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Original Article

Physical Medicine and Rehabilitation Section

Effectiveness of MusicGlove on Motor and Psychological Symptoms in Parkinson's Disease: A Quasi-experimental Study

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ABSTRACT

Introduction: Individuals with Parkinson's Disease commonly experience both physical and psychological effects, which subsequently affect their ability to perform daily activities and overall wellbeing. MusicGlove is an emerging adjunct proposed to address the motor issues but also the psychological ones with references to improving motivation and participation in individuals with Parkinson's Disease.

Aim: To determine the effectiveness of the MusicGlove on hand dexterity and the psychological response in individuals with Parkinson's disease.

Materials and Methods: A quasi-experimental study was performed on 40 individuals with Parkinson disease January 2021 to June 2021 from local community settings in Chengalpattu district, Tamil Nadu, India. They were recruited and divided into a control group (n=20) and experimental group (n=20). Hand dexterity and psychological responses were assessed using the Box and Block Test (BBT), Beck's Depression Inventory (BDI), and Apathy Inventory (AI) as pre and post-test measures. Both groups received conventional occupational therapy for three weeks in total, and in addition to this, the experimental group received the MusicGlove. The control group included muscle stretching and strengthening activities with therapeutic putty and using activities such as connecting circles where the subject is given a sheet of paper with 25 circles, each containing 25 numbers or letters. They were asked to connect these in ascending, alternating numerical, and alphabetical order. Sessions were conducted for 30 minutes with two sets of repetitions. Descriptive statistics were used to examine data using the Statistical Package for Social Sciences (SPSS) version 24.0.

Results: The study results revealed that there was no statistically significant difference found between the groups but clinically significant differences were found between the groups with post-test scores on motor symptoms that were measured by BBT: $\mu=-1.2534$, $p=0.211$ (BBT Dominant); $\mu=-0.9400$, p-value=0.3472 (BBT Non Dominant), and psychological symptoms that were measured by BDI; ($\mu=-1.0445$, p-value=0.2983) and AI; ($\mu=-1.0445$, p-value=0.9203).

Conclusion: The study concluded that conventional occupational therapy along with MusicGlove was effective in improving hand dexterity and psychological responses in Parkinson's disease patients. Also, further study needs to be conducted to warrant its long-term impact of intervention on hand dexterity and psychological responses.

Keywords: Assistive technology, Dexterity, Occupational therapy

INTRODUCTION

Dexterity is the ability of the hand to perform various coordinated hand and finger movement patterns that become refined and well-executed as an individual develops. In Parkinson's disease, the exact cause of dexterity problems is currently unknown. However, due to the effects near the higher centers, namely the cortex-more accurately, the premotor and supplementary motor areas-resultant lesions affecting these portions cause reduced signal transfer to the subcortical structures, namely the commissures, the cerebellum, basal ganglia, etc., which thereby reduce the refinement of movement, causing not only hand dexterity unilaterally but bilaterally as well [1]. Parkinson's disease patients, in addition to the tremors, rigidity, and bradykinesia, experience difficulty in performing their daily tasks and occupations due to unilateral and bilateral involvement, rendering them dependent [2].

The psychological impact on Parkinson's disease patients is not uncommon, affecting everyday tasks, mood, and motivation of the person to engage in activities. It has been shown that various psychological responses that Parkinson's disease patients experience are related to a variety of causes, out of which the neurotransmitter concept stands out. Here, due to lesions within or directly to the cortical and subcortical areas, there is a reduction or inhibition of various neurotransmitters, specifically 5-Hydroxytrypamine, which distinguishes its role in depression and anxiety within Parkinson's disease patients [3]. Acting as a transporter protein molecule, its functions are inhibited due to various causes, such as alterations in genetic expression and others that include the lack of production of these proteins. However, the inadequacy of this molecule attributes to the varied states of anxiety and depression, leading to various limitations in occupations and activities of daily living with responses such as avolition, anhedonia, etc., [3].

Music acts as a specific stimulus to obtain motor and emotional responses by combining movement and stimulation of different sensory pathways. The efficacy of active Music Therapy (MT) on motor and emotional functions in patients with Parkinson's disease shows effective motor, affective, and behavioural functions, recommending active MT as a new method for inclusion in Parkinson's disease rehabilitation programs [4]. The MusicGlove caters to the needs pertaining to physical dysfunction but also the emotional and psychological responses. Ten participants diagnosed with stroke, exhibiting severe to moderate hand impairment, engaged in the study for four sessions over two weeks using the glove. The primary outcome measure was the BBT. The results showed that the MusicGlove was shown to be a motivating device for repetitive training of functional hand grips, with music significantly increasing performance and motivation among the participants [5]. Interventions involving music play a crucial role in the rehabilitation of Parkinson's disease, effectively addressing both motor and non motor symptoms and yielding promising results on motor symptoms and psychological responses. However, literature on non motor symptoms is scarce in number therefore results are less certain results [6].

Moreover, a study conducted on chronic stroke patients with moderate hemiparesis, randomly assigned to use the MusicGlove, isometric, or conventional hand therapy, showed significant changes in the group that received the MusicGlove showing that it not only addressed the motor issues but also psychological aspects, such as motivation and participation [7]. Interventions involving music offers a key ground rehabilitating Parkinson's disease, effectively impacting both motor and non motor symptoms, and producing promising results on motor symptoms and psychological responses [8].

The MusicGlove is just not a good device for hand-based rehabilitation in stroke population only, but that the versatility of this device needs to be tested on other populations with similar hand impairments. Currently, there is no evidence supporting hand-based technological interventions that incorporate both hand dexterity and psychological responses specifically in Parkinson's disease. Hence, the present study aims to establish the effectiveness of the MusicGlove on hand dexterity and psychological responses in Parkinson's disease.

MATERIALS AND METHODS

A quasi-experimental study design was opted for this study. Data collection was conducted from the Chengalpattu district from January to June 2021 over a six-month period. Ethical clearance was obtained from the Institutional Ethical Committee (IEC) of SRM Medical College Hospital and Research Center, SRMIST, Chengalpattu, with ethical clearance number 2078/IEC/2020. Dependent variables included hand dexterity and psychological responses, while the independent variable was the MusicGlove. A total of 40 participants were incorporated from local housing facilities with Parkinson's disease and institutional records through convenience sampling. Informed consent was obtained from participants.

Inclusion criteria: Parkinson's disease patients with Hoehn and Yahr scale stage 2-3 [9,10]; Unified Parkinson's disease rating scale [11-13] non motor (psychological response) 4/16 and motor (hand dexterity) 50/108, suggesting mild to moderate impairment; Age between 55-65 years; Mini-Mental State Examination score >24 [14,15]; Both male and female participants were included in the study.

Exclusion criteria: Individuals with severe cognitive impairments, visual impairment, hearing impairment, physical impairment, or disability were excluded from the study.

Procedure

Overall, data collection lasted for 12 weeks. Baseline measures included the Box and Block Test (BBT) [16-18], Becks Depression Inventory (BDI) [19], and Apathy Inventory (AI) [20], followed by post-test data collection after the intervention.

Screening Tools

1. **Hoehn and Yahr Scale:** Extensively used for clinical grading, this scale defines a wide range of motor function as well as non motor functions and the progression of Parkinson's disease stages over time. It is a freely available scale. The scoring and interpretation include stages from unilateral involvement to confinement to a wheelchair/bed [10].
2. **Unified Parkinson's Disease Rating Scale (UPDRS):** This scale is widely used, having four sections focusing on non motor aspects, motor aspects, motor examination, and motor complications in Parkinson's disease. Each symptom is rated on a 5-point Likert-type scale, with increased scores indicating more severe impairment. The maximum total score is 199. The scale has good utility and excellent clinimetric properties making it viable to use amidst a broad spectrum of Parkinson's disease. It has high concurrent validity and internal consistency [11-13].
3. **Mini-Mental State Examination (MMSE):** This tool assesses various cognitive status, encompassing skills such as comprehension, reading, writing, orientation, and drawing abilities. Scoring ranges from no impairment to severe cognitive impairment. The MMSE has high concurrent validity, test-retest reliability, and inter-rater reliability. It is a freely available scale [14,15].

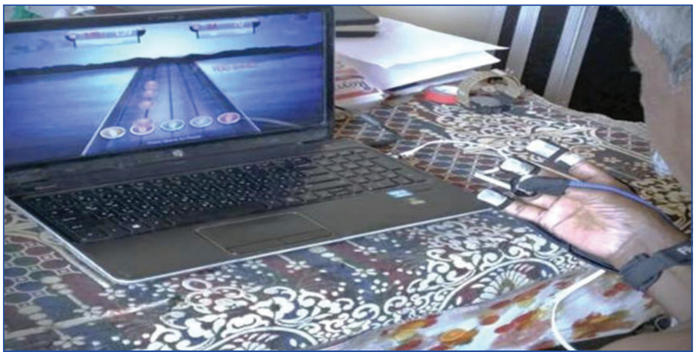
Outcome Measures

1. **BBT:** It measures unilateral gross manual dexterity and is administered by asking the client to move blocks, one by one, from one compartment of a box to another of equal size within 60 seconds. To establish and record baseline scores, initiate the test with the unaffected upper limb. Furthermore, a 15-second trial period is allowed at the start of each side. Clients are scored based on the number of blocks transferred from one compartment to the other in 60 seconds [17]. Higher scores indicate better manual dexterity. The test-retest reliability for BBT was reported as excellent (ICC=0.97 for the right hand and ICC=0.96 for the left hand) [18]. The inter-rater reliability of BBT, as shown by Pearson correlation coefficients, showed excellent agreement (r=1.00 for the right hand and r=0.99 for the left hand). The validity of BBT was established by comparing it to the Functional Autonomy Measurement System (FAMS) [17], showing excellent correlations (r=0.80) with the Action Research Arm Test (ARAT). Pearson correlations were also found between the BBT and the FAMS (r=0.47 for the right hand and r=0.51 for the left hand). It is a paid scale.
2. **BDI:** The BDI measures clinical observations of depression at cognitive, emotional, and emotional levels, consolidating 21 symptoms and attitudes rated from 0 to 3 in terms of intensity. Items were chosen to assess the intensity of depression. The 21 symptoms and attitudes include: Mood, Pessimism, Sense of Failure, Lack of Satisfaction, Guilt Feelings, Sense of Punishment, Self-dislike, Self-accusation, Suicidal Wishes, Crying, Irritability, Social Withdrawal, Indecisiveness, Distortion of Body Image, Work Inhibition, Sleep Disturbance, Fatigability, Loss of Appetite, Weight Loss, Somatic Preoccupation, and Loss of Libido. The BDI is often self-administered and generally takes 5-10 minutes to complete [15]. It is scored from 0 to 3 to reflect intensity and summed linearly to create a total score ranging from 0 to 63. Scores of 0-9 indicate negligible/minimal depression, 10-18 indicate mild to moderate depression, 19-29 indicate moderate to severe depression, and 30-63 indicate severe depression. The coefficient alpha was 0.87. Regarding test-retest reliability, the BDI's correlations are greater than 0.60. The concurrent validity of the BDI with respect to other measures of depression is high, as it is not only related to clinical assessments of depression (>0.60) but also demonstrates strong positive relations [19]. It is a freely available scale.
3. **Apathy Inventory (AI):** The scale consists of three dimensions, namely lack of interest, emotional blunting, and lack of interest, which are useful for screening the presence of apathy and determining its severity. The scale is administered while the participant engages in activities, enabling the administrator to score accordingly. Each question is scored from 0 (normal) to 4 (severe), with the total score (range 0-12) calculated by summing the scores of every item. Each item has several characteristic signs and symptoms that enable the administrator to score accordingly. Scoring from 0 to 4 is considered severe, 5-9 is moderate, and 9 to 12 is mild. The interrater reliability is 0.81, test-retest reliability is 0.90, and the high internal validity Cronbach's alpha is 0.76 [20]. It is a freely available scale.

Intervention Protocol

Control group: The control group consisted of 20 individuals. The protocol included muscle stretching and strengthening activities with therapeutic putty [21], and using activities such as connecting circles. In this activity, the subject is given a sheet of paper with 25 circles, each containing 25 numbers or letters. They are asked to connect these in ascending, alternating numerical, and alphabetical order. Sessions were conducted for 30 minutes with two sets of repetitions. These activities have been proven effective over the counterpart therapeutic intervention and are still used in practice to address issues with hand dexterity. In addition to this cognitive behaviour techniques were used to motivate and address the psychological response.

Experimental group: The experimental group also consisted of 20 individuals. The protocol included basic instruction and orientation of the MusicGlove, along with specific instructions on how to operate it, don and doff the glove, play the game, and hit or strike a note. This was done for 15 minutes. Following this, the actual therapy began, which included a trial or tutorial within the game attempted for one minute. Subsequently, the main program was initiated, containing songs for dexterity with a duration of 70 notes in one minute and 26 seconds, and speed, which included 90 notes to be hit under one minute and 50 seconds. and soon after, they were made to play a total of 12 songs interconnecting dexterity and speed, taking roughly 45 minutes [Table/Fig-1]. After completion, the final scores were obtained on the application, denoting various aspects of dexterity denoted by the number of notes hit or missed [5,7].



[Table/Fig-1]: Participant using MusicGlove intervention in experimental group.

STATISTICAL ANALYSIS

Descriptive statistics were used to examine data distribution and group them using SPSS version 24.0 Outcome measures data within and between groups were analysed using the Wilcoxon signed-rank test and the Mann-Whitney U test, respectively. The hypothesis was tested against the data to reveal any statistically significant difference, thereby showing the effect of treatment, denoted by an Alpha level of p-value=0.05.

RESULTS

[Table/Fig-2] showed that there was no statistically significant difference seen between the pretest and post-test scores of BBT Dominant, BBT non dominant, BDI, and AI (z-value=-1.826, p-value=0.068; z-value=-1.841, p-value=0.066; z-value=-1.841, p-value=0.066; z-value=-1.841, p-value=0.066), respectively in the control group. However, upon observing the pretest and post-test data, it shows that the data was data was clinically significant based mean difference between pre-test and post-test scores.

[Table/Fig-3] showed that there was no statistically significant difference seen between the pretest and post-test scores of BBT dominant, BBT non dominant, BDI, AI, MusicGlove speed, and dexterity (z-value=-1.857, p-value=0.063; z-value=-1.461, p-value=0.144; z-value=-1.841, p-value=0.066; z-value=-1.890, p-value=0.059; z-value=-1.841, p-value=0.066; z-value=-1.841, p-value=0.066), respectively in the experimental group.

[Table/Fig-4] showed that there was no statistically significant difference seen between the pretest scores of BBT dominant, BBT non-dominant, BDI, and AI (μ-value=-1.2534, p-value=0.211; μ-value=-0.9400, p-value=0.3472; μ-value=-1.0445, p-value=0.2983; μ-value=-1.0445, p-value=0.9203), respectively.

Outcome measure	Test	Mean±Std. Dev.	z-value	p-value
BBT dominant	Pre	28.75±1.70	-1.826	0.068
	Post	37.00±3.16		
BBT non dominant	Pre	26.50±1.91	-1.841	0.066
	Post	31.00±2.30		
BDI scores	Pre	22.75±4.99	-1.841	0.066
	Post	16.25±4.11		
AI scores	Pre	6.00±0.81	-1.841	0.066
	Post	8.25±1.25		

[Table/Fig-2]: Pre-test and post-test scores of BBT, BDI and AI in control group.
p≤0.005, Wilcoxon signed rank test was used to compare the pre-test and post-test scores of BBT, BDI and AI. The results showed that there was no statistically significant difference seen between the pre-test and post-test scores of BBT Dominant, BBT Non-dominant, BDI and AI

Outcome measure	Test	Mean±Std. Dev.	Z value	p-value
BBT dominant	Pre	33.25±3.09	-1.857	0.063
	Post	44.25±2.75		
BBT non dominant	Pre	28.50±1.91	-1.461	0.144
	Post	39.25±2.75		
BDI scores	Pre	27.50±3.10	-1.841	0.066
	Post	16.25±2.87		
AI scores	Pre	6.00±1.41	-1.890	0.059
	Post	11.75±1.25		
MusicGlove speed	Pre	37.75±3.77	-1.841	0.066
	Post	43.50±3.41		
MusicGlove dexterity	Pre	42.50±4.04	-1.841	0.066
	Post	47.75±3.30		

[Table/Fig-3]: Comparison of pre-test and post-test scores of BBT, BDI and AI in experimental group.
p≤0.005 Wilcoxon signed rank test was used to compare the pre-test and post-test scores of BBT, BDI and AI. The results showed that there was statistically significant difference seen between the pre-test and post-test scores of BBT Dominant, BBT non-dominant, BDI, AI, MusicGlove speed and dexterity

Outcome measure	Test	Mean±Std. Dev.	μ-value	p-value
BBT dominant	Control	28.75±1.70	-1.2534	0.211
	Experimental	33.25±3.09		
BBT non dominant	Control	26.50±1.91	-0.9400	0.3472
	Experimental	28.50±1.91		
BDI scores	Control	22.75±4.99	-1.0445	0.2983
	Experimental	27.50±3.10		
AI scores	Control	6.0000±0.81	-1.0445	0.9203
	Experimental	6.0000±1.41		

[Table/Fig-4]: Comparison of pre-test scores of BBT, BDI and AI between control and experimental group.
p≤0.005 Mann-Whitney U test was used to compare the pre-test and post-test scores of BBT, BDI and AI. The results showed that there was no statistically significant difference seen between the pre-test scores of BBT dominant, BBT non-dominant, BDI and AI

Mann-Whitney U test was used to compare the post-test scores of BBT, BDI and AI where the results showed that there was no statistically significant difference seen between the pre-test and post-test scores of BBT Dominant, BBT Non-dominant, BDI and AI (μ-value=-1.432, p-value=0. 0.321; μ-value=-0.856, p-value=0.246; μ-value=-1.135, p-value=0.371; μ-value=-0.254, p-value=0.325) respectively [Table/Fig-5].

Outcome measure	Test	Mean±SD	μ value	p-value
BBT dominant	Control	37.00±3.16	-1.432	0.321
	Experimental	44.25±2.75		
BBT non dominant	Control	31.00±2.30	-0.856	0.246
	Experimental	39.25±2.75		

BDI scores	Control	16.25±4.11	-1.135	0.371
	Experimental	16.25±2.87		
AI scores	Control	8.25±1.25	-0.254	0.325
	Experimental	11.75±1.25		

[Table/Fig-5]: Comparison of post-test scores of BBT, BDI and AI between control and experimental group.
$p \leq 0.005$

DISCUSSION

The study has provided insights towards the use of the MusicGlove in Parkinson rehabilitation; however, the results of the present study have not claimed to be statistically significant. The non significant results of the study may have been linked to a variety of causes, which might have included increased session duration, frequency, fatigue, lack of motivation, and adherence to the intervention. The control group had performed the conventional intervention protocol for hand function developed [21], which included muscle strengthening activities using therapeutic putty (soft and medium resistance) to improve hand and finger function. Starting from a global to a specific pattern, which needed clients to roll the putty, shape and mold it to an object using unilateral and bilateral movements along with digital and palmar assistance. In addition to this, subjects were asked to connect circles and dots, which formed numbers or letters in an alternating manner. These activities worked on the principle of repetition and intensity, which in turn evoked a learning experience, thus providing the basis for improvement in the functional use of the hand within these subjects [22].

The effect on manual dexterity within Parkinson's disease patients is mainly attributed to the three cardinal symptoms (bradykinesia, rigidity, and tremors), which indirectly affect movement patterns, speed, and intensity overall. With repeated practice and feedback of these movements, it was concluded to be an effective means to enable some degree of functional independence within these patients. Generally, dexterity is segregated into fast-acting or early selection where the appropriate type of grip needed is selected, followed by the resultant force generated to execute and maintain the grip in regards to its orientation, modulation, and intended use, which corresponds to the movements within the spectrum of hand functions and, hence, translates into everyday functional tasks.

The experimental group underwent both traditional occupational therapy intervention and MusicGlove, which enabled better adherence to the intervention and better motivation to engage. The MusicGlove was designed to improve dexterity within the stroke population, but the present study strived to determine its effectiveness in Parkinson's disease patients. The MusicGlove is primarily built upon the foundation of sensorimotor learning, based on repetition and feedback. Sensorimotor learning occurs due to various interactions between neurons, cortical, and subcortical systems, which integrate multisystem information to bring about a response that is not reflexive. In Parkinson's disease patients, the cortical areas pertaining to the premotor, prefrontal, and temporal cortex are closely related to the resultant bradykinesia, tremors, and rigidity [23]. Since the primary area of lesion in Parkinson's disease patients is within the basal ganglia, the various nigrostriatal pathways interconnecting the cortical and subcortical areas are compromised as the disease progresses. Hence, a combination of various information across the cortex is not appropriately perceived and interpreted, causing disturbances in performance. When using the MusicGlove, the visual and auditory sensations are relayed to the higher centers, which then process the information and relay the signals back to the end organ, passing through the descending pathways. Following this, the resultant output is depicted by the hand gestures performed by the participant. When this process is repeated, it invokes various neural circuits that get activated, causing sensorimotor learning to occur [24].

The effect of music as a major contributor in the management of psychological responses in various conditions has long been documented by several authors who suggest that music is a key factor in managing various psychological responses like depression, anxiety, apathy, insomnia, etc., [25].

Using the MusicGlove, psychological responses are catered to in the songs being heard and played. Participants hear the song and perform the corresponding actions, to which the songs continue to play. If not, then the music skips to the next note to be played. Music plays a vital role in the activation of several synaptic neural circuits within the auditory and premotor areas, which causes subsequent activation of the regions that have been rendered inactive. Coupled with motor performance, this translates into smoother and more fluid movement [26]. MusicGlove integrates these foundational literatures, where when patients engage in the MusicGlove while listening to the music, the areas of the brain responsible for processing sound and frequency get activated. This, in turn, activates several synaptic neural circuits which, along with sound, process the outgoing motor impulses from the cortical centers to the subcortical structures, enabling movements within Parkinson's disease patients to become smooth, coordinated, and intentional. In addition to this, sensorimotor learning is implemented as a result of repetitive performance.

The experimental group shows statistically significant improvement in hand dexterity and psychological response. Moreover, participants in the experimental group adhered to the intervention and were motivated to engage in the intervention due to the attractive overlay of the device (visual and auditory feedback) compared to the control group; in addition to this, participants under experimental group experienced fatigue due to the intense repetition of movements. This is in agreement with a previous study [11] which suggested that repetitive finger movement causes movement arrest and early fatigue within Parkinson's disease patients.

There were a few observations made about the usability of the MusicGlove in our participants. Frequent fatigue symptoms were reported by clients. This draws our attention to the need for further studies to evaluate the usability of this device.

Clinical Implications

Hand dexterity and psychological response in Parkinson's disease are an emergent field where surplus data is not readily available. Hence, the current study aimed to find the effectiveness of the MusicGlove for dexterity and psychological response. The findings suggest that the MusicGlove is effective in improving hand dexterity and psychological response in Parkinson's disease patients. Moreover, it can be easily used to keep the participant engaged in the intervention with appropriate breaks to address the issue of early fatigue. The MusicGlove may be used to improve hand dexterity and psychological response in Parkinson's patients.

Limitation(s)

Firstly, a smaller sample size and secondly, convenience sampling were used. Further controlled studies are needed to generalise the effectiveness of MusicGlove in Parkinson's disease.

CONCLUSION(S)

The present study concluded that MusicGlove intervention shows improvement in hand dexterity and psychological response in Parkinson's disease patients. Future studies need to be conducted on a larger population, and the study can be conducted to improve the generalisation; also, the effects of fatigue while using the MusicGlove need to be addressed. Integration of both dominant and non dominant hands in MusicGlove intervention should be explored to determine any implications on functionality after using MusicGlove in activities of daily living. Lastly, the long-term depth of MusicGlove on manual dexterity and psychological response in Parkinson's disease patients needs to be investigated.

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