BALNEO RESEARCH Balneo and PRM Research Journal
English Edition
e ISSN 2734 - 8458 p ISSN 2734 - 844X ROMANIAN ASSOCIATION OF BALNEOLOGY

Research article

Postural Analysis in Patients with Parkinson's Disease and the Importance of Physical Exercise for Postural Correction

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Citation: Zippenfening H.A., Matichescu M.L., Raducan M.R. and Amaricai E. - Postural Analysis in Patients with Parkinson's Disease and the Importance of Physical Exercise for Postural Correction
Balneo and PRM Research Journal **2023**, *14(3): 573*

Academic Editor(s):
Gabriela Dogaru

Reviewer Officer:
Viorela Bembea

Production Officer:
Camil Filimon

Received: 05.07.2023
Accepted: 15.08.2023
Published: 01.09.2023

Reviewers:
Simona Pop
Constantin Munteanu

Publisher's Note: Balneo and PRM Research Journal stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Abstract: In the case of Parkinson disease, the postural abnormalities accentuate as the disease advances. The loss of the gravity center is determined by the deviations from the normal posture like the changing of the head position, the anterior bending of the trunk and semi flexions of the superior and inferior members. The aim of this study is to identify the modifications of the posture and of the alignment of the body in the case of the Parkinson disease patients, following the physical exercise program.

Within the study, forty patients with Parkinson disease were analyzed using Softului GaitON Posture Analysis. Following the postural analyses, the patients were integrated into a physical exercise program, for six months.

The results of the study indicate significant positive changes concerning the realignment of the head posture, p=0.02, of the shoulders p=0.02, anterior superior iliac crest. Through the postural analyses system, we monitored the evolution and the efficacy of the rehabili-tation program, in its dynamic.

The GaitON Posture Analysis system proved to be a good indicator for the evaluation and the monitoring of the patients with Parkinson disease. The physical exercise pro-gram, which was recommended to the patients, demonstrated to be effective and an im-portant tool for the improvement of the posture..

Keywords: Parkinson's disease, Postural Analysis, Physical exercise

1. Introduction

Postural changes are particular characteristics of patients with Parkinson's disease, being present in 20% of cases. Postural abnormalities are more pronounced as the disease progresses[1].

There are three main types of postural disorders associated with Parkinson's disease. Camptocormia is an involuntary anterior bending of the trunk in orthostatism and during gait. The camptocormia is alleviated when the patient is in sitting position with a lumbar fixed point with more than 30° and in supine position with a thoracic supporting point over 45° [2]. The patients adopt a compensatory posture in order not to lose the center of gravity, with the elbows, hips and knees semi flexed [3]. Another specific postural change

of Parkinson's disease is represented by Pisa syndrome. It is defined as a lateral inclination with at least 10°, stressed while going on long distances and in sitting position with anterocollis (involuntary anterior bending of the neck with at least 45°) [4]. Through the evolution to advanced stages of Parkinson's disease there can be changes due to deformations of the hands, cubital deviations and flexion of the metacarpophalangeal joints, and extension of the interphalangeal joints. Plantar inversion and dorsiflexion of the hallux can be also present [5].

The changes in posture is a prime indicator of the postural instability, often encountered in the advanced phases (absent in the initial phase of the disease and in the young patients); these are the consequence of the loss of postural reflexes. The loss of postural reflexes is a preceding factor of falls. It is also responsible for the impossibility of unassisted standing and the fall of the patient at the point of sitting on the chair ("sitting in bloc") or at the point of swiftly rising off the chair without postural control. The changes in postural reflexes are responsible for the festinating gait (a very quick and uncontrolled gait); the patient brings the foot in front in order to remain in the center of gravity of a flexed body and to prevent the falls [6].

The postural evaluation requires a validated method and it should be analysed in a clinical context in order to be the guideline for the subsequent diagnosis and rehabilitation. The first method for postural evaluation is the direct observation of the global position. It should be recorded by a trained observer who should apply further an evaluation scale. [7,23]. The simple postural evaluation can be done with a wall goniometer, followed by the photographic examination of the pacient. [2,4] In order to identify postural changes and asimmetries of the different parts of the body, the new methods of analysis of the static situation and of the walking one are based on intelligent softwares as is the case of GaitOn Posture, applied for the present study[8].

GaitOn Posture Analysis System analyses the posture and the body alignment anteriorly, posteriorly and laterally. The analysis protocol of posture identifies key postural errors of the body from more angles making a report of the deviations. This system is also used from static position, gait, running or different activities [8]. GaitON is an appropriate evaluation tool for diagnosing initial postural disorders, postural comparisons before and after rehabilitation programs. It also monitors the effects of the orthosis, and evaluates of the stages of motor development in children [8]. The method of postural evaluation with the help of the GaitON Posture Analysis software comprises of the determination of the alignment of the vertebral column, pelvis and inferior limbs through axis analysis after importing images done with the help of the marks at the level of the analysis areas.

The objective of our study was to identify differences of body alignment in patients with Parkinson's disease after a physical exercise program.

1. Results

The study group included 40 patients (45% men and 55% women), aged between 52 and 75 years. The participants of the study are according to the Hoehn and Yahr staging [10] distributed in stage 2 (40%- 16 patients) and stage 3 (60 % - 24 patients), respectively.

Table 1. Characteristics of Parkinson's disease patients

Characteristics	Parkinson's disease patients
Number	40
Gender	
- Male (%)	18 (45)
- Female (%)	22 (55)
Age (years), mean (SD)	67.23(6.37)
Weight (kg), mean (SD)	73.73 (14.71)
Height (cm), mean (SD)	166.23 (10.14)
BMI (kg/m²), mean (SD)	26.43 (4.00)

N: number patients; BMI: body mass index; SD: standard deviation;

Table 2. Postural analysis of the patients from the anterior and lateral view before and after physical exercise program

Anterior view	Before physical exercise	After physical exercise	p
Horizontal alignment of the Head Mean (SD) N = 16	6.80 (3.40)	4.33 (3.95)	0.02
Horizontal alignment of the Acromions Mean (SD) N = 23	3.90 (1.65)	2.78 (2.07)	0.02
Horizontal alignment of the ASIS's Mean (SD) N = 25	4.45 (2.78)	3.38 (1.82)	0.006
Lateral Trunk Alignment Mean (SD) N = 16	5.96 (2.50)	4.80 (3.13)	0.055
Lateral View	Before physical exercise	After physical exercise	p
Forward Head Angle Mean (SD) N = 40	23.30 (12.41)	21.48 (12.55)	0.003
Genu Recurvatum Mean (SD) N = 5	1.30 (1.34)	1.16 (2.11)	0.43

N= number of patients, SD= Standard Deviation

Figure 1,2,3,4. The horizontal alignment of the head, of the acromion, of the anterior superior iliac crest (grades, anterior view pre Fig. 1,3 and post Fig. 2,4)

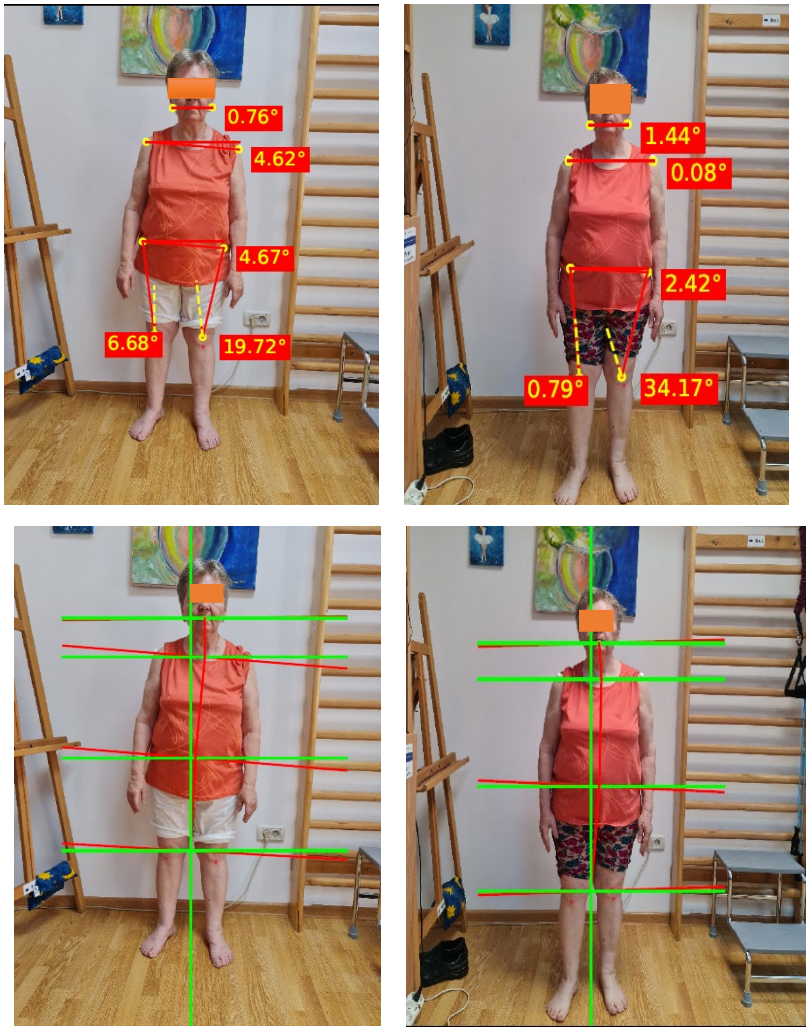
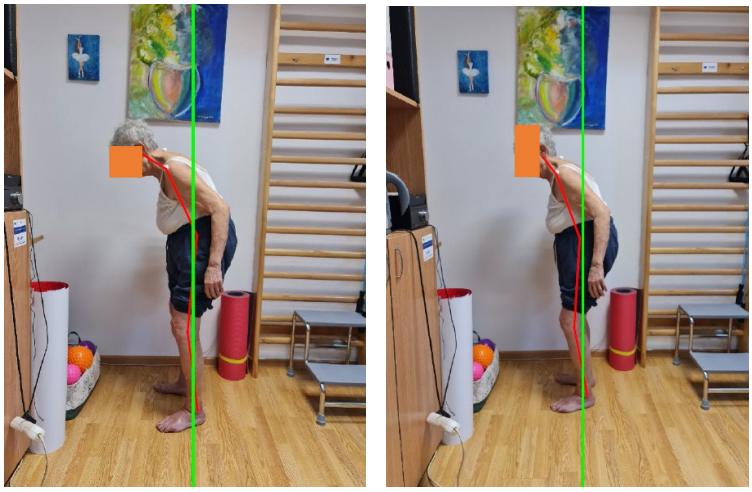


Figure 5,6 The analysis of the head foreward position grade, the acromion and the anterior superior iliac crest (lateral view pre Fig. 5 and post Fig. 6)

Figure 7,8 The profile analysis of the knee posture, pre Fig. 7 and post Fig. 8 (Genu Recurvatum).



We analysed the body posture before and after the physical exercise program and we can observe statistically significant changes before and after treatment concerning the values of the angles with whom inclines the head towards the 0° reference value, when we include in the analysis only the cases in which before the treatment existed a deviation of the head position.

As for the allignment of the shoulders, when we do not include the patients who had normal values of the shoulders before the treatment, there can be observed a statistically significant improvement of the posture of the other patients who had before the treatment deviations in the shoulders posture, due to the fact that, on average, there exists a more significant statistic between the angle with which the shoulders incline themselves and the 0° reference value before the treatment than after the treatment.

When we excluded the patients who had before the treatment the pelvis at a normal level already, we can observe an improvement of the other patients with deviations of the pelvis, due to the fact that, on average, the difference between the angle with which the pelvis inclines and the 0° reference value is greater before the treatment than after the treatment, difference which is statistically significant.

If we eliminate the patients who had before the treatment a vertical allignment of the trunk and we do a statistical analysis only including the paatients who have deviations of the trunk, in order to see the difference between before and after treatment, we can observe that before the treatment, the difference between the angle with which the trunk inclines itself and the 0° reference value is truly greater than after treatment, but not statistically significant, with $t(15)=1.68$, $p=0.055$, $p>0.05$ – p has a tendency to be statistically significant, which means that the group is not sufficiently enough in order to show the studied phenomenon = highly probable the studied phenomenon becomes statistically significant at a greater group of patients.

Q Angle Right for men, reference value of the right Q angle is < + 15°. After t test application for a single group, it can be observed that, before the treatment, the patients of masculine sex, with Valgus Knee (+), have values of the right Q angle which does not differ statistically significant than the reference value of 15°. This thing signifies that before physical exercise program, the values with + of the right Q angle of the patients of masculine sex does not differ statistically significant on average than 15° = before the treatment, there are no statistically significant differences between right Q angle values and reference value of 15°.

For women, the reference value of right Q angle is < + 20°, the patients of feminine sex with Valgus Knee (+), have on average, before physical exercise program, right Q angle in an normal interval (< 20°). After the treatment, the right Q angleof the patients of feminine

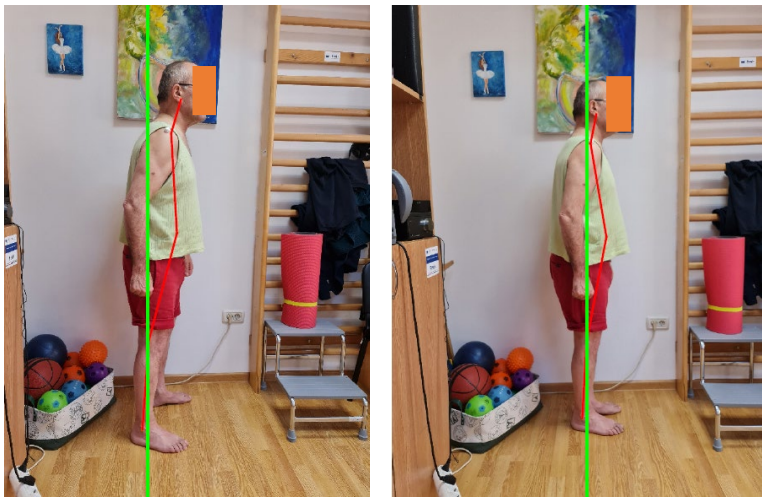
sex with valgus Knee (+) remains hereafter statistically significant less than the reference value, indicating the fact that the patients of feminine sex maintain even after right Q angle treatment is statistically significant less than the reference of 20°, integrating hereafter in the normal interval, < + 20°, with t(19)= -3.97, p=0.001.

Left Q Angle for men, the reference value of left Q angle is < + 15°. For women, the reference value of left Q angle is < + 20°. After treatment, there are no statistically significant differences between the values of left Q angle of the feminine patients with valgus Knee (+) and the reference value of 20° because the studied patients do not present pathological deviations before inclusion in the recovery programme.

These results show the fact that the proposed physical exercise programe in case of the Q angle has also an effect of stabilisation, a positive effect of the recovery programme in case of progressive neurodegenerative pathologies.

Lateral View can be seen a statistically significant improvement concerning the head posture from profile at the studied group, due to the fact that although before and after the treatment, the head angle is statistically significant reduced than how it should have been (reference value), after the treatment there is a statistically significant difference smaller bewteen the head angle and the reference value.

Figure 9, 10 Lateral View



Before the treatment, Shoulder Angle is, on average, statistically significant greater than the reference value of 52°, that is the patients have on average, before the treatment , the shoulder angle in a normal interval, after treatment, the patients have values of the shoulder angle which does not differ statistically significant than the reference value of 52°. This shows a stagnancy which means a positive aspect in the case of patients with Parkinson's disease.

In the case of Genu Recurvatum the reference value of the knee angle is < - 10°. Because the values are already normal, the analysis pre and post test is insignificant.

Figure 11, 12, 13, 14 Lateral View

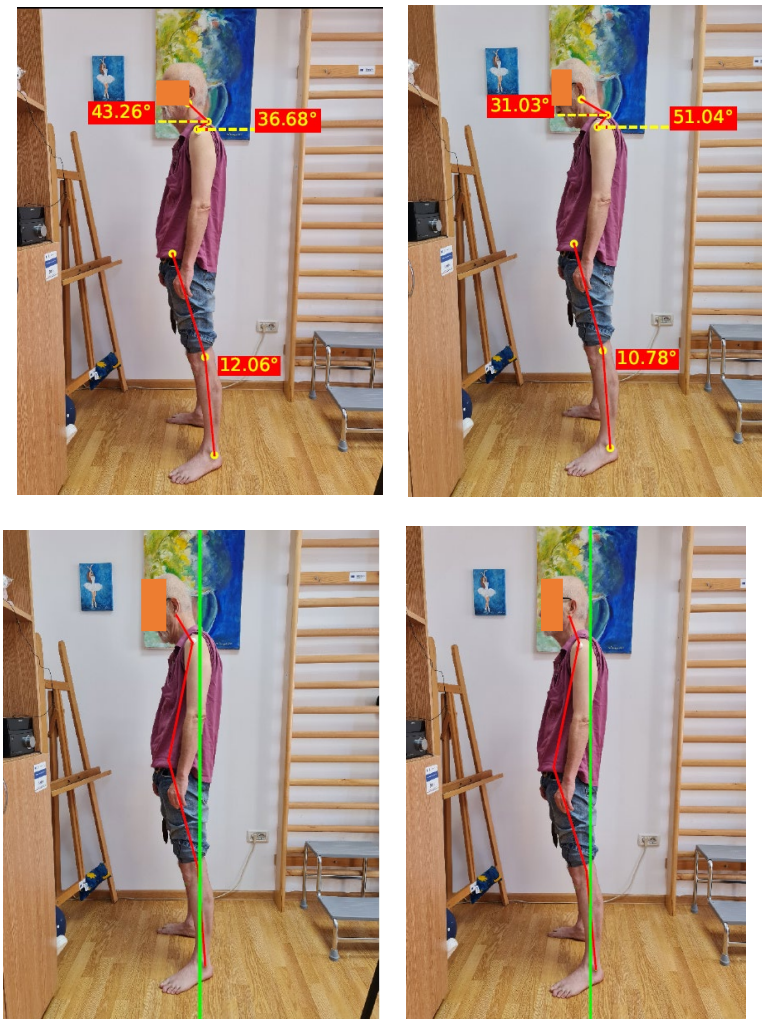


Table. 3 Posterior postural analysis (before kinetotherapy and after 6 months of programme)

Posterior View						
Rear Foot Angle Left Mean (SD)	Rear foot Eversion (+) N = 13			Rear foot inversion (-) N = 8		
	Before physical exercise	After physical exercise	P	Before physical exercise	After physical exercise	p
	9.91 (19.60)	3.32 (4.43)	0.14	7.20 (3.06)	3.95 (4.60)	0.08
Rear Foot Angle Right Mean (SD)	Rear foot Eversion (+) N = 19			Rear foot inversion (-) N = 9		
	Before physical exercise	After physical exercise	P	Before physical exercise	After physical exercise	p
	9.80 (16.65)	7.51 (18.82)	0.04	4.91 (3.30)	4.21 (4.46)	0.30

N= number of patients, SD= Standard Deviation

Figure 15, 16, 17, 18 The analyses of the angle of the foot (inversion, eversion) before the recovery programme Fig. 15 and after the recovery programme Fig. 16

2. Discussion

A study published in 2021 with 43 patients in stage 3 and 4, respectively, of Parkinson's disease, analyses the limit of stability (postural stability) [11] by posturography, (Tecnobody, PROKIN, System Italia) [12] analysing the voluntary postural control by measuring the active limits of stability while requesting the patients to do complex tasks in different directions. Several types of movements used in testing are also found in our physical exercise program, stressing on the posture control of the shoulders in order to maintain the centre of gravity. As in our study as well, the researchers had significant results in case of patients with Parkinson's disease with a stage III in comparison with the patients in stage IV. Through this research, the specialists have identified not only the grade of stability of the patients, but they also identified postural abnormalities depending on the evolution of the disease [12].

Tassorelli C. et al. wrote in 2019 a pilot study about "The role in rehabilitation in deep brain stimulation of the subthalamic nucleus of Parkinson's disease". The study had 34 patients with Parkinson's disease with bilateral deep brain stimulation (DBS) of the subthalamic nuclei (STN). The procedure can be associated with functional disorders of different types and intensities. The participants at the study were included in programmes of medical rehabilitation which included physical exercise program with stress on increasing joint amplitude, active exercises, coordination exercises and walking exercises

with maintaining the body posture for a period of 4-8 weeks. After finishing the study, the patients were examined in a motor manner with the help of UPDRS scale and functional independence motor (FIM) and the results showed a significant improvement of the motor parameters. Physical exercises program improved functionality [13].

A randomized study published in 2019 at *Parkinsonism and Related Disorders* describes a 4-week programme, which involves exercises for changing and correction of the posture of anterior flexion of the trunk for patients with Parkinson's disease. The study started from a big number of patients which who present the pathological bending of the trunk in flexion and negative impact on which the unfavorable evolution of this manifestation produces unbalances, pain, a high risk of lesions through falling. In the study there were included 37 patients with anterior flexion of the trunk, they were randomized in an experimental group formed by 19 patients and a control group of 18 patients. The first group followed an autocorrection of the posture programme through active exercises with visual and proprioceptive feedback, with passive and active exercises of stabilizing the trunk. The control group followed a joint mobilization programme, stretching, balance exercises and walking. The programmes had a duration of 60 minutes per 5 days a week. After finishing the programme, firstly it was analysed the flexion of the trunk forward (the grade) and secondly, it was applied the UPDRS. Results showed that the experimental group had a significantly greater reduction of the trunk flexion than the control group, which shows that the rehabilitation training specific for the trunk decreased the severity of the flexion [14].

A meta-analysis published in 2023 by Sensors (Basel) approaches the problematics of trunk posture of the patients with Parkinson's disease and the role of the physical exercises program in trunk posture correction, the improvement of the balance, the reduction of fall frequency. In the meta-analysis, eight studies showed that the interventions with specific exercises produced improvements in trunk posture and a significantly improved static balance [15].

Bearing in mind the negative impact that the symptomatology of Parkinson's disease concerning the functionality and independence exists a greater preoccupation for the analysis of the gait and modified posture by the disease, a Review published in 2022 is done from 10 studies from the last 10 years comprising of 244 patients which analysed the quality of gait: the velocity of the gait, postural stability, gait rigidity and and the balance of the limbs in gait. After the result interpretation, it is mentioned the importance of detection and supervision of the gait aspects. This Review shows different methods of supervision of the gait in order to identify in time the appeared changes with the aim of profilactic intervention in correcting the gait or to administer the right dose of treatment [16].

An observational study done in 2019, with 45 patients, debates the influence of postural deformation at the neck and the pain at the patients with Parkinson's disease. As well as in our study, they analyse the changes in the neck posture. Moreover, the authors think that trunk alignment contributes at the function of the neck of the patients with Parkinson's disease who suffer from different postural deformations, such as Pisa syndrome or camptocormia or anterocollis. The results show that the change in neck posture in Parkinson's disease with the major changes mentioned above are associated with severe infliction of the neck and the presence of pain at this level [17].

Another Review, published in january of this year (2023), analyses the axial postural abnormalities which involve the vertebral column deformations, an extremely met effect at the patients with Parkinson's disease which has a negative impact and debilitating in time. In this review there were taken into consideration 19 studies which analysed the postural changes and they identified that thsese changes are directly influenced by the age of the patients, the longer duration of the disease, its stage, motor fluctuations and also the level of rigidity and the life style concerning the physical activities [18]. Also in

this year, (February 2023) there was published a study in *Journal of Neural Transmission* which approaches the postural changes and postural complications (Pisa syndrome and camptocormia) and the pain as a negative effect regarding the evaluation of the quality of life of the patients with Parkinson's disease. At a number of 45 patients with postural changes and postural complications, there were analysed the characteristics of pain, fluctuations and musculoskeletal disorder generated by the posture. There was demonstrated that the patients who had complications such as Pisa syndrome and camptocormia, it provokes a greater pain than in patients with a simple changed posture [19].

Ambar Ekar and co. studied the postural change on a group of 127 patients with Parkinson's disease and identified that half of the studied group with stressed bradykinesia developed postural disorders [20]. A Review published in Seminar in Neurology in 2021 by Terry D Ellias confirms the conclusion that the aforementioned study proved the fact that the motor symptoms such as bradykinesia, tremor, rigidity make postural modification and contribute to the early invalidity, but there exists an increasing number of proofs which unveils the benefits of physical therapy and exercises for alleviating the motor and non-motor signs, improving the physical function and reducing the disability [21].

A meta-analysis published in 2022 follows the benefits of kinetotherapy programmes for alleviating motor symptoms on a long-term on average six months for a total of 523 patients. The results showed that physical exercise program for six months or more could improve effectively the motor symptoms of the patients with Parkinson's disease, regardless if combined or not with antiparkinsonian treatment. Also, physical exercise on long-term reduces the medical treatment dose [22].

4. Materials and Methods

We included in the study patients diagnosed with Parkinson's disease. The exclusion criteria were: Parkinson's disease stage 4 and 5 (according to Hoehn and Yahr scale [8]), patients enable to maintain orthostatism or without permanent support gait, body asymmetries given by other pathologies (hip joint prosthesis, ankylosing spondylitis, severe scoliosis or kyphosis, neurological disorders - hemiparesis).

The study was done between 20th of September 2022 and 20th of February 2023, at Social Integration/Reintegration Centre for people in difficulty from Timisoara, Romania.

In order to determine the postural analysis with the help of GaitON Posture Analysis, the patient must maintain a standing position. The patient is evaluated from three positions: anterior view (the markers are positioned at the level of the antero-superior iliac crest, the central point of the knee-cap and on the tibial tuberosity, both right and left), posterior view (the markers are positioned at the base of the heel, the Achilles tendon insertion, the center of Achilles tendon and 15 cm above the Achilles tendon insertion, both right and left), and lateral views (the markers are positioned at the C7 spinous process, the middle point of the humeral head, the major femoral trochanter, the lateral femoral epicondyle, and lateral malleolus, both right and left).

The posture analysis was performed before starting an exercise program and after 6 months. The patients did the exercise program with a frequency of two times a week (in an organized frame) and followed home recommendations.

The postural analysis was done by the same physical therapist (H.A.Z.). The measuring procedure lasts approximatively 10 minutes per patient and it comprised of applying markers on the analysis areas and taking photographs of the patients from three angles: anterior, lateral and posterior.

The duration of a exercise session was between 45 and 90 minutes. The physical exercise program consisted in 15-20 exercises per session; the frequency and intensity of the exercises varied according each patient effort capacity.

The exercise program targeted the superior area of the trunk, starting from the cervical spine, shoulders, thorax. The strengthening of the pelvic musculature and the promotion of the knees extension were also included. The exercises program started with arm up with movements of laterality, left-right, alternative inclinations of the head and circular movements of the head. Stretching exercises for the cervical area were added. The exercises were performed in the sitting position: movements of the chin to the chest, ascending and descending of the arms (with respiratory movements), upper limbs strengthening with weights of 0.5 kg, elastic band, knee extension with 0.5 kg weights. The exercises done in orthostatism included: extension of the arms, weights of 0.5 kg in the hands, extends the arms laterally, with dumbbell of 0.5 kg alternative flexions and extensions of the superior limbs. The trellis exercises were: grabs with his hands a fitness ball whom he rolls it on the surface of the trellis until the highest level, with the back at the trellis, flexion of the superior limb, extends the inferior limb from the knee joint on the bar of the trellis and then pushes the heel on the floor.

All the recommended exercises for the patients have as a purpose, the correction of the posture of the back, shoulders, waists and the promotion of the extension of the knees and the body alignment [8].

With the help of the dumbbells, elastic bands and weights the musculature tonifies for body consolidation. The exercises from orthostatism trains the stability and ability in statics and gait [9]. The exercises with the fitness ball or from the supine position promotes mobility through stretching.

5. Conclusions

The physical exercise program proposed for the patients with Parkinson's disease for postural correction proved to be efficient because it has brought positive changes concerning the allignment and correct repositioning of the head, shoulders, trunk and pelvis in physiological parametres. Also, the program has a profilactic effect due to the fact that the patients who had in normal range of deviations, maintained during the entire physical exercise programme without having an unfavourable evolution, bearing in mind the progressive evolution of the disease.

The body position influences the balance and gait, an abnormal posture favours fallings and the risk of accidents, increases the grade of disability. The correction of the abnormal posture is extremely important for the patient's independence in doing the proposed activities.

Another notable element concerning the physical exercise program is the manner in which was done and the attention at how the patients did the programme because the results showed that after the program there were not negative unbalances from the anteriorly analysed values and the posteriorly analysed values, which means that the patients were correctly supervised during the programme.

GaitON Posture Analysis programme is a good indicator for the evaluation and supervising the posture and allignment. With the help of this program, we can identify particularly elements of finesse concerning the position of the head, shoulders, pelvis, knees or sole which can be corrected through the physical exercise programs. All analysed elements helped in building the personalised program for the correction of posture and the body allignment.

Author Contributions: Conceptualization, H.A.Z., E.A. and.; methodology, H.A.Z. and E.A.; validation, H.A.Z. and E.A.; formal analysis, H.A.Z., R.M.R., M.L.M.; data curation, H.A.Z.; writing—original draft preparation, H.A.Z.; writing—review and editing, H.A.Z., E.A., R.M.R. and M.L.M..; visualization, A.E., M.L.M.; supervision, A.E. All authors have read and agreed to the published version of the manuscript

Funding: This research received no external funding

Institutional Review Board Statement: In conformity with the ethical standards, participation at the study was voluntary, they were informed about the testing procedure. All participants at the study accepted in written form for the data processing and for the scientific use. The study was approved by the Ethical Committee of Victor Babes University of Medicine and Pharmacy, Timisoara, Romania, Ethical Notification No.49/15.09.2022 and is in conformity with the Helsinki Declaration.
Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patients to publish this paper.
Conflicts of Interest: The authors declare no conflict of interest.

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