**870.5±162.6***	557.4–1199.2	**862.7±175.7***	543.1–1260.0
Maximum pressure [n/cm^2]	44.4±20.0	17.0–97.5	61.8±26.2	17.0–123.5
Contact time [ms]	1188.0±393.6	780.0–2080.0	1203.0±473.5	20.0–2080.0
Area under the pressure/time curve [(n/cm^2)×s]	29.1±12.4	13.6–77.4	43.5±35.7	0.3–157.2
Area under the force/time curve [(n)×s]	683.1±249.1	404.5–1328.1	745.2±354.9	10.9–1668.6
Moment of maximum pressure [ms]	808.2±352.0	25.0–1690.0	817.6±377.3	10.0–1530.0
Moment of maximum pressure as% of propulsion time	69.3±20.8	25.0–93.9	71.5±20.4	16.0–94.6
Moment of maximum force [ms]	629.7±293.6	270.0–1160.0	689.3±321.8	10.0–1310.0
Moment of maximum force as% of propulsion time	52.3±16.2	29.0–76.9	57.5±15.4	23.8–75.5

X±SD – arithmetic mean ± standard deviation;
* –statistically significant differences ($p<0.05$, Mann-Whitney U test) between the results of gait parameters in males and females.

Table 2. Comparison of gait parameter values for the affected and healthy legs; non-parametric Wilcoxon's pair order test for dependent samples with subdivision into individual anatomical areas of the foot. Statistically significant differences ($p<0.001$) have been marked with an arrow.

Parametr	Results of measurements			
	Affected leg		Healthy leg	
	X±SD	Range	X±SD	Range
Mask 1 (big toe)				
Maximum force [n]	91.4±57.9	8.6–209.3	118.6±76.6	8.6–295.4
Contact time [ms]	854.3±497.5	180.0–2080.0	1007.3±498.8	20.0–2020.0
Area under the force/time curve [(n)×s]	37.8±34.3	1.7–156.1	69.8±86.1	0.2–356.3
Mask 2 (remaining toes)				
Maximum pressure	18.5±14.8	3.5–80.0	23.3±21.4	4.5–123.5
Area under the pressure/time curve [n/cm^2]	8.3±6.6	0.6–22.4	11.0±10.3	0.1–52.7
Area under the force/time curve [(n)×s]	19.9±16.4	0.6–73.4	24.7±20.1	0.1–67.6
Mask 7 (heel)				
Maximum pressure as% of propulsion phase	33.5±11.6	15.5–56.0	28.1±13.7	5.6–54.7

to the instant of maximum force) and as a percentage of the whole foot-ground contact time (propulsion phase). The moments of maximum force for the affected and healthy legs did not differ in a statistically significant way.

Comparative analysis

A statistical analysis was performed to compare the gait parameters obtained for individual anatomical areas of the foot (masks), with an indication of those parameters where statistically significant differences were observed for the affected and healthy legs.

Asymmetry was observed in three masks: mask one (big toe), mask two (remaining toes) and mask seven (heel). The differences in the values obtained for the affected leg and the healthy leg were highly significant ($p<0.001$, Wilcoxon's test). The results are summarized in Table 2.

In mask one (big toe), the maximum force, the contact time, and the area under the force/time curve were lower for the affected leg versus the healthy leg. In mask two (remaining toes), the maximum pressure, the area under the pressure/time curve, and the area under the force/time curve were lower for the affected leg versus the healthy leg.

In mask seven (heel), the moment of maximum force, expressed as a percentage of the duration of the propulsion phase in the affected leg, was significantly later for the affected leg versus the healthy leg.

For the purposes of statistical evaluation, any abnormal gaitline pattern was assigned the value of "1," whereas normal patterns were assigned the value of "2." The mean value for the affected leg was 1.17±0.38, whereas for the healthy leg it was 1.47±0.51.

Discussion

The available literature [16,17] points to asymmetry of gait in patients with osteoarthritis of the hip; similarly as in our results, static asymmetry (when standing) is not detectable unless the affected leg is structurally shorter by more than 2 centimeters. Similar asymmetry is observed in the presence of significant fixed flexion deformity in the affected hip joint, resulting in functional shortening of the affected leg [17,18].

Significant step shortening has been observed for both legs in patients with osteoarthritis of the hip when compared to an age-matched control group of healthy adults [14,19]. In our material, statistically significant asymmetry was observed for step length: when the step length of the affected leg was compared to that of the healthy leg, the latter had a 3.52% greater mean value.

Dynamic testing indicated several differences for particular legs.

The total foot-ground contact area indicated small but statistically significant differences between the results for the affected and healthy leg. This parameter is highly variable from individual to individual, and depends on many factors, such as body weight, foot size, and the possible presence of deformities (e.g. pes equinovalgus).

It seems clear that single parameters are of little or no diagnostic or research value; rather, they should be analyzed in comparison between the feet (assuming that the feet are both free of deformities), while the results that best indicate asymmetry are those related to the values of the area under the pressure/time curve, i.e. the value characterizing the total ground reaction pressure exerted during the whole duration of foot-ground contact time [9].

For the maximum force measured for the whole foot, no statistically significant differences between the two legs were observed. Statistically significant differences were observed between the group of males and females; however, these values appear to result from the differences in mean body weight observed between these groups.

Statistically significant differences were also observed for maximum pressure.

In the evaluation of foot-ground contact time, no statistically significant differences were observed between the lower extremities.

The area under the pressure/time curve describes the total foot-ground reaction force per area unit during the whole duration of the propulsion phase; therefore, the comparison of the affected and healthy legs in this respect can be considered a good indicator of symmetry of weight-bearing during gait [10]. For this parameter, we observed asymmetry in our material: the mean values for the affected leg are significantly lower than the values recorded for the healthy leg.

The area under the force/time curve is a derivative of maximum foot-ground reaction force; this parameter is considered in the literature to show high inter-individual variability [20]. No statistically significant differences between the two legs were observed for this parameter in our study.

The moment of maximum pressure and the moment of maximum force allow us to assess the duration of maximum pressure throughout the whole propulsion phase. Due to high inter-individual variability, both these parameters are considered to be of uncertain scientific value in the functional assessment of gait [12]. We expected both these parameters to demonstrate asymmetry in patients with unilateral osteoarthritis of the hip; however, we observed no statistically significant asymmetry in these parameters.

The gaitline is a parameter difficult to evaluate objectively, owing to the high variability of its shape and the difficulty involved in describing it in absolute, numerical values. However, our results demonstrate that this parameter can be very useful in quick evaluation of the presence or absence of gait pathology, since it does not require time-consuming calculations. The literature also indicates that discrete disorders of gait equilibrium and stability, sometimes presenting as a very discrete limp, can result in a significantly altered gaitline [21–23].

The method we used in our study involved characterization of the gaitline with two values: normal, i.e. nearly straight and free of deformities, or abnormal, i.e. showing some irregularities. This method has been adopted as a result of our analysis of the literature, where it has been suggested as a quick method to identify the presence or absence of gait pathology. The gaitline is almost invariably normal in the age-matched normal population [21].

In our study, most patients (25 out of 30) had an abnormal result for the affected leg, whereas the healthy leg had an abnormal result in 16 of 30 patients. Assigning numeric values (1 – abnormal gaitline, 2 – normal gaitline) allowed us to quantitatively calculate mean values and compare them; the mean value for the affected leg was close to 1 (1.17±0.38), whereas the mean value for the healthy leg was nearly halfway between 1 and 2 (1.47±0.51). The gaitline appears to be a useful parameter indicating the presence or absence of gait pathology. The curve is plotted automatically, and does not require additional calculations; therefore, when a dynamic pedobarography system is available, such as the EMED SF-4, it can be used for quick assessment of gait.

Our evaluation of gait parameters was undertaken based on a compilation of various methods found in the literature [6,21]; characteristic changes were sought for weight-bearing in individual areas of the foot, possibly associated with osteoarthritis of the hip. The results we obtained did not indicate any unequivocal differences in the characteristics of static weight-bearing in the studied group. Statistically significant differences were observed in weight-bearing in the big toe area (lower mean values of maximum force, contact time, and area under the force/time curve), as well as the remaining toes (lower mean values of maximum pressure, area under the force/time curve and area under the pressure/time curve) for the affected leg versus the healthy leg. This differences indicates asymmetry, consisting in lower weight-bearing for all toes in the affected leg in patients with osteoarthritis of the hip.

In the heel area, statistically greater values were observed for the moment of maximum force (expressed as a percentage of the duration of foot-ground contact) for the affected leg versus the healthy leg. This difference indicates a faster increase in the slope of weight-bearing in the heel area in the initial contact phase in the affected lower extremity.

Statistically significant differences in weight-bearing were observed in three of the seven analysed areas and in three of the thirteen analyzed parameters. All values apart from one (the moment of maximum force expressed as a percentage of the total duration of the propulsion phase in the heel mask) are lower for the affected leg than for the healthy leg.

The duration of the testing process using this methodology is only approximately 45 minutes; the associated discomfort for the patient is minimal. The described method has been streamlined for the use of elementary gait analysis in clinical practice. Apart from the pedobarography device, only simple measurement devices, such as a ruler or yardstick, are required. With a little practice, this simple and repeatable methodology appears to produce reliable results and allows for quick performance of the test. Full gait analysis, by contrast, requires very difficult and time-consuming tests and costly instrumentation. In addition to pedobarography, the process also includes electromyographic recording of the function of individual muscles and registration of kinetic parameters, using five computer-linked video cameras. The study procedure is long, requires the patient to spend a long period of time nude and with electrodes and space orientation markers glued to his/her body. The full gait analysis methodology is therefore associated with considerable discomfort for the patient, and is not widely used in clinical practice [18,24]. Its usefulness is thus practically limited to tests in sports medicine.

It turns out, however, that pedobarographic gait analysis alone can yield considerable data, the numeric analysis of which is rather complex. By identifying only a few of the most valuable parameters as described above, however, the method can be simplified, and yet it is still capable of supplying reliable and repeatable results, useful in clinical practice.

Conclusions

Characteristic disorders of gait are observed in patients with osteoarthritis of the hip. These disorders are mainly related to asymmetry of weight-bearing in the lower extremities, while asymmetry of step length, weight-bearing and step length are also decreased in the affected leg in unilateral hip arthritis.

The pedobarographic methodology adopted in our study is useful in clinical practice and in monitoring the physical fitness and gait efficacy of patients with osteoarthritis of the hip. When appropriate standards are observed, the method is highly sensitive and reliable.

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