UDK 616.858-008.6-085:796.015.11 **Original Scientific Paper**
Doi 10.7251/SANUS2503209P

THE EFFECT OF INTERVAL TRAINING ON THE GAIT PARAMETERS OF PEOPLE WITH PARKINSON'S DISEASE: AN EXPERIMENTAL CLINICAL STUDY

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Abstract. *Gait training is an important and effective segment of kinesitherapy and rehabilitation for people with Parkinson's disease. Specificity such as interval training in the literature indicated an improvement in cardiorespiratory fitness, but not on gait quality and dynamic stability. The aim of this study is to examine the effect of tredmil interval training in people with Parkinson's disease on gait parameters. A prospective experimental, double-blind study conducted in 46 patients aged 63.3±9.8 years selected by random sampling assigned to two groups based on even and odd numbers. During the 21 rehabilitation days, all subjects had 5 days a week the same general program of kinesitherapy and occupational therapy lasting 80 minutes, and the experimental group had an additional program on the treadmill in the form of interval training with 4 minutes of their average walking speed and 3 minutes of break through 4 repetitions. Rehabilitation outcomes were monitored by the application of standardized tests Tineti Balance Scale, Time Up and Go (TUG) test and objective analysis of the software program Zebris HP cosmos FDMT device at the beginning and end of rehabilitation. The mobility and balance of patients assessed by the Tinetti test showed better results in the experimental group before and after treatment, the significance between the groups in terms of change was p = 0.3. The statistically significant difference between the groups in terms of UP&GO was p = 0.4. Patients in both groups have a similar support phase, swing phase, double support, stride length, stride time, and rhythm, including changes after treatment. There was no significant difference in improvements between the groups. In the control group, a significant reduction in total double support and cadence was observed. In the experimental group, a significant increase in stride length and an increase in walking speed were observed. Objective measurements of the outcomes of interval training on the treadmill did not confirm greater significance and better results of spatio-temporal gait parameters compared to the standard rehabilitation program.*

Key words: Interval tredmil training, rehabilitation, Parkinson's disease

Introduction

PD is a progressive movement disorder characterized by hallmark motor symptoms of bradykinesia/akinesia, rigidity, tremor, and postural instability[1]. PD is a common neurodegenerative disorder that occurs in about 1% of adults over the age of 60 years old. PD affects between 0.5% and 1.0% of adults aged 65 to 69 years, and 1% to 3% of those 80 years of age and older [2].

In physiotherapy, this neurological disease is briefly described by two terms: hypertonus and hypokinesia. This combination of tone and movement creates a poor posture, which, with difficult initiation of movements, creates a characteristic gait pattern in people with this disease. The gait pattern is determined by certain sequences such as the absence of reciprocity and a decrease in arm swing compared to steps that are generally small, accelerated with increased load on the forefoot and a difficult change of direction that requires a higher cognitive component. [3-6].

Initially, these difficulties are overcome but over time, as the disease progresses, bradykinesia increases, changes of direction when performing daily activities that require walking become more difficult, episodes of freezing gait appear and falls are often reported[7-9]. “Parkinsonian gait” as type of gait impairment is associated with increased falls and can negatively impact the quality of life

The main problems of gait in Parkinson's disease are a decrease in stride length with a decrease in speed, impaired coordination, a decrease in stride length with an increase in stride frequency, an inability to perform effective steps at the beginning of walking or a complete cessation of steps while walking, and problems performing two tasks at the same time while walking. In kinesitherapy, treadmill training is often created when specific training principles are used to achieve improvements in walking, speed and stride length.

Aim: Can we improve step initiation by improving spatio-temporal gait parameters with treadmill interval training?

Material and work methods

PICO design: a prospective, double-blind controlled clinical study included a total of 46 patients of both sexes, suffering from PD, aged 50-68 years.

Criteria for inclusion of patients with PD: patients diagnosed with PD by a neurologist and grade I-II according to the Hoehn -Yahr scale (HY) for assessing the stage of PD (unilaterally and bilaterally manifested symptoms of PD, with or without postural disorders), patients belonging to the PD subtype with dominant postural instability and gait disorders (Postural Instability Gait Disorder - PIGD)*;* stable antiparkinson-dopaminergic therapy at 4 weeks prior to the start of the study*;* able to walk for 20 min unassisted, patients who agreed to the examination and signed the informed consent

Exclusion criteria from the research will be patients who*:* does not agree to the proposed rehabilitation, patients who stop rehabilitation (of their own volition or were transferred to another health facility due to deterioration of their health condition or

in case of death)*;* refuse to perform the intended measurements;patients who have stopped taking pharmacological therapy, patients who no longer wish to participate in this research.

Exclusion criteria will be patients who have: confirmed associated neurological disease*;* vestibular impairments, diseases and injuries of the proximal segment of the upper limb, spine and lower limb, *and patients* with diagnosed psychological disorders

Simply by random sampling, the subjects were divided into two groups. Each subject being numerically marked: The experimental group was formed with subjects marked with an even number (23 subjects), and the subjects marked with an odd number represented the control group (23 subjects).

Both groups had, during the 21-day rehabilitation, a standard program consisting of kinesitherapy for 40 minutes, 5 days a week, and occupational therapy for 40 minutes, 5 days a week. The experimental group also had an additional program on the treadmill that consisted of interval training consisting of 4 sessions at a speed that the subjects could achieve without fatigue for 4 minutes, followed by a 3-minute break. The initial speed at which the tape was moved was 0.5 km/h and would increase to the speed that the patient could achieve in the next 20 seconds.

All PD patients were tested with the Unified Parkinson's Disease Rating Scale (UPDRS), Tineti Balance Scale, Time Up and Go (TUG) test, and spatiotemporal parameters of gait were objectively verified by 3D analysis using the software program Zebris FDMT H/p Cosmos before beginning, and after rehabilitation.

Unified Parkinson's disease ratings scale (UPDRS)-III is a commonly used assessment tool for body bradykinesia, rigidity, tremor, posture, gait, facial expressions and speech components in individuals suffering from PD. The motor examination consists of 33 scores based on 18 items. Separate evaluations assess the right and left side of the body, as well as a facial masking and speech ability section that are subsequently used to assign disease stage and an overall motor score. Scores on the UPDRS-III can range between 0-132, with larger scores indicating greater impairment. All questions are based on a 5-point Likert type scale (0=normal, 1=slight, 2=mild, 3=moderate, 4=severe) (Goetz et al., 2008)[10].

The timed up-and-go (TUG): The Timed Up and Go Test (TUG) assesses mobility, balance, walking ability, and fall risk in older adults. The test has the task of determining the risk of falling by changing the position of the body during simple tasks performed by the examinee: getting up from a sitting to standing position, and starting to walk a length of 3 meters, followed by a change of direction of movement for 360 degrees around the placed marker and returning back to the chair on which the examinee must sit down again.. TUG was found to be a sensitive and specific measure for identifying elderly individuals who are prone to falls. [11]. A recent study published in 2022., found the TUG test to be a strong predictor of mortality, highlighting other established risk factors such as chronic diseases in the geriatric population of low- and middle-income countries [12]. The Tinetti balance assessment tool (TIN) The TIN is a clinical tool used to rate gait patterns and balance

performance. It is also called the Performance Oriented Mobility Assessment (POMA), assesses a person's perception of balance and stability during daily activities and their fear of falling[13-14]. Each item on the assessment is scored on a 2-point scale. The gait and the balance portions can be combined for a score of 28. Higher values indicate better performance. The TIN has been shown to have adequate reliability with intraclass correlation coefficients of 0.8 and above in those with PD [15].

Zebris medical device is a specially developed technology built into a treadmill that tracks movements three-dimensionally, measures the distribution of pressure/force on the surface, and analogically records biomechanical data generated during the walking cycle. The system consists of an ergometer-moving belt in which a number of calibrated high-quality, capacitive sensors are installed, which register pressure (power) on the surface in all phases of walking and balance in the standing position, and provides information on numerous spatial and temporal walking parameters.

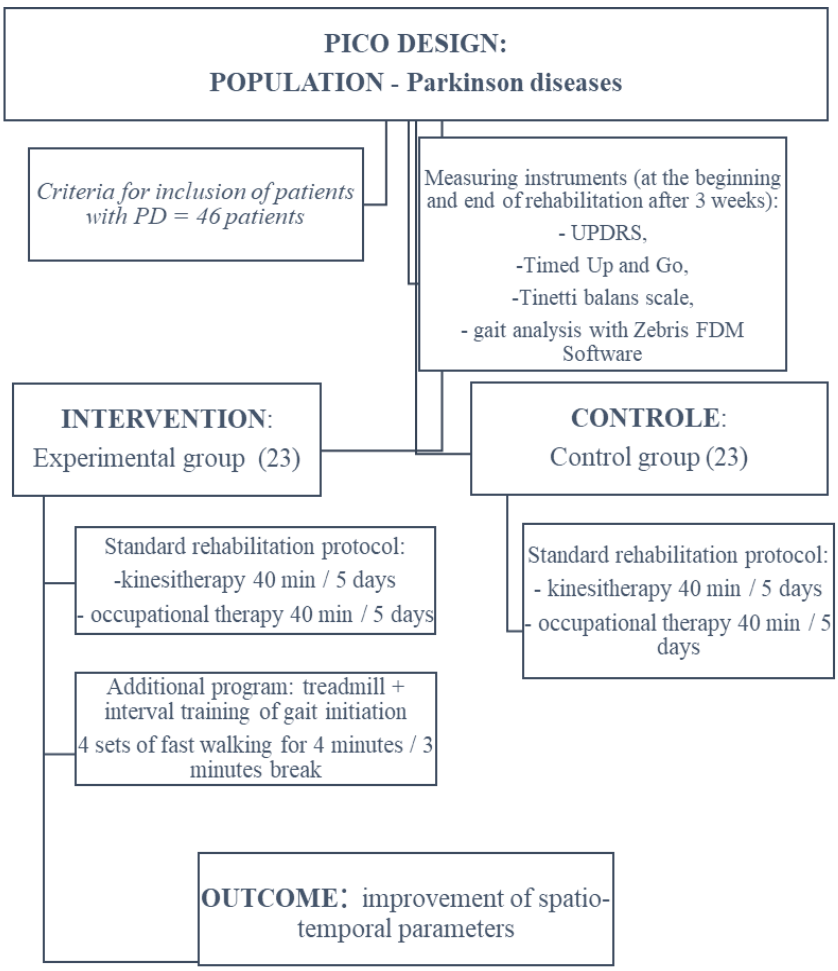

Figure 1. Presentation of the research methodology

All statistical analyses were performed in SPSS 20.0 (SPSS Inc., Chicago, IL). Results were presented as frequency, percent, mean – standard deviation (SD). The chi-squared and t-test were used to compare the two groups. All P values less than 0.05 were considered significant.

Results

The study included 46 patients divided into experimental and control group (each 23 patients). Average age of all participants is 63.3 ± 9.8 years, dominantly males 29 (63,0%). Descriptive statistics of examined groups regarding the basic characteristics is presented in Tabel 1. The average age is similar in both groups, a bit higher in control. The male gender is dominant in both groups, with no difference in distribution between groups. The anthropometric findings reveal similarity in examined groups, a bit higher BMI in control group, but without statistical significance. HY index is significantly higher in control group.

Table 1. Basic characteristics of patients

	Experimental (n=23)	Control (n=23)	p value
Age (years)	60.9 ± 10.8	65.7 ± 8.3	0.099 [a]
Gender Male	14 (60.9%)	15 (65.2%)	1.000 [b]
BMI (kg/m^2)	27.6 ± 4.3	30.1 ± 6.3	0.120 [a]
Leg length (cm)			
Left	88.9 ± 7.8	88.3 ± 6.0	0.752 [a]
Right	88.7 ± 8.1	88.4 ± 6.0	0.870 [a]
HY			
1	14 (60.9%)	7 (30.4%)	0.038 [b]
2+	9 (39.1%)	16 (69.6%)	

[a]t test [b]Pearson chi square test

Patients in both groups have similar foot rotation, including change after the treatment (Table 2). Step width was significantly higher in experimental group before the treatment, but the change is not significant. Contrary, in control group, significant increase in step width is observed. Finally, no significant difference regarding the step width improvement between groups is observed. Step length and step time were similar in both groups. In experimental group significant increases in step length left and right is observed, and in control group significant increases in step length left and step time left is observed. No significant difference regarding the step length and step time improvement between groups is observed.

Table 2. Foot Rotation and Step characteristics

	Experimental (n=23)	Control (n=23)	P value
Foot rotation (°)			
Left before	10.47 ± 4.75	11.03± 5.67	0.722 [a]
Left after	10.83 ± 4.69	11.13± 4.87	0.830 [a]
ΔLeft	0.36 ± 4.32	0.11 ± 3.22	0.827 [a]
Right before	10.66 ± 4.49	10.07± 4.57	0.660 [a]
Right after	10.20 ± 4.28	10.26± 3.87	0.960 [a]
ΔRight	-0.46 ± 4.27	0.20 ± 4.16	0.603 [a]
Step width (cm)			
Before	11.22 ± 3.77	9.00 ± 3.37	0.041 [a]
After	11.57 ± 3.49	10.22± 3.88	0.222 [a]
ΔStep width	0.35 ± 2.90	1.22± 2.28*	0.264 [a]
Step lenght (cm)			
Left before	37.83 ± 9.51	35.09± 12.05	0.397 [a]
Left after	41.65 ± 6.77	39.65± 10.81	0.457 [a]
ΔLeft	3.83 ± 7.39*	4.57± 4.25*	0.680 [a]
Right before	37.04 ± 8.83	38.74± 14.81	0.640 [a]
Right after	40.96 ± 8.51	40.09± 10.77	0.763 [a]
ΔRight	3.91 ± 6.39*	1.35± 13.77	0.422 [a]
Step time (sec)			
Left before	0.84 ± 0.29	0.89 ± 0.34	0.569 [a]
Left after	0.85 ± 0.18	0.98 ± 0.36	0.131 [a]
ΔLeft	0.01 ± 0.28	0.09±0.11*	0.224 [a]
Right before	0.80 ± 0.18	0.94 ± 0.49	0.216 [a]
Right after	0.83 ± 0.17	0.93 ± 0.30	0.169 [a]
ΔRight	0.30 ± 0.18	-0.01±0.49	0.752 [a]

*significant change (delta equals value after minus value before) in examined group
[a]t test

Table 3. Step phases, Stride and Cadence

	Experimental (n=23)	Control (n=23)	P value
Stance phase (%)			
Left before	69.19 ± 3.71	71.13 ± 8.41	0.320 [a]
Left after	68.76 ± 3.24	68.73 ± 5.16	0.984 [a]
ΔLeft	-0.43 ± 2.86	-2.40 ± 6.09	0.168 [a]
Right before	70.84 ± 3.69	70.63 ± 5.25	0.879 [a]
Right after	70.31 ± 3.38	70.47 ± 4.47	0.891 [a]
ΔRight	-0.53 ± 2.71	-0.17 ± 4.61	0.745 [a]
Swing phase (%)			
Left before	30.81 ± 3.71	28.77 ± 8.28	0.289 [a]
Left after	31.24 ± 3.24	31.27 ± 5.16	0.984 [a]
ΔLeft	0.43 ± 2.86	2.50 ± 6.13	0.149 [a]
Right before	29.16 ± 3.69	29.37 ± 5.25	0.877 [a]
Right after	29.69 ± 3.38	29.53 ± 4.47	0.891 [a]
ΔRight	0.53 ± 2.71	0.16 ± 4.61	0.742 [a]
Total Double (%)			
Before	40.09 ± 6.88	41.00 ± 10.61	0.732 [a]
After	39.03 ± 6.19	39.27 ± 8.27	0.912 [a]
ΔTD	-1.06 ± 4.99	-1.73 ± 3.63*	0.605 [a]
Stride length (cm)			
Before	73.96± 17.84	73.61 ± 24.65	0.957 [a]
After	81.30± 14.34	80.04 ± 20.39	0.809 [a]
ΔSL	7.35± 12.90*	6.43 ± 15.00	0.826 [a]
Stride Time (sec)			
Before	1.64 ± 0.44	1.84 ± 0.73	0.278 [a]
After	1.69 ± 0.35	1.91 ± 0.63	0.146 [a]
ΔST	0.04 ± 0.44	0.07 ± 0.51	0.844 [a]
Cadence (step/min)			
Before	75.78± 14.81	73.65 ± 17.96	0.663 [a]
After	72.74± 12.86	68.96 ± 16.05	0.382 [a]
ΔCadence	-3.04 ± 14.36	-4.70 ± 9.78*	0.651 [a]

*significant change (delta equals value after minus value before) in examined group
[a]t test

Patients in both groups have similar stance phase, swing phase, total double, stride length, stride time and cadence, including changes after the treatment (Table 3). No significant difference in improvements between groups is observed. A significant decrease in the total double and cadence is observed in the control group. A significant increase in the stride lenght is observed in the experimental group.

Table 4. Velocity, UPDRS, UP&GO, Tinetti and 10m test

	Experimental (n=23)	Control (n=23)	P value
Velocity (km/h)			
Before	1.73 ± 0.61	1.62± 0.69	0.574 [a]
After	1.82 ± 0.58	1.66± 0.68	0.381 [a]
ΔVelocity	0.10 ± 0.19*	0.04± 0.11	0.220 [a]
UPDRS II			
Before	13.26 ± 6.44	17.09 ± 6.91	0.059 [a]
After	11.91 ± 6.67	15.74 ± 6.18	0.050 [a]
ΔUPDRS II	-1.35 ± 1.53*	-1.35 ± 1.50*	1.000 [a]
UPDRS III			
Before	33.70± 12.41	45.00 ± 10.18	0.002 [a]
After	29.70± 12.49	40.65 ± 10.50	0.002 [a]
ΔUPDRS III	-4.00 ± 2.73*	-4.35 ± 2.44*	0.651 [a]
TINETTI			
Before	22.30 ± 2.27	20.65 ± 2.40	0.021 [a]
After	24.35 ± 2.14	23.17 ± 2.01	0.021 [a]
ΔTINETTI	2.04 ± 1.72*	2.52 ± 1.41*	0.308 [a]
UP & GO			
Before	14.82± 12.10	16.65 ± 5.10	0.508 [a]
After	11.65 ± 7.83	12.65 ± 3.28	0.578 [a]
ΔUP & GO	-3.17 ± 4.40*	-4.01 ± 2.67*	0.439 [a]
10 m test			
Before	3.59 ± 0.97	3.05 ± 0.69	0.035 [a]
After	3.90 ± 0.99	3.41 ± 0.68	0.058 [a]
Δ10m_test	0.30 ± 0.43*	0.36 ± 0.36*	0.643 [a]

*significant change (delta equals value after minus value before) in examined group
[a]t test

Patients in both groups have similar velocity, including change after the treatment (Table 4). In experimental group, significant increase in velocity is observed. UPDRS II, UPDRS III before and after the treatment were significantly higher in control group but the changes were almost identical in both groups, without significance. Tinetti and 10m test were significantly higher in experimental group before and after the treatment, but, same as UPDRS, no significance between groups regarding the change is observed. No significant differences between groups regarding the UP&GO is observed, just significant change withing groups.

Discussion

Gait and balance deficits are cardinal motor symptoms of Parkinson's disease (PD) caused by impaired function of the basal ganglia, worsen with disease progression and lead to reduced mobility and quality of life and contribute significantly to the increased risk of decline in this population [16-17].

The range of kinesitherapy procedures for maintaining the quality of life and maintaining better movement and walking patterns includes tredmill gait training.

Treadmill training can be used to allow people with Parkinson's disease to maintain (in terms of a high number of repetitions) complex gait cycles. Starting from the fact that this kind of training is a popular way of kinesiotherapy procedure that is carried out around the world, we asked a research question: can we improve step initiation by improving spatio-temporal gait parameters with treadmill interval training. Interval walking training on the treadmill included alternating periods of brisk walking on the treadmill and rest periods. The specific duration and intensity of interval training were adjusted to the individual abilities of the individual. With standardized and objective measurements, we compared two groups that underwent identical rehabilitation procedures, with the experimental group having an additional program of exercises according to the type of interval gait training. Considering that the initiation of walking is one of the difficulties faced by people suffering from Parkinson's disease, we chose a program of interval tredmil gait training in which the used walking speed was reduced by 40% compared to the performance of the individual measured in the gym. Interval training was performed in 3 sets of 4 minutes with a break of 3 minutes. Such an additional exercise program was supposed to show us as objectively as possible whether there is a difference by practicing gait initiation in people who have purposefully trained this item or whether a standardized kinesitherapy program is equally relevant for spatio-temporal parameters. A change in gait pattern in people with PD is a common occurrence due to a neurodegenerative disorder that occurs in about 1% of adults over 60 years of age[18]. Our total sample of 46 subjects had an average age of 63.3 years, which puts them in the group of the initial stage, while in similar studies this age limit is slightly higher[19 -20].

If we take into account the inclusion criterion, in our study the subjects belonged to the I and II disease scales according to the Hoehn-Yahr index, which means that they had unilateral involvement, usually with minimal or no functional disability, i.e. bilateral or midline involvement without impaired balance. According to the frequency, we can see that there was a difference in the qualitative and quantitative characteristics of the groups we monitored in our research, and that there were more subjects with unilateral body involvement in the experimental group. Such categorization of subjects should realistically give a better outcome compared to the control group. Also, in both groups we had a higher participation of men (60.3% in the experimental group and 65% in the control group), which is often the finding in other studies when it comes to treadmill walking training[20].

Based on the software analysis, the results of spatial parameters of gait indicated that the position of the feet in the ground was similar in both groups, which means that the basic pattern did not change during the training, but also during the general kinesitherapy program itself. Although the experimental group had a gait on a slightly wider basis, during the therapy this difference was lost compared to the control group, and in the end, the heel spacing in both groups had no statistical differences. What was different was that after interval training, the length of the left and right strides

was extended, as opposed to the control group, where asymmetry in stride length occurred due to the extended left stride.

The support and swing phases did not show a significant difference between the groups, but the double support and cadence decreased in the control group. A similar observation was made in 2022 by Gaßner et al. when they concluded that treadmill walking did not show significant benefits compared to individualized physiotherapy. (Which, again, is the opposite of Radder et al. from 2020 who showed in their meta-analysis that such training on a treadmill improves walking results[21]. We are aware that this study has limitations primarily because it does not create neurocognitive and psychological profiles of individuals because spatiotemporal parameters are influenced by cognitive function, psychological factors, emotional well-being and pharmacological therapy plan [22-23], We need to include additional elements of measurement and categorization of the sample according to the level of cognitive and psychological disorders and impairments. Mehrholz and colleagues [11], observed in a recent meta-analysis of 18 trials that treadmill therapy is effective in improving gait speed and stride length in PD. Furthermore, this form of training may improve dynamic postural control and regularity of gait [24-25].

Conclusion

In the research we conducted, there are no significant differences are observed between the groups regarding the UPDRS test, the Tinetti test and the UP&GO test other than significant changes within the groups. On the other hand, the question remains whether the results of the research and similar meta-analyses with which we compared our research, did objective measurements and software analysis of gait, which is essentially missing in previous research, or the choice of the type of training on the treadmill is not the training of choice by which people with a milder form of Parkinson's disease would be treated. Statistically significant differences were not found in our study. That is why research with a larger number of subjects is needed, which, with an adequate design and method setting, could give clearer results.

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UTICAJ INTERVALNOG TRENINGA NA PARAMETRE HODA OSOBA SA PARKINSONOVOM BOLEŠĆU- EKSPERIMENTALNA KLINIČKA STUDIJA

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Sažetak. *Trening hoda je važan i efikasan segment kineziterapije i rehabilitacije za osobe sa Parkinsonovom bolešću. Specifičnost poput intervalnog treninga u literaturi je ukazala na poboljšavanje kardiorespiratorne kondicije ali ne i na kvalitet hoda i dinamičku stabilnost.Cilj rada je ispitati uticaj tredmil intervalnog treninga kod osoba s Parkinsonovom bolešću na parametre hoda. Prospektivna eksperimentalna, dvostruko slijepa studija sprovedena kod 46 pacijenata starosti 63.3±9.8 godina odabranih slučajnim uzorkovanjem raspoređenih u dve grupe na osnovu parnih i neparnih numera. Tokom 21 rehabilitacionog dana, svi ispitanici su imali 5 dana u sedmici istovjetan opšti program kineziterapije i okupacionu terapiju u trajanju od 80 min, a eksperimentalna grupa je imala i dodatni program na tredmil traci u vidu intervalnog treninga sa po 4 minute njihove prosječne brzine hoda i 3 minute pauze kroz 4 ponavljanja. Ishodi rehabilitacije praćeni su primjenom standardizovanih testova Tineti Balance Scale, Time Up and Go (TUG) test te objektivnom analizom softwerskog programa Zebris HP cosmos FDMT uređajem na početku i na kraju rehabilitacije. Mobilnost i balans pacijenata ocjenjen Tinetti testom je pokazao bolje rezultate u eksperimentalnoj grupi pre i posle tretmana, značajnost između grupa u pogledu promjene iznosila je p = 0,3. Statistička značajna razlika između grupa u pogledu UP&GO iznosila je p = 0,4. Pacijenti u obe grupe imaju sličnu fazu oslonca, fazu zamaha, dvostruki oslonac, dužinu koraka, vrijeme koraka i ritam, uključujući promjene nakon tretmana. Nije primjećena značajna razlika u poboljšanjima između grupa. U kontrolnoj grupi primijećeno je značajno smanjenje ukupnog dvostrukog oslonca i kadence. U eksperimentalnoj grupi primijećeno je značajno povećanje dužine koraka i povećanje brzine hoda. Objektivna mjerenja ishoda intervalnog treninga na tredmil traci nisu potvrdila veću značajnost i bolje rezultate prostorno-vremenskih parametara hoda u odnosu na standardni program rehabilitacije.*

Ključne riječi: *Intervalni tredmil trening, rehabilitacija, Parkinsonova bolest*