# Is Differential Training More Effective than Rhythmic Auditory Stimulation for Training Gait and Balance in Individuals with Parkinson's Disease?

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**Summary.** *The Aim.* To compare the effect of rhythmic auditory stimulation and differential training on gait and balance in individuals with Parkinson's disease.

*Methods.* 24 individuals (45–70 years of age) with Parkinson's disease (stages 1–3) and without freezing of gait (FOG) episodes were divided into two groups, each consisting of 12 patients. During physiotherapy, one group of patients had differential training practice, and the second group – rhythmic auditory stimulation practice. The efficiency of different methods was assessed by measuring step length and walking speed. Balance was evaluated using the Fullerton Balance Scale.

*Results.* Step length statistically significantly ($P<0.05$) increased in both groups: in Group 1 – from 64.08±4.29 to 66.72±3.19 cm and in Group 2 – from 59.22±4.23 to 61.87±3.71 cm. In Group 1, the walking speed before physiotherapy was 64±0.62, and after physiotherapy 67.5±0.71 steps per minute. In Group 2, the walking speed before the application of rhythmic auditory stimulation was 63.64±0.74, and after the procedure 69.18±0.72 steps per minute. After physiotherapy, balance also statistically significantly ($P<0.05$) improved in both groups: in Group 1 – from 20.25±1.5 to 33.58±0.91 points, and in Group 2 – from 19.27±1.2 to 27.73±0.98 points.

*Conclusion.* Rhythmic auditory stimulation was statistically significantly more effective when improving the patients' walking speed, and differential training – when improving the patients' balance.

**Keywords:** Parkinson's disease, physiotherapy, efficiency, differential training, rhythmic auditory stimulation (gait, balance).

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## INTRODUCTION

Parkinson's disease is one of the most common neurodegenerative disorders, being second only to Alzheimer's disease [1], and can cause both motor and non-motor dysfunctions [2]. Motor dysfunctions are caused by degeneration of the dopaminergic neurons in the compact part of the substantia nigra, which results in the reduction of dopamine levels in the corpus striatum [3]. These changes in the nervous system are thought to be caused by both genetic and environmental factors [4, 5].

Studies conducted in the age group of >55 years have shown that the prevalence of Parkinson's disease in Europe is as high as 410 cases per 100 000 population per year [3]. Parkinson's disease causes functional limitations that could be avoided by applying physiotherapy procedures. For this reason, there is an ongoing search for maximally effective physiotherapy techniques for the improvement of such patients' functional status and independence [6].

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Rhythmic auditory stimulation is one of the most researched physiotherapy techniques in treating patients with Parkinson's disease. Rhythmic auditory stimulation is applied taking into consideration the phenomenon known as paradoxical movement (Lat. *kinesiaparadoxica*). This means that the motor functions of patients with Parkinson's disease are undamaged, but their use is impaired in the absence of some external trigger, e.g. noise or a military march [2]. Changes in the basal ganglia disturb the internal perception of the duration and rhythm of movement, which may be compensated by external rhythmic auditory stimulation, where the acoustic rhythm stimulates the motor rhythm through the relatively close connections between the auditory and the motor zones [7]. In other words, the external rhythm may stabilize neuron networks that generate internal rhythms [8, 9]. The effect of this technique on the balance and gait of patients with Parkinson's disease has been analyzed in a number of articles, yet the results concerning individual indices of gait are inconclusive and call for more detailed research [10–12].

The differential training technique is less known and less frequently applied in clinical practice. This technique is more commonly used when training professional ath-

letes (e.g. in football, shot put, or speed skating). Attempts are made to integrate this technique into physiotherapy programs when treating patients after spontaneous injuries or a stroke [13]. We have found only one study that analyzed the effect of differential training on the gait of patients with Parkinson's disease. However, this study was flawed because it failed to analyze the effect of this technique on individual indices of gait or on balance; therefore we conducted a more exhaustive study on the effect of differential training and rhythmic auditory stimulation on different indices of the functional status of patients with Parkinson's disease.

## THE AIM OF THE STUDY

The aim of the study was to compare the effect of differential training and rhythmic auditory stimulation in physiotherapy on gait and balance of patients with Parkinson's disease.

## MATERIALS AND METHODS

We examined all hospitalized patients with Parkinson's disease and included 24 patients who met the following inclusion criteria: age 45 to 70 years; mild or undefined cognitive disturbance detected by applying the *Mini-Mental State Examination (MMSE)*; stage 1–3 Parkinson's disease diagnosed using the modified *Hoehn and Yahr Staging Scale*; and undocumented cases of freezing of gait. Parkinson's disease diagnosis was made and medical treatment (according each patient's condition) was set by neurologist. We evaluated functional state of patients (which is the most important thing for the physiotherapists and for the patients as well) therefore the duration of the disease was not so important for us.

The subjects were randomly distributed into two groups, each consisting of 12 subjects. To verify the homogeneity of both groups we used UPDRS's (Unified Parkinson's Disease Rating Scale) motor part and we did not get any significant difference between the groups (Group 1 – 9.08±1.16 points, Group 2 – 18.64±0.93 (P>0.05)). Group 1 subjects underwent differential training during physiotherapy, and Group 2 patients received rhythmic auditory stimulation. The subjects underwent 30 minute sessions of individual physiotherapy 5 times per week – on the average, 6 procedures. The aim of physiotherapy was to improve the patients' functional status. To achieve this, relaxation, static and dynamic respiration, muscle stretching and strengthening exercises, as well as exercises improving static and dynamic balance, gait, and other functional movements were applied. Relaxation, passive muscle stretching, and diaphragmatic breathing exercises were the same in both groups, while other exercises were selected according to the chosen technique. In Group 1, when applying the differential training technique, spontaneity and irregularity were important, whereas in Group 2, when applying the rhythmic auditory stimulation technique, the patients had to be instructed to try and perform exercises following the given rhythm. Both techniques have a variety of modes of application because in differential training the exercises are not repeated, while in rhythmic auditory stimulation the rhythm may be produced with a tuning fork, music, chanting, or clapping.

The effectiveness of the different techniques was evaluated by measuring the step length (cm) and walking speed (steps per minute), while postural control at rest and anticipatory and reactive postural control were evaluated using *Fullerton's Advanced Balance Scale (FAB)* consisting of 10 items evaluated from 0 to 4 points [14].

The results obtained during the study were processed using *SPSS 20.0 for Windows* and *Microsoft Excel 2007* computer software. We calculated arithmetic means, changes in mean values, and standard errors of the means. The significance of the differences in mean values between independent samples was evaluated by applying the non-parametric Mann-Whitney-Wilcoxon criterion, and between dependent samples – the Wilcoxon criterion. This criterion was selected because of the small number of subjects in both groups. The difference when P<0.05 was evaluated as statistically significant.

## RESULTS

### Comparison of step length between the groups

There was no difference in step length between the groups prior to physiotherapy. After physiotherapy, step length statistically significantly (P<0.05) increased in both groups (in Group 1 – from 64.08±4.29 cm to 66.72±3.19 cm, and in Group 2 – from 59.22±4.23 to 61.87±3.71 cm). Even though step length increased in both groups, the inter-group comparison revealed no statistically significant difference between the groups (Fig. 1).

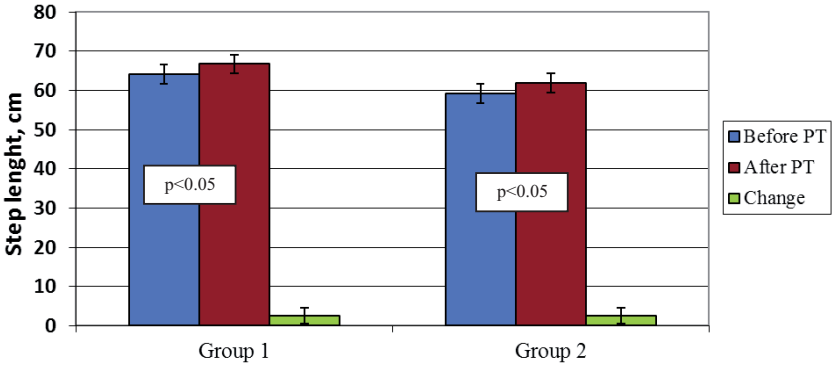


Fig. 1. **Step length in Groups 1 and 2 before and after physiotherapy (PT)**

### Comparison of walking speed between the groups

There was no difference in walking speed between the groups prior to physiotherapy. In Group 1, the walking speed before physiotherapy was 64±0.62 steps per minute, and after physiotherapy – 67.5±0.71 steps per minute. In Group 2, the walking speed before the application of rhythmic auditory stimulation was 63.64±0.74 steps per minute, and after the procedure – 69.18±0.72 steps per minute. A statistically significant (P<0.05) difference was found when comparing changes in walking speed between the two groups. After physiotherapy, walking speed in Group 2, which underwent rhythmic auditory stimulation, was greater than that in Group 1, which received differential training (P<0.05) (Fig. 2).

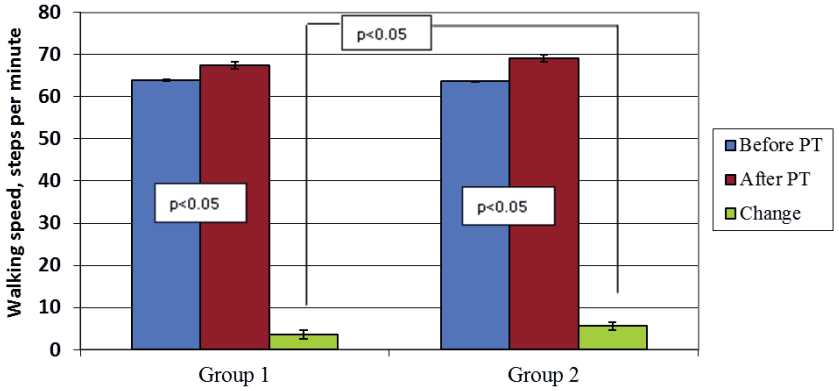


Fig. 2. **Walking speed in Groups 1 and 2 before and after physiotherapy (PT)**

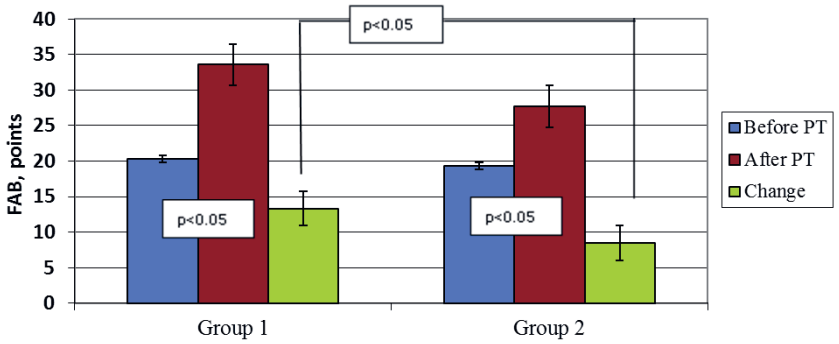


Fig. 3. **Balance in Groups 1 and 2 before and after physiotherapy (PT)**

### Comparison of balance between the groups

There was no difference in balance between the groups prior to physiotherapy. After physiotherapy, balance statistically significantly (P<0.05) improved in both groups (in Group 1 – from 20.25±1.51 points to 33.58±0.91 points, and in Group 2 – from 19.27 ± 1.2 points to 27.73±0.98 points). The comparison between the groups showed that after physiotherapy, balance in Group 1, which underwent differential training, was evaluated with statistically significantly higher scores than in Group 2, which underwent rhythmic auditory stimulation (P<0.05) (Fig. 3).

## DISCUSSION AND CONCLUSION

This study showed that the application of rhythmic auditory stimulation increased the walking speed in patients with Parkinson's disease. The results of this study are in line with those obtained by J. M. Haudorff et al. [8] and P. Arias and J. Cudeiro [6], where a statistically significant increase in walking speed was found when applying rhythmic auditory stimulation in patients with Parkinson's disease. Most frequently studies indicate the positive effect of rhythmic auditory stimulation on the coefficient of variation of step length [15, 16], while our study revealed a positive effect on the step length in patients with Parkinson's disease. An increase in step length when applying rhythmic auditory stimulation was also observed in a study conducted by J. M. Hausdorff. The same study also demonstrated an increase in step duration following the application of rhythmic auditory stimulation [8].

The results of our study are also in line with those of a study by M. P. Ford et al., where patients with Parkinson's disease received rhythmic auditory stimulation – yet with an increasing tempo. The mean tempo was 157 bpm (*beats per minute*). The study showed that the application of rhythmic auditory stimulation with an increasing tempo improved walking speed, step length, and the rhythm of the steps [17].

One of the selection criteria was the absence of freezing of gait (FOG) episodes. This criterion was selected because of different results obtained when applying rhythmic auditory stimulation in Parkinson's disease patients with and without FOG episodes. A. M. Willems et al. conducted a study where three groups of subjects (healthy individuals, patients with Parkinson's disease with FOG episodes, and patients without FOG episodes) underwent rhythmic auditory stimulation. Walking speed statistically significantly increased in all groups of subjects. The application of rhythmic auditory stimulation had no effect on step length in healthy individuals, while in both groups of patients, step length increased. The authors of the article emphasized that when the tempo of rhythmic auditory stimulation was increased by 10–20% from the initial walking tempo, step length in patients with Parkinson's disease and without FOG episodes increased; meanwhile, in patients with FOG episodes, step length increased only when the tempo of rhythmic auditory stimulation was accelerated by 10%, yet if the tempo was increased by over 10%, step length decreased [18]. For this reason, the authors recommend taking into consideration the presence or absence of

FOG episodes when selecting the tempo of rhythmic auditory stimulation in patients with Parkinson's disease. In our study, the tempo of rhythmic auditory stimulation was increased up to 30%, and we found that step length in patients with Parkinson's disease without FOG episodes increased as well.

Interactive rhythmic auditory stimulation is applied as a differential training technique in the rehabilitation of patients with Parkinson's disease. Because the application of this technique requires special equipment (WalkMate), so far we have found only one study analyzing the effect of interactive rhythmic auditory stimulation on gait in patients with Parkinson's disease. This study was conducted by M. J. Hove, K. Suzuki et al. The gait of healthy individuals and patients with Parkinson's disease was evaluated in three different conditions: when walking without rhythmic auditory stimulation, when walking with rhythmic auditory stimulation at a set rhythm, and when walking with interactive rhythmic auditory stimulation. The authors found that both healthy individuals and patients with Parkinson's disease found it difficult to synchronize their gait with rhythmic auditory stimulation of a set tempo, and thus the fractal scaling of gait deviated from the natural 1/f time distribution of healthy people. Meanwhile, when applying interactive rhythmic auditory stimulation, the fractal scaling of gait in patients with Parkinson's disease became the same as that in healthy individuals [7].

That study did not analyze the effect of differential training on gait indices in patients with Parkinson's disease, yet, according to our findings, the application of differential training increased the patients' step length and walking speed. The comparison of the effect of rhythmic auditory stimulation of a set tempo and differential training on the patients' gait indices showed that changes in step length did not differ between the groups, yet patients who underwent rhythmic auditory stimulation of a set tempo started walking faster than those who received differential training.

In our study, the evaluation of changes in balance among patients with Parkinson's disease following the application of different techniques showed that both rhythmic auditory stimulation and differential training statistically significantly improved the subjects' balance, yet the change was greater when applying differential training. Z. Kadivar, D. M. Corcos et al. in their study also applied rhythmic auditory stimulation in patients with Parkinson's disease and found that the subjects' balance improved, and the improved indices remained stable for at least 4 weeks [19]. This study is thus superior to ours because we did not evaluate the residual value of the achieved effect. We maintain that it would be beneficial to evaluate the duration of the effect of both differential training and rhythmic auditory stimulation, but this would be difficult to do because a part of patients with Parkinson's disease are discharged from hospitals home, and another part – to rehabilitation centres.

Harro CC et al. conducted a study where two different techniques – training on a treadmill (group one) and rhythmic auditory stimulation (group two) – were applied for the improvement of balance in patients with Parkinson's disease. The study showed that subjects in both groups showed improved gait indices and balance, yet no statistically significant difference between the groups was found [20]. The results of our study also showed a statistically significant improvement in both gait indices and balance, but walking speed was greater in Group 2, while Group 1 demonstrated better balance.

## Conflict of Interests

The authors declare that there is no conflict of interests.

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**AR DIFERENCINĖ TRENIRUOTĖ YRA EFEKTYVESNĖ, LAVINANT SERGANČIŲJŲ PARKINSONO LIGA ĖJIMĄ IR PUSIAUSVYRĄ, NEI RITMIŠKA STIMULIACIJA GARSU?**

**Santrauka**

*Tyrimo tikslas* – palyginti sergančiųjų Parkinsono liga ėjimą ir pusiausvyrą, taikant ritmišką stimuliaciją garsu ir diferencinę treniruotę kineziterapijos metu.

*Tyrimo metodika.* Tyrimas atliktas Lietuvos sveikatos mokslų universiteto ligoninės VšĮ Kauno klinikų Neurologijos skyriuje. Tiriamąjį kontingentą sudarė 24 asmenys (45–70 metų), sergantys Parkinsono liga (1–3 stadija), kuriems nėra dokumentuotų ėjimo sustingimo atvejų. Tiriamieji buvo atsitiktinai suskirstyti į dvi grupes po 12 tiriamųjų. Pirmosios grupės tiriamiesiems kineziterapijos metu buvo taikytas diferencinės treniruotės metodas, o antrosios – ritmiškos stimuliacijos garsu metodas. Tiriamiesiems 5 kartus per savaitę buvo taikoma 30 min. trukmės individuali kineziterapija – vidutiniškai 6 procedūros. Skirtingų metodų efektyvumas vertintas matuojant žingsnio ilgį ir ėjimo greitį, o pusiausvyra – Fullerton pusiausvyros testu.

*Išvados.* Tiek taikant ritmišką stimuliaciją garsu, tiek diferencinę treniruotę, statistiškai reikšmingai ($p < 0,05$) padidėjo sergančiųjų Parkinsono liga žingsnio ilgis, ėjimo greitis ir pagerėjo pusiausvyra. Ritmiškos stimuliacijos garsu metodas buvo statistiškai reikšmingai ($p < 0,05$) efektyvesnis, lavinant ėjimo greitį, o diferencinės treniruotės metodas – lavinant pusiausvyrą.

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