Original paper

Body composition assessment by bioelectrical impedance analysis among patients treated with L-dopa for Parkinson's disease

Analiza składu ciała metodą bioimpedancji elektrycznej pacjentów leczonych lewodopą z powodu choroby Parkinsona

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Medical Studies/Studia Medyczne 2018; 34 (2): 120–126
DOI: https://doi.org/10.5114/ms.2018.76872

Key words: Parkinson's disease, body composition, bioelectrical impedance analysis.

Słowa kluczowe: choroba Parkinsona, skład ciała, metoda impedancji bioelektrycznej.

Abstract

Introduction: Among the consequences of Parkinson's disease are disorders in body composition and weight loss.
Aim of the research: An analysis of body composition of patients with Parkinson's disease treated with L-dopa.
Material and methods: A group of 32 patients was examined, including 26 (81.25%) females and 6 (18.75%) males. The study was conducted in the Laboratory for Posturology in the Institute of Physiotherapy at the faculty of Medicine and Medical Sciences, Jan Kochanowski University in Kielce. Body composition was assessed using bioelectrical impedance analysis, which consists of the evaluation of resistance to the flow of an electric current.
Results and conclusions: The majority of body composition parameters remained within the normal ranges. The mean body mass index (BMI) index in patients with Parkinson' disease was 24.12 kg/m^2 and remained within the normal range. The metabolic age of patients was 42.34 years and was considerably lower than the calendar age – 54.28 years. Highly significant differences were observed between males and females according to body height (Z = 3.7541; p = 0.0002), body weight (Z = 3.2592; p = 0.0011), fat mass (%) (Z = 3.1627; p = 0.0016), fat-free mass (kg) (Z = 3.7417; p = 0.0002), muscle mass (kg) (Z = 3.7421; p = 0.0002), visceral fat (Z = 1.9892; p = 0.0467), total body water (kg), total body water content (%) (Z = 3.7428; p = 0.0002), extracellular water (kg) (Z = 3.7448; p = 0.0002), intracellular fluid (kg) (Z = 3.7424; p = 0.0002), and the ratio of extracellular water to total body water (%) (Z = 2.9223; p = 0.0035). There were also significant positive correlations between metabolic age and the Overall Stability Index (r = 0.4057, p = 0.0212) and Front-Back Stability Index (r = 0.3507, p = 0.0490).

Streszczenie

Wprowadzenie: Jedną z konsekwencji choroby Parkinsona są zaburzenia składu ciała i redukcja jego masy.
Cel pracy: Analiza składu ciała pacjentów z chorobą Parkinsona leczonych L-dopą.
Materiał i metody: Przebadano grupę 32 osób, w tym 26 (81,25%) kobiet i 6 (18,75%) mężczyzn. Badanie wykonano w Laboratorium Posturologii w Instytucie Fizjoterapii na Wydziale Lekarskim i Nauk o Zdrowiu Uniwersytetu Jana Kochanowskiego w Kielcach. Skład ciała oceniano metodą impedancji bioelektrycznej.
Wyniki i wnioski: Większość parametrów składu ciała badanych mieściła się w normie. Średni wskaźnik masy ciała (BMI) pacjentów z chorobą Parkinsona wynosił 24,12 kg/m^2. Wiek metaboliczny badanych wynosił 42,34 roku i był znacznie niższy od wieku kalendarzowego – 54,28 roku. Wysoce istotne różnice między kobietami a mężczyznami dotyczyły wysokości ciała (Z = 3,7541, p = 0,0002), masy ciała (Z = 3,2592, p = 0,0011), zawartości tkanki tłuszczowej (%) (Z = 3,1627, p = 0,0016), masy tkanki beztłuszczowej (kg) (Z = 3,7417, p = 0,0002), masy mięśni (kg) (Z = 3,7421, p = 0,0002), wskaźnika tkanki wisceralnej (Z = 1,9892, p = 0,0467), całkowitej zawartości wody (kg), całkowitej zawartości wody (%) (Z = 3,7428, p = 0,0002), wody zewnątrzkomórkowej (kg) (Z = 3,7448, p = 0,0002), wody wewnątrzkomórkowej (kg) (Z = 3,7424, p = 0,0002) i stosunku wody zewnątrzkomórkowej do całkowitej zawartości wody (%) (Z = 2,9223, p = 0,0035). Wystąpiły także istotne, dodatnie korelacje między wiekiem metabolicznym a ogólnym wskaźnikiem stabilności (r = 0,4057, p = 0,0212) i przednio-tylnym wskaźnikiem stabilności (r = 0,3507, p = 0,0490).

Introduction

Parkinson's disease (PD) concerns 1% of the human population aged 40–60 years, but can happen also among younger individuals [1]. In this disease, the symptoms occur due to degenerative changes of nervous cells in the substantia negra and in other pigment-bearing neurons within areas of the brain [2, 3]. Among the consequences of PD are disorders of body composition and weight loss [4]. Studies show that in nearly a half of the patients weight loss occurs as early as at the beginning of the disease [5]. Patients lose weight even if their diet is higher in calories than that of healthy individuals at a similar age [6]. In this disease there are often problems related with an abnormal function of the gastrointestinal tract, caused mainly by disorders concerning the autonomous system [7, 8]. Disorders in body composition and reduction of its mass are not beneficial from the aspect of maintenance of the health of a patient suffering from PD; therefore, its monitoring and prevention are important [9, 10]. The causes of weight loss in patients with PD are related , on the one hand, with the sole process of eating and weakening of appetite, and on the other hand – a change in muscle metabolism [11]. The patients' eating problems may result from difficulties with biting, chewing, swallowing, and difficulties with using cutlery resulting from tremor and muscle rigidity [12]. In turn, the loss of appetite is the consequence of disorders in the sensation of flavour and smell, disorders in the function of the gastrointestinal tract (too quick feeling of satiety), and low mood (depression) often accompanying the disease [13, 14]. As a result of these factors, the patient eats less than the body requirements and begins to lose weight. Body weight loss is additionally enhanced by the intensification of muscle metabolism [15, 16]. This is related with motor symptoms accompanying the disease, such as tremor, involuntary movements, and increased muscle tension [17]. During muscle tremor, similar to volitional contractions of the skeletal muscles, considerable amounts of heat are produced as a result of accelerated oxygenation of energetic components [18]. This means, that patients with PD, despite low physical activity (the disease limits the possibility to perform physical exercises), in order to maintain constant body weight, may need the supply of a larger number of calories during the day, compared to their healthy contemporaries [19, 20].

Aim of the research

The objective of the study was an analysis of body composition of patients with PD treated with levodopa.

Material and methods

A group of 32 patients with PA were examined, members of the Parkinson Disease Association in Kielce (Poland); the majority were females – 26 (81.25%), and there were 6 (18.75%) males. 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 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 of the objective of the study and gave 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. All patients were treated with L-dopa. This is a natural amino acid – catecholamine – produced in the process of tyrosine hydroxylation, catalysed in the reaction by tyrosine hydroxylase. It is the precursor of dopamine, which causes an increased concentration of this neurotransmitter in the brain. The duration of disease was over five years. The daily dose of L-dopa remained within the range 600–1000 mg/day. Body composition was assessed using the method of bioelectrical impedance analysis, which consists of the evaluation of resistance to the flow of an electric current. As a research instrument, a body composition analyser was used (Tanita MC 780 MA). During the examination, three frequencies were applied: 5 kHz, 50 kHz, and 250 kHz. The examination was performed in a standing position. The patient was asked to remove jewellery and metal accessories of clothing, which may disturb current flow. During the examination the patient had bare feet and was asked to step on the analyser's base in a way that each foot was on two metal electrodes. After measurement of body mass, the patient grasped electrodes in both slightly separated hands and stood still for approximately 30 s. Contraindications for the examination are pacemaker, metal implants, and pregnancy. Examination of the body composition by the method of bioelectrical impedance analysis is non-invasive and safe. As a result of the measurement, the following variables were obtained: body mass (kg), body mass index (BMI) (kg/m^2), metabolic age, fat mass (%), fat mass (kg), fat-free mass (kg), muscle mass (kg), visceral fat, total body water (kg), total body water (%), extracellular water (kg), intra-cellular water (kg), and the ratio of extra-cellular water to total body water (%). The Biodex Balance System was used to assess postural stability. Postural stability testing was performed with both feet positioned on a stable surface with the eyes open. The postural stability testing consisted of three 20-second trials separated by a 10-second interval. The following were used to assess postural stability: the Overall Stability Index (°), Anterior-Posterior

Stability Index (°), and the Medial-Lateral Stability Index (°).

Statistical analysis

The variables were compared according to gender using the Mann-Whitney *U* test. The application of this test did not require group equality, normal distribution, or homogeneous variance. The relationship between body composition and postural stability was analysed using the Spearman's rank correlation coefficient. The *p*-values $p < 0.05$ were considered statistically significant.

Results

The mean respondents' age was 54.28 years. The mean age in females was 54.58 years. The mean age in males was 53.00 years. Comparison of distribution between the two genders showed that the differences were insignificant ($Z = 0.2659$, $p = 0.7903$). The mean body height (cm) was 165.5. The mean body height in females (cm) was 162.6. The mean body height in males (cm) was 177.8. The comparison of distribution between the two genders indicated highly significant differences ($Z = 3.7541$, $p = 0.0002$) (Table 1). The mean body mass (kg) was 66.14. The mean body mass in females (kg) was 62.74. The mean body mass in males (kg) was 80.85. Comparison of distribution between the two genders showed highly significant differences ($Z = 3.2592$, $p = 0.0011$). The mean BMI was 24.12 kg/m^2. The mean BMI in females was 23.78 kg/m^2. The mean BMI in males was 25.57 kg/m^2. The comparison of distribution between the two genders showed insignificant differences ($Z = 1.4735$; $p = 0.1406$). The mean metabolic age was 42.34 years. The mean metabolic age in females was 42.35 years. The mean metabolic age in males was 42.33 years. Comparison of distribution between the two genders showed insignificant differences ($Z = 0.2175$; $p = 0.8278$) (Table 1). The mean fat mass (%) was 27.14. The mean fat mass in females (%) was 28.8. The mean fat mass in males (%) was 19.95. The comparison of distribution between the two genders indicated highly significant differences ($Z = 3.1627$; $p = 0.0016$). The mean fat mass (kg) was 18.04. The mean fat mass in females (kg) was 18.46. The mean fat mass in males (kg) was 16.23. The comparison of distribution between the two genders showed that the differences were insignificant ($Z = 0.5795$; $p = 0.5622$). The mean fat-free mass (kg) was 48.1. The mean FFM (kg) in females was 44.28. The mean FFM (kg) in males was 64.62. The comparison of distribution between the two genders showed highly significant differences ($Z = 3.7417$; $p = 0.0002$). The mean muscle mass (kg) was 45.65. The mean muscle mass (kg) in females was 42.02. The mean muscle mass (kg) in males was 61.38. The comparison of distribution between the two genders showed highly significant differences ($Z = 3.7421$; $p = 0.0002$). The mean visceral fat was 6.69. The mean visceral fat in females was 6. The mean visceral fat in males was 9.67. The comparison of distribution between the two genders indicated significant differ-

Table 1. Results of analysed 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	
Body 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	
Body 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	
BMI [kg/m^2]	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 (MA)	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. Results of analysed body composition variables and postural stability

Parametr	Gender	Arithmetic mean	Standard deviation	Minimum	Lower quartile	Median	Upper quartile	Maximum	Mann-Whitney *U* test
Body composition variables									
Fat mass (%)	Total	27.14	6.35	16.80	22.23	26.45	32.28	38.10	$Z = 3.1627$ $p = 0.0016$
	Females	28.80	5.80	17.70	24.25	28.30	33.70	38.10	
	Males	19.95	2.39	16.80	18.53	20.25	20.63	23.70	
Fat mass [kg]	Total	18.04	5.55	9.50	14.10	15.90	21.78	29.80	$Z = 0.5795$ $p = 0.5622$
	Females	18.46	5.95	9.50	14.10	15.90	23.20	29.80	
	Males	16.23	3.03	12.50	14.53	15.70	17.63	21.10	
Fat-free mass [kg]	Total	48.10	9.01	36.70	42.65	45.30	49.08	70.10	$Z = 3.7417$ $p = 0.0002$
	Females	44.28	3.92	36.70	42.43	44.65	46.75	52.70	
	Males	64.62	4.86	57.10	62.05	65.45	67.88	70.10	
Muscle mass [kg]	Total	45.65	8.58	34.80	40.45	43.00	46.55	66.60	$Z = 3.7421$ $p = 0.0002$
	Females	42.02	3.73	34.80	40.23	42.35	44.35	50.00	
	Males	61.38	4.63	54.20	58.95	62.20	64.48	66.60	
Visceral fat	Total	6.69	3.28	2.00	4.00	6.00	8.25	14.00	$Z = 1.9892$ $p = 0.0467$
	Females	6.00	2.71	2.00	4.00	6.00	7.75	12.00	
	Males	9.67	4.08	5.00	6.25	10.00	13.00	14.00	
Total body water [kg]	Total	34.00	6.19	26.30	30.20	32.15	34.80	49.20	$Z = 3.7428$ $p = 0.0002$
	Females	31.40	2.79	26.30	29.98	31.60	32.95	37.50	
	Males	45.25	3.41	40.50	43.08	45.45	47.83	49.20	
Total body water (%)	Total	51.53	4.48	43.90	47.88	52.30	54.95	58.50	$Z = 2.8257$ $p = 0.0047$
	Females	50.50	4.28	43.90	47.13	50.75	53.85	58.50	
	Males	56.02	1.87	53.10	55.05	56.20	57.50	58.00	
Extra-cellular water [kg]	Total	14.87	2.38	11.20	13.38	14.35	15.93	20.40	$Z = 3.7448$ $p = 0.0002$
	Females	13.95	1.42	11.20	13.30	13.80	15.13	16.40	
	Males	18.87	1.27	16.90	18.25	18.95	19.73	20.40	
Intra-cellular water [kg]	Total	19.13	3.93	14.60	16.75	17.95	19.80	28.80	$Z = 3.7424$ $p = 0.0002$
	Females	17.45	1.62	14.60	16.23	17.55	18.28	21.10	
	Males	26.38	2.24	23.60	24.83	26.15	28.45	28.80	
Extra-cellular water/total body water (%)	Total	2.07	40.00	42.20	43.70	45.33	48.90	43.90	$Z = 2.9223$ $p = 0.0035$
	Females	1.93	41.30	42.78	44.45	46.00	48.90	44.40	
	Males	0.98	40.00	41.55	41.90	42.18	42.90	41.73	
Anthropometric variables									
Overall Stability Index (°)	Total	0.50	0.35	0.20	0.30	0.40	0.60	1.90	$Z = 2.0545$ $p = 0.0399$
	Females	0.55	0.37	0.20	0.30	0.50	0.60	1.90	
	Males	0.30	0.13	0.20	0.20	0.25	0.38	0.50	
Anterior-Posterior Stability Index (°)	Total	0.35	0.24	0.10	0.20	0.30	0.40	1.30	$Z = 1.3825$ $p = 0.1668$
	Females	0.37	0.26	0.10	0.20	0.30	0.40	1.30	
	Males	0.23	0.10	0.10	0.20	0.20	0.28	0.40	
Medial-Lateral Stability Index (°)	Total	0.27	0.25	0.10	0.10	0.20	0.30	1.10	$Z = 1.7927$ $p = 0.0730$
	Females	0.30	0.26	0.10	0.10	0.20	0.30	1.10	
	Males	0.13	0.05	0.10	0.10	0.10	0.18	0.20	

Table 3. Correlation between metabolic age, surface rotation of the vertebrae, and postural stability variables

Statistical variables		Metabolic age		
		Overall Stability Index (°)	Anterior-Posterior Stability Index (°)	Medial-Lateral Stability Index (°)
Spearman correlation coefficients (*r*)		0.4057	0.3507	0.1529
Standard error of the (*r*)		0.1669	0.1710	0.1804
95% CI in (*r*)	0.0556	–0.0084	–0.2171	–0.3776
	0.6669	0.6298	0.4845	0.3384
t-test for significance of the (*r*)		2.4312	2.0515	0.8477
Degree of freedom (d*f*)		30	30	30
P-value		0.0212	0.0490	0.4033

ences (Z = 1.9892; p = 0.0467). The mean total body water (kg) was 34. The mean total body water (kg) in females was 31.4. The mean total body water (kg) in males was 45.25. The comparison of distribution between the two genders showed highly significant differences (Z = 3.7428; p = 0.0002). The mean total body water (%) was 51.53. The mean total body water (%) in females was 50.5. The mean total body water (%) in males was 56.02. The comparison of distribution between the two genders showed highly significant differences (Z = 2.8257; p = 0.0047). The mean extracellular water (kg) was 14.87. The mean extracellular water (kg) in females was 13.95. The mean extracellular water (kg) in males was 18.87. The comparison of distribution between the two genders showed highly significant differences (Z = 3.7448; p = 0.0002). The mean intracellular water (kg) was 19.13. The mean intracellular water (kg) in females was 17.45. The mean intracellular water (kg) in males was 26.38. The mean the ratio of extracellular water to total body water (%) was 43.9. The mean ECW/TBW (%) in females was 44.40. The mean ECW/TBW (%) in males was 41.73. The comparison of distribution between the two genders showed highly significant differences (Z = 2.9223; p = 0.0035) (Table 2). The mean overall stability index (°) was 0.5. The mean overall stability index (°) in females was 0.55. Mean overall stability index (°) in males was 0.3. Comparison of the distribution between both genders showed significant differences (Z = 2.0545; p = 0.0399). A higher overall stability index in females showed their worse postural stability, compared to males. The mean anterior-posterior stability index (°) was 0.35. Mean anterior-posterior stability index (°) in females was 0.37. Mean anterior-posterior stability index (°) in males was 0.23. Comparison of the distribution between both genders showed that the differences were insignificant (Z = 1.3825; p = 0.1668). The medial-lateral stability index (°) was 0.27. Medial-lateral stability index (°) in females was 0.3. Medial-lateral stability index (°) in males was 0.13. Comparison of the distribution between both genders showed that the differences were insignificant (Z = 1.7927; p = 0.0730). The comparison of distribution between the two genders showed highly significant differences (Z = 3.7424; p = 0.0002). In our study, there were also significant positive correlations between metabolic age and the overall stability index (r = 0.4057, p = 0.0212) and front-back stability index (r = 0.3507, p = 0.0490). The higher metabolic age was associated with the higher overall stability index and higher front-back stability index (Table 3).

Discussion

In our study, the vast majority of PD patients' body composition parameters were normal, and metabolic age was significantly lower than calendar age. The results confirm the proper planning and course of treatment as well as the proper nutrition of the subjects. In other similar studies among PD patients, rarely were the subjects underweight, and the risk of malnutrition was common but stable. However, the value for the arm skin fold increased. There was a decrease in muscle circumference in the upper half of the arm. The percentage of individuals with poor handshake pressure increased. Correlations between dietary and motor variables and non-motor PD characteristics were scarce to moderate. In addition, increased anxiety was correlated with weight loss, BMI, and arm skin fold value. As the disease progressed, redistribution in the body structure from muscle to fat occurred [21]. In a different study, the body composition of PD patients was analysed 3 years after diagnosis. Based on the method of electrical impedance, a slight increase in body mass was noted. It was strongly correlated with increased body fat, waist circumference, body-height-to-waist-circumference ratio, and total skin fold. In this work, we also demonstrate the relationship between body mass changes and the level of physical activity, and the relationship between body mass changes and mental health. At the onset of the disease, weight gain was accompanied by an increase in waist circumference and body mass. The opposite

correlation was observed for BMI and physical activity level [22]. Another objective of the study was the prospective assessment of body fat and its distribution in patients with PD. The distribution of adipose tissue in PD patients was compared with healthy subjects of similar age using magnetic resonance imaging. Magnetic resonance imagings (MRIs) were conducted for 12 months. Total body fat volume as well as visceral fat did not show any significant differences between PD patients and healthy subjects, regardless of the moment of measurement. However, in PD patients, a decrease in the volume of subcutaneous adipose tissue was observed, as well as a higher ratio of visceral fat to subcutaneous fat, compared to the control group. It has been reported that 16 patients did not lose weight, while nine patients lost from 0.5 to 10 kg. Fat distribution was altered and the ratio of visceral to subcutaneous fat increased [23]. In PD the most important therapeutic role is ascribed to drugs. However, nutrition should be approached as an additional but very important element supporting treatment. Although in this case an adequate diet will not restore health, it may affect the effectiveness of the drugs taken and maintain the proper level of nutrition, which guarantees an optimum state of health and good general wellbeing. It should be remembered that the idea of the application of a diet while treating patients with levodopa results from the interactions taking place between the drug and amino acids contained in food proteins. The reduction and control of the amount of proteins consumed enable an increase in the effectiveness of the drug during an advanced stage of the disease in most patients in whom motor fluctuations are observed. During the process of digestion of proteins, they are decomposed to amino acids, in which form they are absorbed and subsequently used by the body to form its own proteins constructing muscle tissue, entering into the composition of body fluids, immune antibodies, or independent enzymes or hormones. From the aspect of chemical structure, levodopa is also an amino-acid. However, it belongs to the group of so-called large neutral amino acids (LNAA). Amino acids are absorbed in the same way, with the participation of the same carrier as, for example, levodopa and amino acids LNAA from food; they compete between them in the process of absorption and passing to the brain. Thus, if we consume a meal rich in proteins before taking levodopa, then its absorption in the intestine will be hindered. In addition, the amino acids circulating in blood will slow down their crossing through the blood-brain barrier. This is equivalent to a decrease in the effectiveness of the action of the drug, because an improvement of wellbeing after taking levodopa occurs only after its penetration to the brain. The obtained results show the correct planning and course of treatment, and the patients' adequate nutrition.

Conclusions

The majority of the patients' body composition parameters remained within normal values. The patients' metabolic age was considerably lower than their calendar age. Highly significant differences between males and females were observed with respect to body height and weights, fat mass, fat-free mass, muscle mass, visceral fat, total body water (kg), total body water (%), extracellular water, intracellular water, and the ratio of extracellular water to total body water (%). There were also significant positive correlations between metabolic age and the overall stability index and front-back stability index. The higher metabolic age was associated with the higher overall stability index and higher front-back stability index. Body composition disorders and the reduction of its mass are not beneficial from the point of view of maintenance of the health of the patient ill with Parkinson's disease; therefore, systematic examinations and prevention are important. The obtained results show correct planning and course of treatment, as well as proper nutrition of patients.

Conflict of interest

The authors declare no conflict of interest.

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