

RESEARCH ARTICLE

The Ronnie Gardiner Rhythm and Music Method – a feasibility study in Parkinson's disease

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Abstract

Purpose: To assess the feasibility of the novel intervention, Ronnie Gardiner Rhythm and Music (RGRM™) Method compared to a control group for patients with Parkinson's disease (PD). **Method:** Eighteen patients, mean age 68, participating in a disability study within a neurological rehabilitation centre, were randomly allocated to intervention group ($n = 12$) or control group ($n = 6$). Feasibility was assessed by comparing effects of the intervention on clinical outcome measures (primary outcome: mobility as assessed by two-dimensional motion analysis, secondary outcomes: mobility, cognition, quality of life, adherence, adverse events and eligibility). **Results:** Univariable analyses showed no significant differences between groups following intervention. However, analyses suggested that patients in the intervention group improved more on mobility ($p = 0.006$), cognition and quality of life than patients in the control group. There were no adverse events and a high level of adherence to therapy was observed. **Conclusions:** In this disability study, the use of the RGRM™ Method showed promising results in the intervention group and the adherence level was high. Our results suggest that most assessments chosen are eligible to use in a larger randomized controlled study for patients with PD.

Keywords

Music therapy, neurological disorders, Parkinson's disease, quality of life

History

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► Implications for Rehabilitation

- The RGRM™ Method appeared to be a useful and safe method that showed promising results in both motor and cognitive functions as well as quality of life in patients with moderate PD.
- The RGRM™ Method can be used by physiotherapists, occupational, speech and music therapists in neurological rehabilitation.
- Most measurements were feasible except for Timed-Up-and-Go.

Introduction

Music as therapy has been used for many years as an alternative method in patients with Parkinson's disease (PD) [1–3]. It has been proven useful in neurological rehabilitation [4–7]. Recent research has shown that listening to and performing music may affect many different brain structures involving cognition, sensorimotor areas and even emotional processes [8–10]. Music therapy can be active, where participants sing, make movements and play instruments, or passive, with participants listening to music [1,2]. The focus of active music therapy lies on functional skill redevelopment [5] and engages sensory processes, attention, memory-related processes, perception–action related mediation (mirror neuron system activity), multisensory integration and social cognition [9]. It has also been suggested that active music

therapy may stabilize the disturbed sense of rhythm in patients with PD [2,11].

PD is a progressive disease associated with neurodegeneration of the dopaminergic cells in the basal ganglia, characterized by progressive motor impairment, a variety of cognitive disorders, sleep disorders and depression [12,13]. The management includes drug therapy with levodopa [12] and, in some cases, neurosurgical treatment [14], but there is also increasing support for the use of rehabilitation therapies such as physiotherapy [15] and speech therapy [16]. Physiotherapy aims at increasing functional ability and minimizing secondary complications by movement rehabilitation including transfers, upper limb function, balance, gait and cognitive movement strategies, and thereby enhancing independent living and quality of life [15,17,18]. A common and effective strategy to improve gait performance and mobility is to apply external (auditory) cueing techniques [19]. Thaut and colleagues showed that rhythmic auditory stimulation during a gait-training programme for patients with PD significantly improved gait velocity, stride length and step cadence compared to a control group [20]. Rhythm is a powerful stimulus for activity and several studies have shown that therapies including rhythm are beneficial

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for patients with PD [6,21–24]. In addition, it has been suggested that music may affect the reward system of the brain [25].

The novel music-based movement therapy Ronnie Gardiner Rhythm and Music (RGRM™) Method was developed in 1993, and has been implemented in rehabilitation and health care centres in Sweden. The intervention focuses on exercises that challenge cognition and sensorimotor control to improve mobility and coordination in patients with neurological deficits through the use of rhythm and music. The recommended amount of training is twice weekly for at least 12 weeks. Many patients with PD avoid participation in rehabilitation therapies due to fear of falling, anxiety, lack of motivation or pain [26]. The RGRM™ Method is considered enjoyable, motivating and engaging and may help in increasing motivation for rehabilitation. It is a complement to other rehabilitation methods and may be used by physiotherapists as well as occupational or speech therapists. Physical abilities, like weight shifting, rising from a chair, postural stability with secondary tasks and sequences of action as well as kinaesthetic awareness are practised through rhythmic, reciprocal movements, all of which are suggested by King and colleagues [27]. The exercises are performed preferably standing up, but can be done sitting down on chairs without armrest if participants are unable to stand. It can be performed as class or individually. The method is mentioned in the Swedish National Guidelines for Stroke Care [28] and there are a few small theses that show positive effects on mobility, speech fluency and quality of life in patients with stroke. This is the first study to evaluate the method in patients with PD, although the method is frequently being used for individuals with PD.

The purpose of this study was to examine the feasibility of and effects from the RGRM™ Method on mobility, cognition and quality of life in patients with PD.

Methods

This study was a randomized, single-blinded disability study with pre- and post-test evaluation. The study protocol was approved by the local Ethical Review Board and all patients gave written informed consent to participate.

Patients

Patients were recruited from Parkinson's Society in the Swedish county of Ostergotland. A maximum of 30 persons was initially set with the intention to allocate them into equally large groups. Interested potential patients were screened to determine if they met the following inclusion criteria: (1) diagnosis of PD; (2) any duration of PD; (3) any PD therapy or treatment, but stable; (4) able to get down in a squatting position and to walk at least 10m without support; (5) correctable auditory and visual capability and (6) able to access transportation to and from research sessions. Exclusion criteria were (1) secondary or atypical PD; (2) colour blindness; (3) severe depression; (4) participating in any other on-going study or (5) having ≥ 3 points per question in part I (evaluation of mood and initiative), in question numbers 13–15 in part II (describing activities of daily

life, specifically related to falling, freezing and walking) and in question numbers 24–30 in part III (describing motor function, specifically related to hand movements, leg agility, sit-to-stand, posture and gait) of the Unified Parkinson Disease Rating Scale (UPDRS) [29]. UPDRS is evaluated by interview and clinical observation.

Procedure

A pre-test evaluation including neurological examination was done two weeks prior to the intervention and post-tests were done two weeks after the intervention. Because of fewer eligible patients than expected, and because of expected larger statistical variations in the intervention group, it was decided to randomize the patients into different-sized groups: intervention group ($n=12$) and control group ($n=6$). An independent source, concealed from the researchers, used a computer-based program for randomization process. All assessments were done by the main author and a PD nurse during the “on phase” of medication and neurological examination was performed by a neurologist. All assessors were blinded to group allocation; however, it was not possible to blind patients or the RGRM™ practitioner. No change in medication was allowed and no new activities were permitted during the study period. Patients in the control group were offered to participate in a separate session of training with the RGRM™ Method, once the study period was over.

Intervention programme

The intervention comprised 12 supervised one-hour sessions over a period of six weeks (twice weekly), and was provided as a class. The sessions of the intervention consists of three phases. In the first phase, the programme aims at relaxation and improving self-awareness as well as focus and concentration accompanied by soft classical music; e.g. Mozart, while doing breathing exercises and stretching movements. This phase also aims at establishing a relationship with the RGRM™ practitioner and lasts approximately 5 min. The second phase begins with simple rhythmical exercises like handclapping to music or metronome, in order to “feel the beat”. It then progresses with exercises consisting of handclaps and foot-stomping with left and right hand and/or foot to the sound of specially selected music. During this phase, patients follow the, for this method unique, “notes” in the shape of specific symbols accompanied by specific sound enunciations. The symbols are shaped like hands or feet, or a combination of hand and foot (18 in total) and are projected as large symbols against the wall (Figure 1). The colour red symbolizes the left side of the body and the colour blue symbolizes the right side of the body.

The sound enunciations associated with the symbols are based on the sounds from a drum kit. For example, if the “note” shaped as a blue hand is projected, this corresponds to tapping the right thigh and simultaneously pronouncing the word “TING” (sound of cymbal). Each beat of the music is accompanied by one of the “notes”. Specific choreoscores with notes projected on the wall are followed beat by beat and the participants must stay

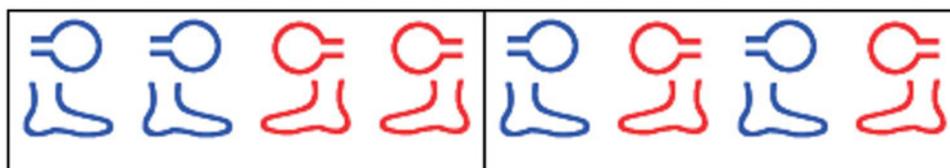


Figure 1. An example of the symbols (“notes”) of the RGRM Method. A blue hand and a blue foot (pointing in the right direction) are accompanied by the tapping on the right thigh and stomping the right foot on the floor and at the same time pronounce the word “TOOM”. The figure shows 2 out of 18 symbols. Reprinted with kind permission from Ronnie Gardiner.

focused all the time in order not to lose track of where on the choreoscore they are. The notes and choreoscores can be used in various ways, e.g. in black and white or with letters only (e.g. TING or TOOM without symbols) to increase the level of difficulty of the exercises. The progression of the exercises is determined by the RGRM™ practitioner, but not individualized. The choreoscores can be followed forwards, backwards or from the bottom to the top in order to increase progression. Countless variations are possible and the combination of the “notes” may frequently be changed to avoid habituation. This phase lasts for approximately 50 min, and the exercises are alternated with just listening to or singing to music. The third phase of the programme lasts about 5 min and aims at relaxing and finishing the session. The certified RGRM™ practitioner wears a special shirt where the back is coloured blue on the right side and red on the left side, aiming to reinforce the impression of left and right side of the body.

Outcome measures

The UPDRS [29,30] total, Hoehn and Yahr [31] stages and Schwab and England [32] scale were used as demographic variables. The primary outcome was mobility as measured by a computer-based, two-dimensional motion analysis system based on the Posturo-Locomotion-Manual (PLM) method, developed for patients with PD [33]. Seven spherical markers (4 cm diameter) covered with light-reflective tape are placed on standardized locations on the most affected side of the body, the side of the head, shoulder, arm, hip and on both legs. The patient is asked to move a small (500 g) object, also covered with reflective tape, repeatedly (3×10 sets) as quickly as possible from a marked starting place on the floor, to a stand located at chin level, 1.5 m in front of the starting place. Thus, the patient is forced to bend when picking up the handle and rise to regain postural stability (Figure 2). An opto-electronic measurement system was used to record movement performance (PDMonitor, QbTech AB, Gothenburg, Sweden). The markers' position in two-dimensional space was recorded every 20 ms by the opto-electronic system using infrared flashlight. The test measures postural stability (Posture), walking (Locomotion) and goal-directed arm movements (Manual), which are all movements important for independence in activities of daily life [33].

Secondary outcomes were two further measures for mobility (Timed-Up-and-Go (TUG) [34], and UPDRS motor score), quality of life using the Swedish version [35] of the Parkinson Disease Questionnaire-39 summary index [36] (PDQ-39) and six measures for cognitive ability. This was evaluated with the Cognitive Assessment Battery (CAB) [37]. CAB provides a cognitive investigation more thoroughly than traditional tests such as Mini Mental State Examination, but less time-consuming than neuropsychological examinations [37]. In total, CAB comprises five different domains: *learning and episodic memory, speed and attention, visuo-spatial functions, language and executive functions*. In order to assess feasibility and evaluate cognitive changes practiced by the RGRM™ Method, a selection of six tests within

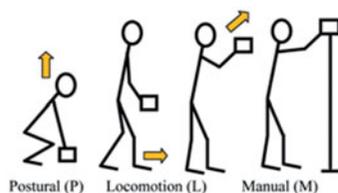


Figure 2. PLM methods' different parts; posture (rising from a squatting position), locomotion (walking forward), manual (targeted arm movement).

all domains were analysed in this study: the Text recall test, the Symbol Digit Modalities Test (SDMT), Clox and Cube, Naming 30 items, Stroop Color-Word Test and the Parallel Serial Mental Operations, PaSMO (see the appendix). In addition, the certified RGRM™ practitioner kept records of sessions, including detailed content of each session and progression within the programme, as well as adherence (participation in the RGRM™ therapy sessions) and participant reports of any adverse events or discomfort.

Power and sample size

The sample size required to show a significant difference between groups for the primary outcome, the PLM, was investigated. We expected an improvement of at least 5%. Given the fact that this is the first feasibility study, there were no previous measures to be used. Therefore, the results from this study were used to calculate the number of patients needed in a larger study with similar design, assuming 80% power and a two-tailed type 1 error of 0.05.

Statistical analysis

Data are presented as mean (SD) or median (IQR). The Mann-Whitney *U*-test was used to test differences between groups and χ^2 or Fisher's exact test was used for differences in proportions. Comparisons within groups were analysed using Wilcoxon signed rank test. No adjustments for multiple comparisons were made. A *p* value of 0.05 was considered to be statistically significant. All analysis was performed using SPSS 17.0 (SPSS Inc., Chicago, IL). For power analysis the “Russ Lenth's power and sample size page” was used [38].

Results

Eighteen patients, eight men and ten women, met the inclusion criteria and were recruited for the study. The mean age was 68.2 ± 5.1 years, mean disease duration 8.8 ± 3.8 years, mean stage on Hoehn and Yahr was 2.4 ± 0.7 , mean Schwab and England was $84.4 \pm 7.0\%$ and mean score on UPDRS total was 41.8 ± 11.4 points. Except for a small difference in SDMT, there were no significant differences between the two groups after randomization prior to intervention (Table 1).

Two patients were lost from the control group. One patient withdrew due to medical complications unrelated to PD, and one was excluded after altered medication during the intervention period. Adherence level was high: 93%. No adverse events or other complaints were reported. Figure 3 presents the flow of patients through the study.

Univariable analyses showed no significant differences between groups following intervention on any of the measurements. The results of the assessments prior to, and post-intervention, can be seen in Table 2.

Mobility

Significant improvements from pre-test to post-test were found in PLM movement time with a median -0.20 s, $p = 0.006$ (max -1.08 , min $+0.20$) and in UPDRS motor score ($p = 0.003$) in the intervention group, whereas no significant changes were seen in the control group (Table 2). No significant differences were found in the TUG test in either group.

Cognitive function

Significant improvements from pre-test to post-test were found in three cognitive tests in the intervention group; verbal memory (Text recall test, $p = 0.036$), language (Naming 30 items,

Table 1. Baseline characteristics of intervention group and control group, median and inter-quartile range (q1; q3) and *p* values for difference.

Outcome measure	Intervention group (n = 12)	Control group (n = 6)	<i>p</i> Value
<i>Motor function</i>			
Timed-Up-and-Go (s)	10.5 (8.3; 13.8)	10.0 (8.3; 11.8)	0.67
PLM movement time (s)	2.07 (1.78; 2.81)	2.20 (1.88; 2.95)	0.54
UPDRS motor score (0–56 p)	19.0 (15.3; 25.0)	17.5 (8.5; 26.5)	0.62
<i>Cognitive function</i>			
Text recall test (0–21 p)	4.0 (3.0; 6.8)	3.5 (0.8; 6.3)	0.54
SDMT (0–110)	36.0 (29.0; 41.5)	20.5 (15.0; 29.8)	0.03
Clox and Cube (0–12)	11.5 (9.3; 12.0)	10.5 (9.3; 11.8)	0.61
Naming 30 items (0–30)	28.0 (27.0; 28.8)	26.0 (21.5; 29.0)	0.22
Stroop Color-Word test (s)	28.0 (22.0; 41.5)	30.5 (24.5; 54.5)	0.59
PaSMO (s)	82.5 (65.5; 87.0)	122.5 (75.3; 277.8)	0.23
<i>Quality of life</i>			
PDQ-39 (0–100 p)	27.8 (16.7; 41.4)	29.8 (22.9; 38.7)	0.72

UPDRS: Unified Parkinson's Disease Rating scale; PLM: Posturo-Lo-motion-Manual; SDMT: Symbol Digit Modalities Test; PaSMO: Parallel Serial Mental Operations; PDQ-39: Parkinson's Disease Questionnaire-39 summary index.

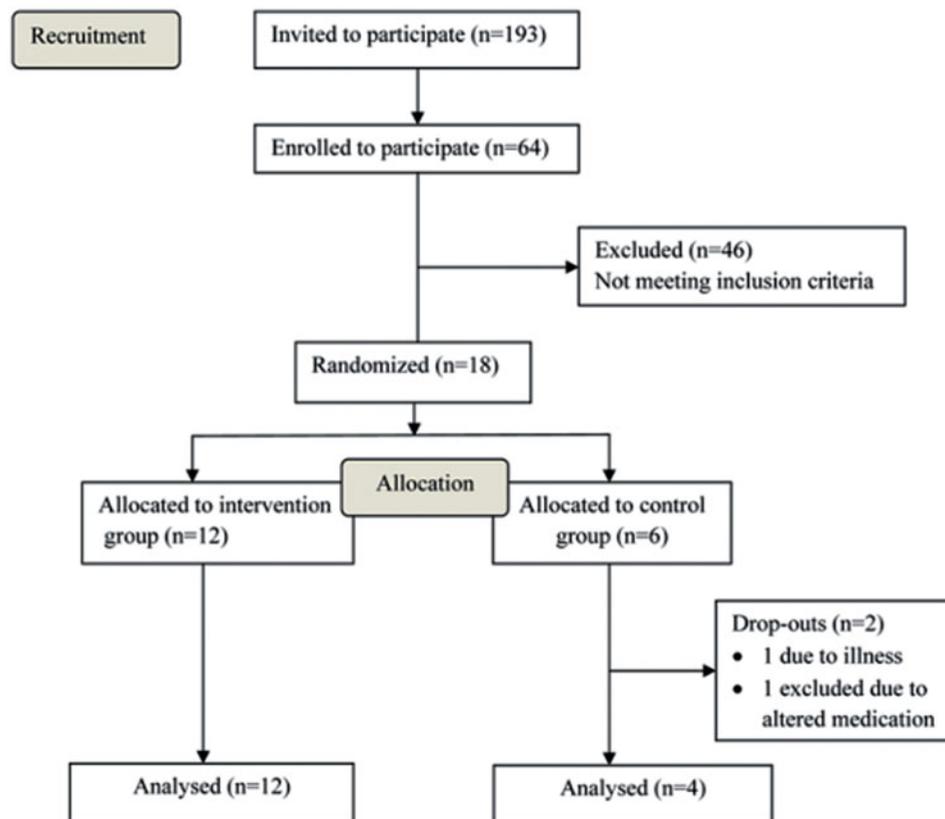


Figure 3. Recruitment of study patients.

$p=0.033$) and executive function and attention (Stroop Color-Word test, $p=0.007$), but no significant improvements in the control group (Table 2).

Quality of life

Significant improvements from pre-test to post-test were found in perceived quality of life in the intervention group ($p=0.031$), but not in the control group (Table 2).

Power calculation

A power calculation was performed based on results of the PLM method with the assumption of a true difference of means of 0.20 s. The level of power was set to at least 80% and level of

significance to 5%. The standard deviation was set to 0.31 based on results from the intervention group. With the assumption of equally large groups, and with an expected drop-out of 20%, a number of 90 patients should be required in a future study with the same design.

Discussion

To our knowledge this is the first study to evaluate the feasibility and effectiveness of RGRM™ Method in patients with PD. The RGRM™ Method proved to be a feasible intervention, in that adherence level was high (93%) of the intervention sessions. The results revealed no statistical evidence for effect of treatment in the intervention group compared to the control group concerning

Table 2. Changes from baseline to follow-up at week 6 on the outcome measures presented as median and inter-quartile (q1; q3) and *p* values for differences.

Outcome measure	Baseline	Baseline <i>p</i> Value	Difference baseline/6 weeks	Between groups comparison <i>p</i> Value	Within groups comparison <i>p</i> Value
<i>Motor function</i>					
PLM movement time (s)		0.54		0.11	
Intervention group	2.07 (1.78; 2.81)		-0.20 (-0.34; -0.03)		0.006
Control group	2.07 (1.78; 2.81)		+0.03 (-0.24; +0.16)		0.715
Timed-Up-and-Go test (s)		0.67		0.33	
Intervention group	10.5 (8.3; 13.8)		-0.5 (-2.0; +1.0)		0.163
Control group	10.0 (8.3; 11.8)		+1.0 (-2.3; +2.0)		1.000
UPDRS motor score (0–56 p)		0.62		0.47	
Intervention group	19.0 (15.3; 25.0)		-4.5 (-8.8; -3.3)		0.003
Control group	17.5 (8.5; 26.5)		-8.5 (-14.0; 0.0)		0.144
<i>Cognitive function</i>					
Text recall test (0–21 p)		0.54		0.63	
Intervention group	4.0 (3.0; 6.8)		+3.5 (-1.5; +4.8)		0.036
Control group	3.5 (0.8; 6.3)		+2.3 (+1.3; +2.9)		0.068
Symbol Digit Mod. Test (0–110)		0.03		0.18	
Intervention group	36.0 (29.0; 41.5)		+1.5 (-4.0; +2.8)		0.753
Control group	20.5 (15.0; 29.8)		+3.5 (+3.5; +12.3)		0.144
Clox and Cube (0–12)		0.61		0.21	
Intervention group	11.5 (9.3; 12.0)		±0.0 (-0.8; +1.8)		0.287
Control group	10.5 (9.3; 11.8)		-0.5 (-1.0; 0.0)		0.157
Naming 30 items (0–30)		0.22		1.00	
Intervention group	28.0 (27.0; 28.8)		+0.5 (0.0; +2.0)		0.033
Control group	26.0 (21.5; 29.0)		+1.0 (0.0; +2.0)		0.157
Stroop Color-Word test (s)		0.59		0.54	
Intervention group	28.0 (22.0; 41.5)		-2.0 (-8.0; -0.3)		0.007
Control group	30.5 (24.5; 54.5)		-0.5 (-16.5; +2.8)		0.581
PaSMO (s)		0.23		0.13	
Intervention group	82.5 (65.5; 87.0)		-6.5 (-17.0; +1.0)		0.054
Control group	122.5 (75.3; 277.8)		-22.0 (-24.0; -6.5)		0.066
<i>Quality of life</i>					
PDQ-39 (0–100)		0.72		0.47	
Intervention group	27.8 (16.7; 41.4)		-3.6 (-6.8; +0.6)		0.031
Control group	29.8 (22.9; 38.7)		-7.3 (-11.9; +12.8)		0.715

PLM: Posturo-Loocomotion-Manual-test; PaSMO: Parallel Serial Mental Operations.

The minus sign on the PLM, UPDRS, Timed-Up-and-Go, Stroop Color-Word, PaSMO and PDQ-39 equals improvement; the plus sign on the Text recall test, Symbol Digit Modalities Test, Clox and Cube and the Naming test equals improvement. $p < 0.05$ (in bold) indicates significant improvements.

primary or secondary outcome measures. All assessments chosen seemed eligible to use except for TUG, because all patients performed within normal variation. The TUG usually provides a reliable measure of functional balance, as it combines sequential motor actions which require components of functional capacity such as flexibility and agility [39]. These components are very important for the performance of everyday tasks such as standing up and sitting down, walking and turning. A better choice perhaps would have been a modified version, the TUGmanual, where the subject carries a glass of water while performing the test, especially because patients with PD often have difficulties in dividing attention, i.e. ‘dual task’ [40], which in a way the PLM test examines (patient picking up an object before walking). These two tests (PLM and TUGmanual) may be a better combination than TUG only.

The authors hypothesized that training with the RGRM™ Method may improve mobility and some intellectual functions which are typically impaired in PD, as well as improving quality of life. This disability study has demonstrated that a 6-week RGRM™ programme can produce improvements in mobility and cognitive function as well as quality of life. Our findings are in agreement with previous studies, where rhythmic elements have been used in patients with PD [2,20,22–24]. Although not all our findings reached statistical significance, the results may be clinically relevant.

It can be argued that a median improvement of 0.20 s in movement time of the PLM test is of small clinical relevance.

However, a major problem with PD is slow mobility. An improvement of 10% (in this case 0.20 s) median may be of considerable importance to these patients in that it may facilitate all activities of daily living such as walking and performing self-selected activities. One patient improved with 1.08 s; similar results have been found by others [41]. This result was also supported by the equally improved results of UPDRS motor function (part III). The correlation with UPDRS motor part has been found to be high ($r = 0.80$) [33]. There is no reason to believe that there was a learning effect involved, as the test only took five minutes to perform and there were almost two months between the testing dates.

Cognitive impairments may be more difficult to cope with than motor impairments in PD [42], and it is therefore considered important to improve impairments such as executive functions and memory. The intervention group improved significantly in three out of six tests. The RGRM™ Method aims at stimulating mental flexibility, increasing the ability to concentrate and achieving a general alertness. These components are quite similar to, for example, the Stroop Color-Word test. It must, however, be taken into consideration, that 12 out of 16 patients performed within normal variations on all tests in the CAB, including the Stroop Color-Word test. The improvement in the Text recall test may be a result of a general alertness due to the training itself. The test is however rather superficial and future studies would gain upon including more thorough memory tests.

The intervention group also reported a significantly improved quality of life after the 6-week period. It has previously been reported that PD patients sometimes avoid participation in rehabilitation programmes due to lack of motivation or anxiety [26]. Music is known to elicit emotional responses, as moving to music activates endorphin-related brain's pleasure circuits [25], and since the RGRM™ Method offers social interaction, as well as body awareness and joy of movement through the deliberate use of music, it is possible that this method may enhance the motivation to participate also in other rehabilitation programmes.

Study limitations

First, the small sample sizes may have given non-significant results, since there were only four patients in the control group and very small changes may substantially affect the results. Allocating patients into two equally large groups would probably have been a better option. Second, the intervention period was only 6 weeks, instead of recommended 12 weeks. Third, it can be argued that the intensity of the training was too low, as all patients were beginners. It has been described that persons with PD often present substantial problems when starting a training period due to poor coordination, balance and strength. Thus, exercise with PD patients usually must start at lower levels of intensity in order to build self-confidence and give adherence to the programme participation. In addition, all patients were members of the Parkinson Disease Society. Most of these persons were curious about this method and given the opportunity, they volunteered to participate, which makes it hard to generalize the results on all persons with PD. The fact that they had a reason to get up, get dressed, travel, spend time in the company with others (social interaction) and so on may also have affected the intervention group in a positive direction (Hawthorne effect [43]). Indeed, the physical activity, *per se*, may give pleasure, increased social interaction, experience of one's body and increased self-confidence. However, this alone does not explain why they improved on the mobility assessments as well as three of the cognitive tests and quality of life. Some additional limits may be mentioned: the subjects were classified as having mild-to-moderate PD according to the Hoehn and Yahr scale, making the results not applicable in patients more severely affected by PD. Furthermore, no follow-ups were performed to see if improvements were maintained.

Conclusion

Despite the small sample sizes and possible significant changes by chance, the present study suggests that the RGRM™ Method may be a useful and appropriate treatment alongside with traditional rehabilitation for patients with PD. The adherence was high and most assessments were applicable. Further, larger studies are needed and power analysis based on results of the present study, assuming a 20% drop-out, suggests 90 patients would be needed in future studies with similar design.

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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References

1. Pacchetti C, Aglieri R, Mancini F, et al. Active music therapy and Parkinson's disease: methods. *Funct Neurol* 1998;13:57–67.
2. Pacchetti C, Mancini F, Aglieri R, et al. Active music therapy in Parkinson's disease: an integrative method for motor and emotional rehabilitation. *Psychosom Med* 2000;62:386–93.
3. de Dreu MJ, van der Wilk AS, Poppe E, et al. Rehabilitation, exercise therapy and music in patients with Parkinson's disease: a meta-analysis of the effects of music-based movement therapy on walking ability, balance and quality of life. *Parkinsonism Relat Disord* 2012;18:S114–19.
4. Aldridge D, ed. Music therapy and neurological rehabilitation: performing health. London: Jessica Kingsley; 2005.
5. Baker F, Tamplin J. Therapy methods in neurorehabilitation – a clinicians manual. London: Jessica Kingsley; 2006.
6. Thaut MH, Gardiner JC, Holmberg D, et al. Neurologic music therapy improves executive function and emotional adjustment in traumatic brain injury rehabilitation. *Ann N Y Acad Sci* 2009;1169:406–16.
7. Bradt J, Magee WL, Dileo C, et al. Music therapy for acquired brain injury. *Cochrane Database Syst Rev* 2010;7:CD006787.
8. Zatorre RJ, Chen JL, Penhune VB. When the brain plays music: auditory-motor interactions in music perception and production. *Nat Rev Neurosci* 2007;8:547–58.
9. Koelsch S. A neuroscientific perspective on music therapy. *Ann N Y Acad Sci* 2009;1169:374–84.
10. Aldridge D, ed. Gesture and dialogue: music therapy as praxis aesthetic and embodied hermeneutic. London: Jessica Kingsley; 2005.
11. Yahalom G, Simon ES, Thorne R, et al. Hand rhythmic tapping and timing in Parkinson's disease. *Parkinsonism Relat Disord* 2004;10:143–8.
12. Yanagisawa N. Natural history of Parkinson's disease: from dopamine to multiple system involvement. *Parkinsonism Relat Disord* 2006;12:S40–6.
13. Park A, Stacy M. Non-motor symptoms in Parkinson's disease. *J Neurol* 2009;256:293–8.
14. Weaver FM, Stern MB, Follett K. Deep-brain stimulation in Parkinson's disease. *Lancet Neurol* 2006;5:900–1.
15. Tomlinson CL, Patel S, Meek C, et al. Physiotherapy intervention in Parkinson's disease: systematic review and meta-analysis. *BMJ* 2012;345:e5004.
16. Herd CP, Tomlinson CL, Deane KH, et al. Comparison of speech and language therapy techniques for speech problems in Parkinson's disease. *Cochrane Database Syst Rev* 2012;8:CD002814.
17. Keus SH, Bloem BR, Hendriks EJ, et al. Evidence-based analysis of physical therapy in Parkinson's disease with recommendations for practice and research. *Mov Disord* 2007;22:451–60; quiz 600.
18. Deane KH, Jones D, Playford ED, et al. Physiotherapy for patients with Parkinson's Disease: a comparison of techniques. *Cochrane Database Syst Rev* 2001;3:CD002817.
19. Lim I, van Wegen E, de Goede C, et al. Effects of external rhythmical cueing on gait in patients with Parkinson's disease: a systematic review. *Clin Rehabil* 2005;19:695–713.
20. Thaut MH, McIntosh GC, Rice RR, et al. Rhythmic auditory stimulation in gait training for Parkinson's disease patients. *Mov Disord* 1996;11:193–200.
21. Enzensberger W, Oberländer U, Stecker K. Metronome therapy in patients with Parkinson disease. *Nervenarzt* 1997;68:972–7.
22. Arias P, Cudeiro J. Effect of rhythmic auditory stimulation on gait in Parkinsonian patients with and without freezing of gait. *PLoS One* 2010;5:e9675.
23. Brown LA, de Bruin N, Doan JB, et al. Novel challenges to gait in Parkinson's disease: the effect of concurrent music in single- and dual-task contexts. *Arch Phys Med Rehabil* 2009;90:1578–83.

24. de Bruin N, Doan JB, Turnbull G, et al. Walking with music is a safe and viable tool for gait training in Parkinson's disease: the effect of a 13-week feasibility study on single and dual task walking. *Parkinsons Dis* 2010;2010:483530.
25. Blood AJ, Zatorre RJ. Intensely pleasurable responses to music correlate with activity in brain regions implicated in reward and emotion. *Proc Natl Acad Sci USA* 2001;98:11818–23.
26. Paul S, Ramsey D. Music therapy in physical medicine and rehabilitation. *Aust Occup Ther J* 2000;47:111–18.
27. King LA, Horak FB. Delaying mobility disability in people with Parkinson disease using a sensorimotor agility exercise program. *Phys Ther* 2009;89:384–93.
28. The National Board of Health and Welfare. National Guidelines for Stroke Care 2005. Stockholm, Sweden; 2005:132 pp.
29. Movement Disorder Society Task Force on Rating Scales for Parkinson's Disease. The Unified Parkinson's Disease Rating Scale (UPDRS): status and recommendations. *Mov Disord* 2003;18:738–50.
30. Siderowf A, McDermott M, Kieburtz K, et al. Test-retest reliability of the unified Parkinson's disease rating scale in patients with early Parkinson's disease: results from a multicenter clinical trial. *Mov Disord* 2002;17:758–63.
31. Hoehn MM, Yahr MD. Parkinsonism: onset, progression and mortality. *Neurology* 1967;17:427–42.
32. Schwab RS, England AC. Projection techniques for evaluating surgery in Parkinson s disease. In: Gillingham FJ, ed. *Third symposium on Parkinson s disease*. Edinburgh: Livingstone; 1969:152–7.
33. Johnels B, Ingvarsson PE, Steg G, Olsson T. The Posturo-Lo-motion-Manual test: a simple method for the characterization of neurological movement disturbances. *Adv Neurol* 2001;87:91–100.
34. Morris S, Morris ME, Ianseck R. Reliability of measurements obtained with the Timed "Up & Go" test in people with Parkinson disease. *Phys Ther* 2001;81:810–18.
35. Hagell P. Feasibility and linguistic validity of the Swedish version of the PDQ-39. *Expert Rev Pharmacoecon Outcomes Res* 2005;5:131–6.
36. Jenkinson C, Fitzpatrick R, Peto V, et al. The Parkinson's Disease Questionnaire (PDQ-39): development and validation of a Parkinson's disease summary index score. *Age Ageing* 1997;26:353–7.
37. Nordlund A, Pahlsson L, Holmberg C, et al. The Cognitive Assessment Battery (CAB): a rapid test of cognitive domains. *Int Psychogeriatr* 2011;7:1144–51.
38. Lenth RV. Java Applets for Power and Sample Size. Available from: <http://www.stat.uiowa.edu/~rlenth/Power> 2006–9; Computer software [last accessed 25 Aug 2010].
39. Gobbi LT, Oliveira-Ferreira MD, Caetano MJ, et al. Exercise programs improve mobility and balance in people with Parkinson's disease. *Parkinsonism Relat Disord* 2009;15:S49–52.
40. Rochester L, Hetherington V, Jones D, et al. Attending to the task: interference effects of functional tasks on walking in Parkinson's disease and the roles of cognition, depression, fatigue, and balance. *Arch Phys Med Rehabil* 2004;85:1578–85.
41. Sunvisson H, Ekman SL, Hagberg H, Lökk J. An education programme for individuals with Parkinson's disease. *Scand J Caring Sci* 2001;15:311–17.
42. Weaver F, Stern M, Follett K. Deep-brain stimulation in Parkinson's disease. *Lancet Neurol* 2006;5:900–1.
43. Benedetti F, Carlino E, Pollo A. How placebos change the patient's brain. *Neuropsychopharmacology* 2011;36:339–54.

Appendix

Table A1. Characteristics of the six tests chosen from the Cognitive Assessment Battery.

Cognitive domain and function	Neuropsychological tests	Possible difficulties	Aim of tests	Performing the tests
Learning and episodic memory	Text recall test	The episodic memory deteriorates. Does not remember recent events, such as hearing a text 10 min earlier	Investigate if the subject consciously can take in information and reproduce verbatim afterwards	A short text of two sentences is read to the subject. Ten minutes later the subject is asked to reproduce the text verbatim
Speed and attention	Symbol Digit Modalities Test (SDMT)	Mental and motor slowness; thinking and doing things take longer time than earlier, difficulties in changing attention between different tasks. It seems impossible to “hurry up”, even on command	To detect any difficulties in dividing attention	The subject has to fill in numbers for different characters under one code key, as many as possible in 90 s
Visuospatial functions	Clox and Cube	The “inner map” is impaired, uncertainty around geographic orientation. More difficult to read a map or read drawings as well as reading the clock	To detect any visuospatial impairments	The subject is asked to draw a clock with hands and afterwards to copy a picture of a cube
Language	Naming 30 items	Difficulties in finding the right words spontaneously. May have difficulties in following a normal conversation	To detect any difficulties in linguistic function (language)	The subject is asked to name 30 objects. Clues are given after 20 s
Executive function as well as directed attention, mental vitality and flexibility	Stroop Color-Word Test	Impaired judgement, difficulties in planning and organizing; makes life chaotic, lower capacity to make multiple tasks simultaneously, impaired impulse control	Testing the executive function and concentration	The subject is shown a sheet of words of colours written in a divergent colour, he then must say “blue” if the word “yellow” is written in a blue colour
Executive function	Parallel Serial Mental Operations (PaSMO)	Impaired judgement, difficulties in planning and organizing; makes life chaotic, lower capacity to make multiple tasks simultaneously, impaired impulse control	Testing the executive function and concentration	The subject is asked to list the alphabet with numbers in between; A-1, B-2, C-3, . . . , as quickly as possible