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Body posture in patients with Parkinson’s disease

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Body posture in patients with Parkinson's disease

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A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
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abstract

Background The purpose of the study was to analyze changes in the body posture and to assess the differences in posture between women and men with PD.

Material/Methods A group of 32 patients were examined, who were members of the Parkinson's Disease Association in Kielce. Body posture was examined by an optoelectronic method – Diers formetric III 4D – using raster stereography.

Results Enlarged chest kyphosis (*hyperkyphosis*) was observed in 11 (34.37%) individuals. Enlarged lumbar lordosis (*hyperlordosis*) occurred in 10 (31.25%) patients. Deepened chest kyphosis and lumbar lordosis (*hyperkyphosis-hyperlordosis*) was noted in 3 (9.37%) individuals. Scoliosis occurred in 28 (87.5%) patients while 4 patients (12.5%) showed signs of scoliotic posture.

Conclusions Significantly more postural defects were observed in individuals with PD compared to those who were healthy. This is especially true in the case of scoliotic posture. Highly significant differences in posture variables were observed between males and females, concerning body height and mass, angle of lumbar lordosis, trunk length (VP–DM) and trunk length (VP–SP). Patients with PD require systematic rehabilitation, which is as important as pharmacological treatment.

Key words Parkinson's disease, body posture, curvature of the spine

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INTRODUCTION

Parkinson's disease (Lat. *morbus Parkinsoni*) is one of the most common diseases of the nervous system. In the course of the disease a wide spectrum of disorders is observed, especially motor, cognitive, and emotional ones. Also disorders in the autonomic nervous system are observed. The disease often begins between the ages of 58–62; however, cases of its earlier development are also noted. It is estimated that the disease occurs in approximately 0.15% of the general population [1, 2, 3]. The morbidity risk in males is slightly higher compared to females [4, 5]. It is estimated that in Poland about 80,000 people are ill with this disease. Apart from motor disorders (e.g. resting tremor, slowness of movements, muscle rigidity, disorders of posture and motor coordination) [6, 7], there occur non-motor symptoms, including emotional disorders, cognitive disorders, vegetative symptoms, disorders concerning sleep and sensory sensitivity [8]. The cause of the development of Parkinson's disease has not been recognized to-date, and its treatment is limited to the symptomatic treatment. The pathomechanism of death of dopaminergic neurons has not been discovered. There are several etiologic hypotheses of Parkinson's disease, among others, the theory of environmental factors and toxins [9, 10], the theory of genetic factors [11, 12], the theory of premature ageing of the *substantia nigra* [13], and the theory of oxidative stress [3, 13, 14]. For the clinical diagnosis of Parkinson's disease the occurrence of two of the three axial symptoms is necessary: resting tremor, slowness of movements (*bradykinesia*), and muscle rigidity. Bradykinesia is the precondition for making the diagnosis of the disease. In daily life, motor symptoms of Parkinson's disease are manifested by difficulties with independent locomotion, performance of precise activities, difficulties in starting movement, balance disorders, and falls [3]. A reduced range of movement in the joints of the lower extremities (shuffling feet along the ground) also occurs, just as walking with small steps, decreased speed, and shortening of the step width and length. Difficulties also occur at the beginning or end of walking, and there is a lack of counter-clockwise rotation of the shoulder girdle against pelvic girdle and of the function of the upper extremities. Difficulties in performing normal trunk twisting while turning and walking occur [3].

Patients are constantly exposed to the sudden loss of balance ending with a fall (palsy). There may occur the preference for falling backward (retropalsy), falling forward (propalsy), or to the sides (lateropalsy). Double support time increases, and a decreased walking speed is observed. There occurs a phenomenon of the so-called 'tunnel' consisting in small steps in front of a narrowing on the route of movement, and also a symptom of so-called 'freezing', i.e. a sudden blockade while walking. Frequently, the patient is not able to take his foot off the floor in order to make the subsequent step. Sudden immobilization may result in the loss of balance. When the blockade of movement happens at the moment of turning back, it may be the cause of a fall. Walking disorders are the most frequent cause leading to falls [3]. In the course of Parkinson's disease, due to, among others, muscle rigidity and bradykinesia, there develops an abnormal body posture and pathological walking pattern. In patient's posture the following symptoms are observed: forward leaning of the head and the neck section of the spine, increased thoracic kyphosis, flattened lumbar lordosis, extensor arm joints position and their adduction and internal rotation, bending elbow joints with pronation, bending of metacarpophalangeal joints, extension of interphalangeal joints, adduction of the thumb, light extension, bending, internal rotation of the hip joints, and light bending of the knee joints [3, 16–23]. In view of the above, the purpose of the study was to analyze changes in the body posture and to assess the differences in posture between women and men with PD.

MATERIAL AND METHOD

A group of 32 patients with PA were examined; they were members of the Parkinson's Disease Association in Kielce; the majority were females – 26 persons (81.25%), and there were 6 males (18.75%). The study was conducted in November 2013 in the Laboratory of Posturology, the Institute of Physiotherapy, Faculty of Medicine and Health Sciences, Jan Kochanowski University in Kielce. All patients were treated with levodopa (L-DOPA; Lat. *Levodopum*). This is a natural amino acid – catecholamine, produced in the process of tyrosine hydroxylation, in the reaction catalyzed by tyrosine hydroxylase. It is the precursor of dopamine, which causes an increased concentration of this neurotransmitter in the brain. The duration of the disease was over 5 years. The daily dose of L-dopa remained within the range of 600–1000 mg/d. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The patients were informed concerning the objective of the study and expressed written consent to participate in this study. The study was non-invasive and free of charge. The patients willingly participated in the study, and perceived it as concern about their state of health.

The body posture was examined by an optoelectronic method – Diers formetric III 4D – using raster stereography. Three-dimensional analysis of the spine is a combination of the latest optical imaging technique and digital data processing. This is a quick and touchless photogrammetric 4D measurement and analysis of the surface of the patient's back and spine. The results of the measurement are very precise, and due to a quick transmission of the image into the computer, analysis of the data takes place directly after performance of the examination. Due to the measurement, it is possible to make a precise diagnosis which would enable the selection of the best possible individual therapy.

During the examination, the patient stands with his back against the device which consists of a digital video camera and a projector. The projector emits parallel measurement lines to the surface of the back, and a digital video camera transmits a three-dimensional image to the computer. Using the photometric method and image processing, the three-dimensional reconstruction of the surface of the back is performed. Further analysis of the registered points takes place automatically, by means of the method of differential geometry. The computer software instantly analyses the data and establishes a digital image of the surface of the back, spine, and the position of the pelvis. In this way, the surface of the back is reconstructed with approximately 7,500 points. The main points of reference are: the point of the strongest bulging curvature C_7, sacral dimples and the beginning of the gluteal furrow, also called the gluteal fold. Apart from the anatomical points of reference, by analysis of the form it is also possible to determine the so-called back symmetry line; this is closely associated with the line of the spinous processes. It is mathematically calculated as the line dividing the back into two halves with minimal left-right asymmetry. In the case of normal posture, the symmetry line is in the forehead view a vertical line, equivalent to the line of the spinous processes. In scoliosis, the symmetry line follows with great precision the line of the spinous processes. The meeting of the conditions of slight asymmetry is not always clear; therefore, it is additionally required that the shapes of the curves, which the symmetry line may assume, were limited to the smooth curves biomechanically allowable and radiologically equivalent to the observed set of forms. This excludes sharp curvatures and inequalities in the symmetry line. The symmetry line is especially important as a starting point for the reconstruction of the spatial course of the spine.

To take a single snapshot, the presentation of the patient lasts for 40 milliseconds. The 4D technology combines the three-dimensional reconstruction of the image of the spine and trunk and the time component. The time interval of the test covers, within six seconds, one cycle of fluctuations (5.6 sec., approx. 300 mm forward/backward, 10 mm one side, on average), as well as one respiratory cycle. During the 6-second presentation of the patient, the camera registers 12 snapshots from which an average value is created. The ultimate result is calculated by the software mean value from all snapshots, slight differences among which are the result of the breathing movements of the chest, and the instability of the patient's posture.

The software allows a precise, three-dimensional determination of the shape of the surface of the back, the course of the line of the spine, and position of the pelvis. The precision of the measurement of points on the surface of the back is 0.5 mm, to the depth of 0.1 mm, and the fixed points 0.8 mm. The reliability of results of analysis of the back using the Diers formetric III 4D has been confirmed by comparison with 500 digital and factually numerically analyzed RTG images. The RTG provides direct and imaging information concerning the form and deviations from normal, yet only in two-dimensional projection. In addition, the disadvantage of RTG examination is the harmfulness of radiation, which makes it impossible to take control images within short periods of time. The Diers formetric III 4D method is a touchless, automatic, and first of all, a non-radiating method of measurement of the body statics. The device allows making three-dimensional diagnosis of scoliosis and body posture defects, evaluation of the motility of the spine, analysis of the shortening of the length of extremities with pelvis tilt position, and control of the course of the disease. The limitations in the use of the Diers formetric III 4D is scoliosis with a Cobb angle higher than 52 degrees, patients with post-operative bruises in the spine region, and patients with considerable obesity.

The room in which the measurement was performed was dimmed in the way not to allow direct sunshine on patient's body. At a distance of approximately 3 m from the optic tripod a dark background was mounted. During the measurement the patient was undressed to shorts and positioned with the back against the camera at a distance of 2 m. The patient assumed a habitual posture, and feet were placed in front of a line fixed to the floor. The projector emitted on the patient's back, dark, horizontal striations of the width of approx. 1 cm. The examination was performed by means of the DiCAM software using the average measurement. This consisted in taking a sequence of twelve snapshots which, by creating the mean value, reduce variances of the posture, and consequently, improve the clinical value of the test. The computer averages the snapshots and registers one of them.

The following parameters describing body posture were analyzed:
1. *kyphotic angle ICT–ITL max°, kyphotic angle inflexion point, cervical-thoracic inflexion point thoracic lumbar max°.* This is a maximum kyphotic angle measured between the tangents to the surface of the upper cervical-thoracic inflexion point (ICT), in the vicinity of the vertebra prominens (VP), and the thoracic-lumbar inflexion point (ITL);
2. *lordotic angle ITL–ILS (max°) (lordotic angle inflexion point thoracic-lumbar inflexion point lumbar sacral max°).* This is a maximum kyphotic angle measured between the tangents to the surface of the surface of the thoracic-lumbar inflexion point (ITL), and the lower lumbar-sacral inflexion point (ILS);
3. *scoliosis angle.* Measurement with Diers formetric III 4D concerns exclusively the spine and shows the curvature angle from 1°.
4. *trunk length VP–DM (mm) (trunk length vertebra prominens – dimple middle).* This is the distance between the VP point (vertebra prominens) and the DM point (dimple middle). DM is the middle point located between the sacral dimples DL–DR (dimple left - dimple right),
5. *trunk length VP–SP (mm) (trunk length – vertebra prominens–sacrum point).* This is a distance between the VP point (vertebra prominens), and the SP point (sacrum point) which is the beginning of the groove between the buttocks (rima ani). It is independent of the patient's position with respect to the measurement system;
6. *pelvic tilt in degrees (°).* Pelvic tilt refers to the difference in the height of sacral dimples DL–DR (dimple left–dimple right), with reference to the transverse surface (cross-section). A positive value means that the right dimple is higher than the left dimple, whereas a negative value occurs when the right dimple is located below the left dimple;
7. *pelvic tilt (mm).* Pelvic tilt refers to the difference in heights of the sacral dimples DL–DR (dimple left–dimple right), in reference to the transverse surface (cross-section). A positive value means that the right dimple is higher than the left dimple, whereas a negative value occurs when the right dimple is located below the left dimple;
8. *surface rotation max°.* This parameter means a maximum rotation of the surface of the vertebrae on a symmetry line. The positive values means a maximum surface rotation to the right, while negative values mean maximum surface rotation to the left side;
9. *surface rotation (+max.)°.* This parameter means a maximum right-side rotation of the surface of the vertebrae on the symmetry line to the right side [24].

Scoliotic posture is considered with the angle of the curvature of the spine from 1–9°, while scoliosis is the curvature from 10°. Normal value for the kyphotic angle was 47–50°, and for lordosis 38–42°. On this basis, posture defects were distinguished. The round back occurs when the kyphotic angle is > 50°, concave back occurs when the lordotic angle is > 42°, and round-concave back is when the kyphotic angle is > 50° and the lordotic angle > 42°, and flat back when the kyphotic angle is < 47° and the lordotic angle < 38°. Normal values for the measurements with the Diers formetric III 4D were compiled by Harzman [25].

Statistical analysis was performed using the statistical package PQStat v. 1.6. The variables according to gender were compared using the Mann-Whitney U test. The p values $p < 0.05$ were considered statistically significant.

RESULTS

Analysis of anthropomorphic variables showed significant differences between women and men for body height ($Z = 3.7541$, $p = 0.0002$) and body mass ($Z = 3.2592$, $p = 0.0011$). However, there was no difference in the BMI ($Z = 1.4735$, $p = 0.1406$) or metabolic age ($Z = 0.2175$, $p = 0.8278$). Enlarged chest kyphosis (*hyperkyphosis*) was observed in 11 (34.37%) individuals. Enlarged lumbar lordosis (*hyperlordosis*) occurred in 10 (31.25%) patients. Deepened chest kyphosis and lumbar lordosis (*hyperkyphosis-hyperlordosis*) was noted in 3 (9.37%) individuals. Scoliosis occurred in 28 (87.5%) patients while 4 patients (12.5%) showed signs of scoliotic posture (Tab. 2). The left-sided pelvic tilt was found in 11 (34.37%) patients, while the right-sided tilt was observed in 12 (37.5%) subjects. Left-sided surface rotation was found in 19 (59.37%) patients and the right-sided tilt in 13 (4.62%) individuals. Right-sided rotation (+max) was found in 27 (84%) patients and lack of rotation was noted in the remaining 5 (16%) cases (Tab. 3). The angle of chest kyphosis (°) was 52.47° on average. A comparison of kyphosis angle distribution indicates non-significant differences between women and men ($Z = 1.2572$, $p = 0.2087$) (Tab. 4). The angle of lumbar lordosis (°) was 42.75° on average. A comparison of lordosis angle distribution in both sexes indicates significant differences ($Z = 2.1271$, $p = 0.0334$) (Tab. 4). The scoliosis angle was about 18.16°. A comparison of scoliosis angle distribution in both sexes showed non-significant differences ($Z = 1.3066$, $p = 0.1914$) (Tab. 4). The length of the torso (VP–DM) (mm) was an average of 445 mm. The comparison of the body length distribution (VP–DM) indicates highly significant differences between women and men ($Z = 2.9939$, $p = 0.0027$) (Tab. 5). The length of the torso (VP–SP) (mm) was 500.9 mm in total. A comparison of the body length distribution (VP-SP) in both sexes indicates highly significant differences ($Z = 2.8249$, $p = 0.0047$) (Tab. 5). The pelvic tilt (°) was on average 0.31° with a deviation of 4.17°. A comparison of the pelvic tilt (°) distribution in both sexes showed non-significant differences ($Z = 1.3754$, $p = 0.1690$) (Tab. 5). The pelvic tilt (mm) was 0.38 mm on average. A comparison of the pelvic tilt (mm) distribution in both sexes showed non-significant differences ($Z = 1.3789$, $p = 0.1679$) (Tab. 5). The surface of the spinal vertebrae rotation (max) was -0.34 on average. A comparison of the surface rotation distribution (max°) indicates non-significant differences between women and men ($Z = 1.1377$, $p = 0.2552$) (Tab. 5). The rotation of the spinal vertebrae surface (+max°) was at an average of 5.59. A comparison of the surface rotation (+max) distribution shows non-significant differences between women and men with PD ($Z = 1.1181$, $p = 0.2635$) (Tab. 5).

Table 1. Results of analyzed anthropometric variables

Anthropometric variables	Gender	Arithmetic mean	Standard deviation	Minimum	Lower quartile	Median	Upper quartile	Maximum	Mann-Whitney U test
Age	Total	54.28	12.24	32.00	46.75	55.00	63.25	85.00	Z = 0.2659 p = 0.7903
	Females	54.58	11.30	32.00	47.50	55.00	62.25	85.00	
	Males	53.00	16.97	32.00	38.00	57.50	66.50	70.00	
Height (cm)	Total	165.5	8.10	150.0	159.5	164.5	170.2	184.0	Z = 3.7541 p = 0.0002
	Females	162.6	5.78	150.0	158.0	164.0	166.7	172.0	
	Males	177.8	3.71	174.0	175.2	177.0	179.5	184.0	
Weight (kg)	Total	66.14	11.05	48.30	58.10	65.60	74.05	89.00	Z = 3.2592 p = 0.0011
	Females	62.74	8.79	48.30	57.35	59.35	71.50	78.20	
	Males	80.85	7.15	71.50	75.55	81.15	86.75	89.00	
	Males	16.23	3.03	12.50	14.53	15.70	17.63	21.10	
BMI	Total	24.12	3.49	17.50	21.65	23.10	26.00	32.30	Z = 1.4735 p = 0.1406
	Females	23.78	3.66	17.50	21.35	22.35	25.78	32.30	
	Males	25.57	2.41	22.90	23.58	25.35	27.43	28.70	
Metabolic age	Total	42.34	11.74	20.00	34.00	43.00	49.25	70.00	Z = 0.2175 p = 0.8278
	Females	42.35	12.03	20.00	34.00	43.00	49.00	70.00	
	Males	42.33	11.45	27.00	35.00	42.50	51.50	55.00	

Table 2. Occurrence of postural defects

Postural defects	Type	Numbers	Percentage
Kyphotic angle (°)	Round back	11	34.375%
	Normal	18	56.25%
	Flat back	3	9.375%
Lordotic angle (°)	Concave back	10	31.25%
	Normal	17	53.125%
	Flat back	5	15.625%
Round-concave back	No	29	90.62%
	Yes	3	9.37%
Scoliosis angle (°)	Scoliosis	28	87.5%
	Scoliotic posture	4	12.5%

Table 3. Occurrence of postural defects

Postural defects	Type	Numbers	Percentage
Pelvic tilt (°)	Left side	11	34.37%
	0	9	28.12%
	Right side	12	37.5%
Pelvic tilt (mm)	Left side	11	34.37%
	0	9	28.12%
	Right side	12	37.5%
Surface rotation max. (°)	Left side	19	59.37%
	0	0	0%
	Right side	13	40.62%
Surface rotation (+max.) (°)	Left side	0	0%
	0		15.62%
	Right side	27	84.37%

Table 4. Kyphotic, lordotic and scoliotic angle

Variables of posture	Gender	Arithmetic mean	Standard deviation	Minimum	Lower quartile	Median	Upper quartile	Maximum	Mann-Whitney U test
Kyphotic angle (°)	Total	52.47	9.45	30.00	45.25	54.00	59.25	69.00	Z = 1.2572 p = 0.2087
	Females	51.42	9.45	30.00	43.75	52.00	57.75	69.00	
	Males	57.00	8.72	43.00	52.75	58.50	63.50	66.00	
Lordotic angle (°)	Total	42.75	10.44	17.00	36.75	41.50	49.25	63.00	Z = 2.1271 p = 0.0334
	Females	44.27	10.78	17.00	40.00	44.50	50.75	63.00	
	Males	36.17	5.56	26.00	34.75	38.00	39.75	41.00	
Scoliotic angle (°)	Total	18.16	9.76	3.00	12.00	16.00	20.25	48.00	Z = 1.3066 p = 0.1914
	Females	19.35	10.19	5.00	12.25	16.50	22.50	48.00	
	Males	13.00	5.73	3.00	11.75	14.00	15.50	20.00	

Table 5. Trunk length, pelvic tilt and surface rotation

Variables of posture	Gender	Arithmetic mean	Standard deviation	Minimum	Lower quartile	Median	Upper quartile	Maximum	Mann-Whitney U test
Trunk length (VP-DM) (mm)	Total	445.0	40.72	327.0	424.7	445.5	468.0	542.0	Z = 2.9939 p = 0.0027
	Females	435.5	37.11	327.0	423.2	435.0	460.5	491.0	
	Males	486.2	29.86	464.0	468.7	472.5	492.0	542.0	
Trunk length (mm)	Total	500.9	40.51	377.0	478.2	501.5	521.0	592.0	Z = 2.8249 p = 0.0047
	Females	492.1	37.92	377.0	474.5	489.0	514.2	584.0	
	Males	538.8	29.25	514.0	520.2	528.0	547.0	592.0	
Pelvic tilt (°)	Total	0.31	4.17	-9.00	-2.00	0.00	2.00	11.00	Z = 1.3754 p = 0.1690
	Females	-0.19	4.08	-9.00	-2.00	0.00	2.00	11.00	
	Males	2.50	4.18	-2.00	0.00	1.00	5.00	9.00	
Pelvic tilt (mm)	Total	0.38	5.89	-12.0	-3.00	0.00	3.00	15.00	Z = 1.3789 p = 0.1679
	Females	-0.35	5.65	-12.0	-3.00	0.00	3.00	15.00	
	Males	3.50	6.41	-3.00	0.00	1.50	5.25	15.00	
Surface rotation (°)	Total	-0.34	9.72	-13.0	-8.00	-4.00	9.00	16.00	Z = 1.1377 p = 0.2552
	Females	0.73	10.15	-13.0	-8.00	-4.00	9.75	16.00	
	Males	-5.00	6.23	-11.0	-7.75	-6.50	-5.25	7.00	
Surface rotation (+max.) (°)	Total	5.59	5.20	0.00	1.00	4.00	9.25	16.00	Z = 1.1181 p = 0.2635
	Females	6.27	5.46	0.00	1.00	6.00	11.50	16.00	
	Males	2.67	2.42	1.00	1.00	1.50	3.50	7.00	

DISCUSSION

Body posture defects are a common symptom of Parkinson's Disease (PD). They are a consequence of structural disturbances in the CNS that control motor activities. In the present study, there were significantly more postural defects in PD patients compared to healthy subjects. This was especially true in the case of scoliosis (> 10°). As mentioned above, scoliosis occurred in 28 (87.5%) persons, and 4 (12.5%) individuals had scoliotic posture (1–9°). In the elderly population without neurological disorders, scoliosis is present in about 3% [24]. In their research, other authors also observed postural abnormalities such as excessive neck flexion (NF), knee bending (KB), lateral bending of the whole body (LB) and forward bending (FB). In men, there was a greater incidence of neck flexion than in women. Other postural defects showed no significant differences between the sexes. It was observed that forward inclination of the body and knee flexion increased with age. The duration of the disease was significantly correlated with excessive flexion of the neck and forward inclination of the body. As the disease progressed, the defects in body posture increased. The dose of levodopa was significantly correlated with the size of the angle of forward inclination. In contrast, doses of dopamine agonists were not significantly correlated with postural changes [26]. In other studies, Parkinson's disease was associated with a higher incidence of scoliosis in women. There was also a positive relationship between the severity of PD symptoms and the extent of scoliosis [27, 28]. In my other studies, research was conducted in the area of postural stability analysis among PD patients. The Biodex Balance System was used to evaluate postural stability. Although the differences in postural stability between genders were non-significant, slightly lower values were observed in men. The standing position of the subjects was characterized by higher sways in the sagittal rather than the frontal plane (A/P > M/L), with a tendency to tilt backwards. Better postural stability was observed in the younger group (up to the age of 75). The subjects in this group obtained significantly better postural stability values [29]. Systematic rehabilitation through the activation of the cortical-subcortical loop improves motor skills, body posture, emotional and cognitive functions, and delays or even counteracts the occurrence of PD. It also improves the quality of body posture, motor skills and physical ability to independently perform tasks, and actively participate in family, professional and social life. Systematic examination of posture in PD patients is also important due to the high risk of falls in this group [31].

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