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# Evaluation of postural stability of people with Parkinson's disease with Biodex Balance System device

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## Summary

Parkinson's disease is an incurable disease of the CNS of progressive and chronic course. Postural Stability of people with Parkinson's is hindered what predisposes to falls. In a person standing seemingly motionless body performs small oscillatory movements caused by differences in antigravity muscle tension. This mechanism is called postural rocking and mobility associated with it is referred to as postural sway. The parameters of rocking are very sensitive indicator of balance control, and can be used to evaluate and detect pathological changes. The aim of the study was to evaluate the stability of posture of people with Parkinson's disease on the basis of posturographic examination.The age range of the patients was from 52 to 85 years (mean 71.8 years). In terms of age the patients were divided into two groups. The first group consisted of 9 people to 75 years old, while the other of 8 people over 75 years old. The postural stability was assessed with Biodex Balance System. The study was performed at the Laboratory of Posturology at the Institute of Physiotherapy at UJK in Kielce. Although Mann-Whitney U test showed no significant differences in postural stability between the sexes, its lower values are reported for men. A standing position of the subjects was characterized by greater deviation in the sagittal plane than in the frontal plane (A/P>M/L) with a tendency to tilt backwards. There were better postural stability results in the younger group (group 1), up to 75 years old. The subjects in this group obtained significantly lower values of postural stability ($t^{\circ}=2.2744$, $p<0.05$).

**Keywords:** postural stability, Parkinson's disease, Biodex Balance System

**Streszczenie**
Zaburzenia stabilności posturalnej są istotnym objawem choroby Parkinsona jako chronicznej niesprawności neurologicznej. Utrzymanie pionowej postawy ciała oraz jej kontrola są procesami wielopłaszczyznowymi. Postępujące i przewlekłe zmiany zanikowe oraz zwyrodnieniowe zmysłu wzroku, czucia głębokiego i układu przedsionkowego zaburzają stabilność postawy. Decydują o występowaniu skłonności do upadków, szczególnie przy gwałtownych ruchach głową. To z kolei prowadzi do osłabienia aktywności ruchowej oraz innych, związanych z tym konsekwencji. W badaniu wzięło udział 17 chorych w tym 12 (70,59%) kobiet i 5 (29,41%) mężczyzn. Grupa badawcza dobrana została spośród członków Stowarzyszenia Chorych na Parkinsona w Kielcach. Przedział wiekowy chorych wynosił od 52 do 85 lat (średnia 71,8 lat). Celem pracy była ocena stabilności postawy osób chorych na chorobę Parkinsona na postawie badania posturograficznego. Do oceny stabilności posturalnej zastosowano platformę Biodex Balance System. Badania wykonano w Laboratorium Posturologii w Instytucie Fizjoterapii na UJK w Kielcach. Choć test U Mann-Whitney nie wykazał istotnych różnic w stabilności posturalnej pomiędzy płciami to niższe jej wartości wystąpiły u mężczyzn. Postawę stojącą badanych charakteryzowały większe wychwiania w płaszczyźnie strzałkowej niż czołowej (A/P>M/L) z tendencją do odchylania się do tyłu**.** Zaobserwowano lepsze wyniki stabilności posturalnej w grupie osób młodszych (grupa 1) do 75 roku życia. Badani tej grupy uzyskali istotnie niższe wartości stabilności posturalnej ($t^{\circ}= 2{,}2744$, $p<0{,}05$).

**Słowa kluczowe:** stabilność posturalna, choroba Parkinsona, platforma Biodex Balance System

## Introduction

Postural stability disorders are an important symptom of Parkinson's disease as a chronic neurological disability. Maintaining an upright posture and its control are multifaceted processes. They are based on the principles of mobility and the exercise of corresponding corrective movements. They allow for a return to the correct position of the center of gravity of the body [1,2,3]. Maintaining postural stability is a dynamic process that involves opposition to various disturbances. These disturbances may result from internal and external environment of man. By deflection of the body in the sagittal and frontal plane a standing person is able to control the posture of the body [4,5]. In people with Parkinson's disease it is much more difficult. Progressive and chronic atrophic and degenerative changes of visual sense, deep sensation and

the vestibular system disturb the stability of posture. It decides on the tendency to falls, especially in sudden movements of the head. This in turn leads to a decrease in physical activity and other related consequences [1].

**Aim of the study**

The aim of the study was to evaluate postural stability in patients with Parkinson's disease on the basis of posturographic examination. Special attention was drawn to the differences in stability between men and women. The stability of age groups and in different planes was also analyzed.

**Material and methods**

The study involved 17 patients, including 12 (70.59%) women and 5 (29.41%) men. The study group was selected from the members of the Association of Patients with Parkinson's in Kielce. The age range of the patients was from 52 to 85 years (mean 71.8 years). In terms of age the patients were divided into two groups. The first group consisted of 9 people to 75 years old, while the other of 8 people over 75 years old. To assess postural stability Biodex Balance System platform was used. Postural Stability Test was done in the position with both feet on a stable surface with eyes open. The platform has was blocked, which means that it was rigid and fully stable. After entering personal data and the height of the patient's body into the system its position was determined. For this purpose a center line of the foot and axes of the platform were used as reference points. The position was determined by entering on the screen of the camera the angle of the foot using the center line (scale 0°–45° separately for the right and left foot, eg. 25° for the left foot and 30° for the right foot) and the position of the heel (scale B – J, 1 – 21 separately for the right and left foot, eg. F7 left foot and E15 right foot).

Postural Stability Test consisted of three 20-second trials, separated by 10-second pause. During the study eyes of the patient were focused on the screen, where the characteristic dot appeared (COP - center of pressure), which was a symbolic representation of the center of body mass. In fact, the COP is the point of application of the resultant force of base reaction. The task of the subject was to balance the body so that the dot (COP) was on the monitor in the center of the circle, at the intersection of coordinate axes. During the test verbal correction of the patient was allowed . The parameters analyzed are as follows:

1. Level of Stability: determines the stability (stiffness) of the platform. Blocked platform is fully stable. Level 8 is the most stable of the moving levels of the platform. Level 1 is the

least stable of the platform. On each level of stability full deflection of the platform is possible, ie. 20 degrees from the horizontal plane in either direction. To place the patient in the middle of the platform before the test, the deflection of the platform is limited to less than 5 degrees. For statistical evaluation stability index will be used: general, anterior/posterior and medial/lateral.

2. The overall stability index (SI) represents the volatility of the position of the platform from the horizontal plane, expressed in degrees, during all movements in the test. Its high value indicates a high amount of movements in the test.
3. Anterior/posterior stability index (AP) reflects the volatility of the position of the platform for movements in the sagittal plane, expressed in degrees.
4. Medial/lateral stability index (M/L) reflects the volatility of the position of the platform for movements in the frontal plane, expressed in degrees.
5. The percentage of time in the zone/square represents the duration of the process of the whole test that the patient spent in the zone/square.

Targeted zones A, B, C and D are equal to the degree of tilt of the platform. They are determined by concentric circles centered at the center of the platform.

- Zone A - from zero to five degrees deviation in relation to the horizontal plane,
- Zone B - from six to ten degrees deviation in relation to the horizontal plane,
- Zone C - eleven to fifteen degrees deviation in relation to the horizontal plane,
- Zone D - from sixteen to twenty degrees deviation in relation to the horizontal plane.
- The squares represent the four quadrants of the test chart between the axes X and Y. For the protocol "Both Feet":
- Square 1 – right front,
- Square 2 – left front,
- Square 3 – left back,
- Square 4 - right back.

Scoring of the patient in this test depends on the number of deviations from the center, which means that the lower the score the better the postural stability [8,10-13]. The main criterion used in the qualifications of the study group was ability to support oneself in a standing position and lack of eye disorders. All parameters recorded by the posturographic platform were collected in a completely non-invasive way, and the device was safe for the study group. The test was

performed in November 2013 at the Posturology Laboratory at the Institute of Physiotherapy of the Faculty of Health Sciences at UJK in Kielce.

The obtained parameters were saved in one database and analyzed statistically. For the evaluation of the variables arithmetic mean, standard deviation (SD) and median were used. To determine the correlation between the BMI with the general stability index Pearson's correlation coefficient was used. For comparison of the overall stability index in two different age groups t-Student test was used for independent variables. The results were recorded in Excel spreadsheet. Statistical significance was adopted at $p<0.05$.

**Results**

Women accounted for the majority of the study group (70.59%), and men only a third (29.41%). The average age of the study group was 71.76 years with a standard deviation of ± 9.36. The median value for the distribution of the results of this scale is 75 years, and the scope of the age range from 52 to 85 years. The average body height was 161.18 cm with a standard deviation of ± 9.07 cm. The median value for the distribution of the results of this scale is 158 cm, and the height range from 150 to 176 cm. The average body mass was 69.56 kg with a standard deviation of ± 10.93 kg. The median value for the distribution of the results of this scale is 69.4 kg, and the range from 52.1 to 86.7 kg. The average body mass index (BMI) was 26.75 kg/m² with a standard deviation of ± 3.4 kg/m². The median value for the distribution of the results of this scale is 27 kg/m², and the range from 20.9 to 34.4 kg/m². The mean general index of stability was 1.93 with a standard deviation of ± 1.5. According to the WHO BMI indicates the state of small overweight. The median for the distribution of the results of this scale is 1.3, and the range of results from 0.5 to 6.7. Mean stability index A/P was 1.56 with a standard deviation of ± 1.47. The median for the distribution of the results of this scale is 1.1, and the range of results from 0.4 to 6.4. Mean stability index M/L was 0.82 with a standard deviation of ± 0.65. The median for the distribution of the results of this scale is 0.7, and the range of results from 0.2 to 2.7. (tab. 1).

There has been inverse relationship between BMI and the stability index ($r = - 0.5945$). The higher the BMI index, the lower the general stability index (Fig. 1).

Another parameter subjected to observation was the time during the test spent in certain zones: A, B, C, D.

The time spent during the test in zone A and for the men was (97%) of all, and for the women (92.8%). The mean time during the test spent in zone B was 7.2% for women, and 3% for men. If the COP was closer to the center of the coordinate system (zone A), it meant a better postural stability (Fig. 1).

Another parameter subjected to observation was the time spent during the test in specific quadrants: Quadrant I – right – front, quadrant II – left – front, quadrant III – left – back, quadrant IV – right – back.

Most often the subjects during the test were in the square III: women (39.6%) and men (25.75%) and square IV, women (55%) and men (35.83%). This reflects the larger deviations of the body in the sagittal plane. In women, this percentage after summing III and IV squares was respectively 94.6% and in men 61.58% (Fig. 2).

In the next study, an analysis of the individual scales by gender was done. The average age of women was about 72.33 years, and the median 74.5 years. Among men the average age was 70.4 years and the median 77 years. Higher mean was recorded in the group of women, but a higher median value was found in men. There was no significant difference between the sexes ($p = 0.8594$). Body height of women was on average 157.42 cm, and the median 156.5 cm. However, among men it was 170.2 cm, and the median 175 cm. Higher mean and medians were found in the group of men. There was a significant difference between the sexes ($p=0.0045$). Body mass of the women was 67.21 kg and the median 67.15 kg. Among the men the mean was 75.22 kg and the median of distribution 76.7 kg. Higher means and medians were found in the group of men. There was no significant difference between the sexes ($p=0.2786$). Body mass index among women was on average 27.14 kg/m² and the median 27.25 kg/m². While among the men the average BMI was 25.8 kg/m², and the distribution median was 24.8 kg/m². Although higher means and medians of body mass index were observed in women, there was no significant difference between the sexes ($p=0.6629$). The mean general stability index among women was 2, and the median 1.45. Among the men analogously 1.78 and the median 1.2. Higher means and medians were found in women. There was no significant difference between men and women ($p = 0.8186$). Stability index A/P among the women was on average 1.6, and the median 1.15. While among the men the average value was 1.46 and the median 0.7. Higher means and medians were found in the group of women. There were no significant differences between the sexes ($p = 0.521$). Stability index M/L in women was on average 0.82, with the median 0.55. While among

the men the average value of the index was 0.84 and the median 0.7. There were no significant differences between the sexes (p=0.7346) (Tab. 2).

Although U Mann-Whitney test showed no significant differences in postural stability between the sexes, their lower values occurred in men. Lower parameters indicate a better postural stability.

There was better postural stability in the younger group (group 1) up to 75 years of age. The subjects in this group obtained significantly lower values of postural stability ($t^{\circ}=2.2744$, $p<0.05$) (tab. 3).

**Discussion**

In a person standing seemingly motionless body performs small oscillatory movements caused by differences in antigravity muscle tension. This mechanism is called postural rocking and mobility associated with it is referred to as postural sway. The parameters of rocking are very sensitive indicator of balance control, and can be used to evaluate and detect pathological changes [1].

From the results obtained for the sway of the COP, it was found that in both women and men bigger body sway dominates in the sagittal plane than in the front one with a tendency to tilt towards the rear. This is evidenced not only by a greater stability index A/P, but also increased time spent in the third and fourth quarters. Some of the work carried out by Baloh et al., or Wegen et al. show a higher rate of imbalances in the frontal plane, while others represent a clear increase in sways in the direction of A/P [11,13]. Viitasalo et al. achieved in patients with Parkinson's disease (PD) increased rocking of posture during quiet standing [14]. Research by Doná et al. showed a low limit of stability and increased rocking of the posture of people with PD compared to healthy subjects. The deterioration of the postural control of the body was significantly associated with a high risk of falls [15]. Paul et al., studied 102 patients with PD and concluded that 59.4% of them had the results of the posture and gait stability test (PS) $\geq 2$, and only 10.9% of patients fell from the stabilometric platform [16]. In addition, research conducted by Czechowicz et al. showed that the visual inspection has a significant impact on the parameters of postural stability in patients with PD [17]. Marchese et al. found no statistically significant differences in terms of sway in patients with PD and healthy people at the old age for trials with eyes open and closed. However, exclusion of visual information caused in both groups

deterioration in the stability of body posture. It demonstrated the extension of sway in the direction of the A/P and M/P [18]. These discrepancies may be related to the severity of the disease, the size of study groups or pharmacological treatment.

Du Pasquier et al. showed that the registration of the movement of CO best reflects postural stability disturbances occurring with age. The authors also observed that closing eyes increased variance of results especially in subjects above 60 years of age [19]. Therefore it can be concluded that maintaining a stable posture in the elderly in a standing position is very difficult, among other things, because of impaired proprioception, weaker eyesight and less muscle strength [12].

**Conclusions**

1. Although the U Mann-Whitney test showed no significant differences in postural stability between the sexes, its lower values occurred in men. Lower parameters indicate a better postural stability.
2. Postural stability of the respondents is characterized by greater sways in the sagittal plane than in the front one**.**
3. Older people have weaker postural stability.

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Table 1. Descriptive statistics of the analyzed scales

| Analyzed scales | Descriptive statistics of the analyzed scales | | | | | | |
|---|---|---|---|---|---|---|---|
| | Mean | Standard deviation | Minimum | Lower quartile | Median | Higher quartile | Maximum |
| Age (years) | 71,76 | 9,36 | 52,00 | 66,00 | 75,00 | 78,00 | 85,00 |
| Body height (cm) | 161,18 | 9,07 | 150,00 | 155,00 | 158,00 | 165,00 | 176,00 |
| Body mass (kg) | 69,56 | 10,93 | 52,10 | 59,90 | 69,40 | 77,10 | 86,70 |
| BMI (kg/m²) | 26,75 | 3,40 | 20,90 | 24,70 | 27,00 | 28,20 | 34,40 |
| General stability index | 1,93 | 1,50 | 0,50 | 1,10 | 1,30 | 2,50 | 6,70 |
| Stability index A/P | 1,56 | 1,47 | 0,40 | 0,80 | 1,10 | 1,40 | 6,40 |
| Stability index M/L | 0,82 | 0,65 | 0,20 | 0,40 | 0,70 | 0,90 | 2,70 |

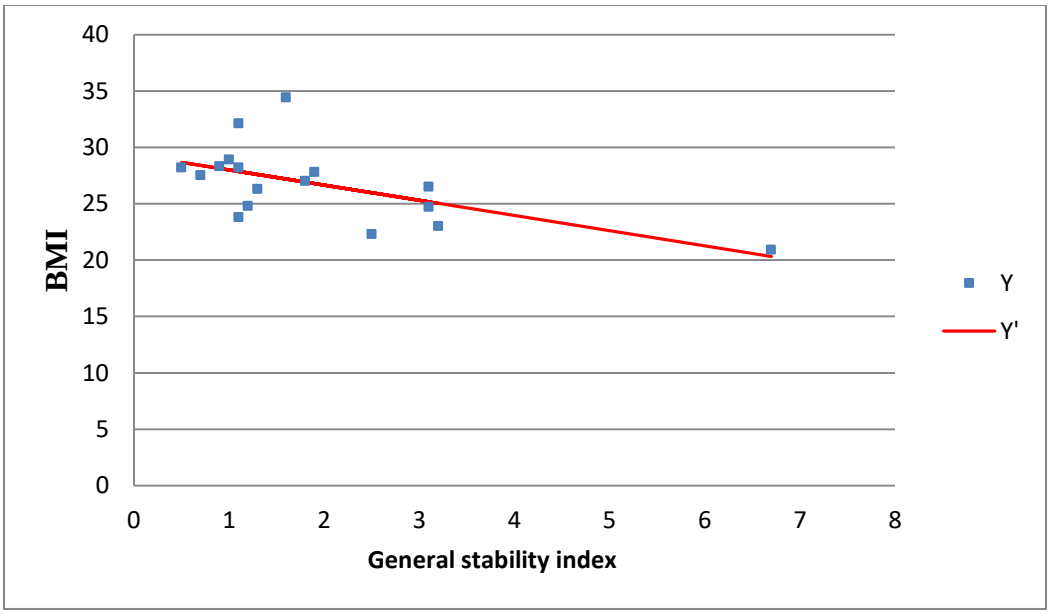


Figure 1. The relationship between BMI and the general stability index

Table 2. Descriptive statistics of the analyzed scales depending on gender

| Analyzed scales | | Descriptive statistics of the analyzed scales | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Standard deviation | Minimum | Lower quartile | Median | Higher quartile | Maximum | U Mann – Whitney test |
| Age (years) | Women | 72,33 | 9,04 | 57,0 | 66,0 | 74,5 | 79,0 | 85,0 | U = 32 p = 0,8594 |
| | Men | 70,40 | 11,06 | 52,0 | 68,0 | 77,0 | 77,0 | 78,0 | |
| Body height (cm) | Women | 157,42 | 6,93 | 150,0 | 153,0 | 156,5 | 159,0 | 175,0 | U = 4,5 p = 0,0045 |
| | Men | 170,20 | 7,26 | 160,0 | 165,0 | 175,0 | 175,0 | 176,0 | |
| Body mass (kg) | Women | 67,21 | 9,98 | 52,1 | 59,75 | 67,15 | 75,6 | 84,2 | U = 19 p = 0,2786 |
| | Men | 75,22 | 12,15 | 58,9 | 67,30 | 76,70 | 86,5 | 86,7 | |
| BMI ($kg/m^2$) | Women | 27,14 | 3,77 | 20,9 | 25,05 | 27,25 | 28,55 | 34,4 | U = 34,5 p = 0,6629 |
| | Men | 25,80 | 2,35 | 23,0 | 24,70 | 24,80 | 28,20 | 28,3 | |
| General stability index | Women | 2,00 | 1,63 | 0,7 | 1,1 | 1,45 | 2,2 | 6,7 | U = 32,5 p = 0,818 |
| | Men | 1,78 | 1,28 | 0,5 | 0,9 | 1,20 | 3,1 | 3,2 | |
| Stability index A/P | Women | 1,60 | 1,60 | 0,5 | 0,85 | 1,15 | 1,35 | 6,4 | U = 36,5 p = 0,521 |
| | Men | 1,46 | 1,28 | 0,4 | 0,50 | 0,70 | 2,70 | 3,0 | |
| Stability index M/L | Women | 0,82 | 0,71 | 0,2 | 0,35 | 0,55 | 1,0 | 2,7 | U = 26,5 p = 0,7346 |
| | Men | 0,84 | 0,55 | 0,2 | 0,7 | 0,70 | 0,9 | 1,7 | |

Table 3. Statistical characteristics of measurement data with age division

| Parameters | | Descriptive statistics of the analyzed scales | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Mean | Standard deviation | Minimum | Lower quartile | Median | Higher quartile | Maximum |
| General stability index | Group 1 | 1,20 | 0,58 | 0,5 | 1,00 | 1,1 | 1,20 | 2,5 |
| | Group 2 | 2,27 | 1,82 | 0,9 | 1,55 | 2,5 | 3,15 | 6,7 |
| Stability index A/P | Group 1 | 0,97 | 0,62 | 0,4 | 0,70 | 1,00 | 1,00 | 2,5 |
| | Group 2 | 2,23 | 1,88 | 0,5 | 1,25 | 1,35 | 2,85 | 6,4 |
| Stability index M/L | Group 1 | 0,49 | 0,27 | 0,2 | 0,3 | 0,4 | 0,6 | 0,9 |
| | Group 2 | 1,20 | 0,76 | 0,3 | 0,7 | 1,0 | 1,6 | 2,7 |

T – student test: $t = 2{,}2744$, $df = 15$, $p<0{,}05$