



Effectiveness of Smart Music Boxing Machine in Improving Upper Extremity Coordination in Patients with Chronic Stroke

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Abstract

This study examined the effectiveness of the Smart Music Boxing Machine in improving upper extremity coordination among patients with chronic stroke. Utilizing a quasi-experimental one-group pre-test and post-test design, the research quantitatively assessed changes in motor performance using the Fugl-Meyer Assessment for Upper Extremity (FMA-UE). The intervention integrated rhythmic auditory stimulation and repetitive boxing movements to enhance motor coordination and engagement. Participants underwent six sessions of structured training, with performance measured before and after the intervention. Findings revealed observable improvements in upper extremity motor function, particularly in arm control, wrist stability, and hand coordination. However, statistical analysis showed no significant difference between pre-test and post-test scores at the 0.05 level of significance. Despite the lack of statistical significance, the intervention demonstrated potential as an innovative and engaging rehabilitation tool. The results highlight the need for longer intervention duration and larger sample sizes to establish significant outcomes and support its integration into stroke rehabilitation programs.

Keywords: Chronic Stroke; Upper Extremity Coordination; Smart Music Boxing Machine; Fugl-Meyer Assessment; Rhythmic Auditory Stimulation

Introduction

Stroke remains one of the leading causes of death and disability worldwide, ranking second globally and among the top causes of disability in the Philippines. Despite advancements in acute stroke care, a significant proportion of survivors experience long-term impairments, particularly in upper extremity function. Approximately 50% of individuals with chronic stroke continue to suffer from limitations in arm and hand use, which greatly affects their independence in activities of daily living. Upper extremity dysfunction after stroke is often characterized by muscle weakness, spasticity, altered tone, and impaired coordination. These deficits result in difficulty performing functional tasks such as reaching, grasping, and object manipulation. Thus, improving upper limb coordination remains a critical goal in stroke rehabilitation. Recent rehabilitation approaches have explored innovative and engaging interventions such as boxing therapy and music-supported therapy (MST). Boxing therapy has demonstrated improvements in motor function, balance, and cognition, while rhythmic auditory stimulation (RAS) enhances motor timing and coordination by using external rhythmic cues. However, most RAS-based interventions focus on gait and balance rather than upper extremity coordination. The integration of music and boxing through a Smart Music Boxing Machine offers a novel rehabilitation approach that combines rhythmic cues, repetitive movement, and interactive engagement.

Despite the individual effectiveness of music therapy and boxing, limited studies have examined their combined application, particularly in chronic stroke patients. This study aims to determine the effectiveness of the Smart Music Boxing Machine in improving upper extremity coordination among patients with chronic stroke using the Fugl-Meyer Assessment Upper Extremity (FMA-UE).

Methods

This study utilized a quasi-experimental one-group pre-test and post-test design to evaluate the effectiveness of the intervention. Participants were selected through purposive sampling from Biñan City Health Office 1. Inclusion criteria included being diagnosed with chronic stroke (≥ 6 months), aged 40–70 years old, and currently undergoing physical therapy. Exclusion criteria included

presence of cardiopulmonary or severe neurological conditions, bilateral or recurrent stroke within the past 6 months, and orthopedic conditions affecting the upper extremities that may contraindicate repetitive punching movements. The primary outcome measure used in this study was the Fugl-Meyer Assessment for Upper Extremity (FMA-UE), a standardized and validated tool for assessing motor recovery post-stroke. It evaluates motor function, coordination, sensation, joint motion, and pain, with a total score ranging from 0 to 66, where lower scores indicate greater impairment. The study was conducted in three phases. In the pre-implementation phase, participants underwent baseline assessment using the FMA-UE. In the implementation phase, participants performed the Smart Music Boxing Machine intervention for 6 sessions. Each session required punching illuminated targets 100 times, starting at the lowest speed, with incremental increases per session, and synchronization of movements with rhythmic auditory cues (music). In the post-implementation phase, participants were reassessed using the FMA-UE. Descriptive statistics (mean and standard deviation) were used to summarize pre- and post-test scores. Inferential analysis using z-test was applied to determine if there were significant differences between pre-test and post-test scores, with a significance level set at $p < 0.05$.

Results and Discussion

This section presents the analysis and interpretation of the data gathered from the previous chapters and the participants based on the objectives of the study (Table 1).

The pre-test results indicated that participants had low to moderate levels of upper extremity motor function, particularly in coordination, wrist control, and hand movements. The mean score for upper extremity was 14.33 (SD = 6.43) out of a maximum of 36, indicating limited voluntary movement and control of the affected arm. Wrist function had a mean of 3.33 (SD = 2.89) out of 10, while hand function recorded 4.67 (SD = 4.04) out of 14, suggesting difficulty in performing fine motor tasks such as gripping and object manipulation. Coordination and speed showed the lowest performance, with a mean of 1.00 (SD = 1.73) out of 6, reflecting challenges in executing smooth and timed movements. Overall, the total motor function score was 23.33 (SD = 14.36) out of 66, indicating that participants were functioning below optimal levels

Profile Variable	z	p	Decision (Null Hypothesis)	Significance
Motor Function				
A. Upper Extremity	-1	0.317	Failed to Reject	Not Significant
B. Wrist	-1	0.317	Failed to Reject	Not Significant
C. Hand	-1	0.317	Failed to Reject	Not Significant
D. Coordination/Speed	-1	0.317	Failed to Reject	Not Significant
Total Motor Function	-1	0.317	Failed to Reject	Not Significant
H. Sensation	0	1.000	Failed to Reject	Not Significant
I. Passive Joint Motion	0	1.000	Failed to Reject	Not Significant
J. Joint Pain	0	1.000	Failed to Reject	Not Significant

Note. z = Wilcoxon signed-rank test statistic and p = significance value. Statistical significance is set at $p < 0.05$.

Table 3: Comparison Between Pre-Test and Post-Test FMA-UE Scores of Chronic Stroke Patients After Smart Music Boxing Machine Training.

prior to the training.

These findings reflect the typical impairments observed in individuals with chronic stroke (Table 2).

After the implementation of the Smart Music Boxing Machine intervention, improvements were observed in all motor components, including upper extremity movement, wrist function, hand control, and coordination. The upper extremity mean increased to 17.67 (SD = 1.15), showing better control and movement of the arm. Wrist function increased to a mean of 5.00 (SD = 0.00), and hand function increased to 7.00 (SD = 0.00), indicating enhanced ability in performing more precise and controlled movements. Coordination and speed also showed a slight increase, with a mean of 1.33 (SD = 1.53). The total motor function score rose to 31.00 (SD = 2.65), reflecting an overall increase in upper extremity performance following the intervention. Meanwhile, sensation, passive joint motion, and joint pain remained unchanged, with consistent mean scores of 12.00 and zero variabilities. These improvements suggest that the intervention was effective in enhancing motor performance through repetitive, rhythm-based movements.

Across all motor function components, upper extremity, wrist,

Respondents	Upper Extremity	Wrist	Hand	Coordination / Speed	Total	Sensation	Passive Joint Motion	Joint Pain
	Max Score = 36	Max Score = 10	Max Score = 14	Max Score = 6	Max Score = 66	Max Score = 12	Max Score = 24	Max Score = 24
1	7	0	0	0	7	12	12	12
2	17	5	7	0	29	12	12	12
3	19	5	7	3	34	12	12	12
Grand Mean	14.33	3.33	4.67	1.00	23.33	12.00	12.00	12.00
Standard Deviation	6.43	2.89	4.04	1.73	14.36	0.00	0.00	0.00

Table 1: Participant's Pre-Test Scores of Fugl-Meyer Assessment Upper Extremity (FMA-UE) Before Smart Music Boxing Machine Training.

Respondents	Upper Extremity	Wrist	Hand	Coordination / Speed	Total	Sensation	Passive Joint Motion	Joint Pain
	Max Score = 36	Max Score = 10	Max Score = 14	Max Score = 6	Max Score = 66	Max Score = 12	Max Score = 24	Max Score = 24
1	17	5	7	1	30	12	12	12
2	17	5	7	0	29	12	12	12
3	19	5	7	3	34	12	12	12
Grand Mean	17.67	5.00	7.00	1.33	31.00	12.00	12.00	12.00
Standard Deviation	1.15	0.00	0.00	1.53	2.65	0.00	0.00	0.00

Table 2: Participant's Post-Test Scores of Fugl-Meyer Assessment Upper Extremity (FMA-UE) After Smart Music Boxing Machine Training.

hand, coordination/speed, and total motor function, the computed z-values were all -1 with corresponding p-values of 0.317. Since these p-values are greater than the 0.05 level of significance, the null hypothesis was not rejected for each of these variables. This indicates that the observed increases in mean scores from the pre-test to the post-test were not statistically significant. Similarly, for sensation, passive joint motion, and joint pain, the computed z-values were 0 with p-values of 1.000, leading to the same decision to fail to reject the null hypothesis. These results suggest that there were no measurable changes in these areas following the intervention, which is consistent with the descriptive results showing identical pre-test and post-test scores.

Conclusions and Recommendations

The study concluded that the Smart Music Boxing Machine showed potential in improving upper extremity coordination among patients with chronic stroke. Although improvements were observed in motor performance, these changes were not statistically significant. It is recommended that future studies increase the sample size and extend the duration of the intervention to better evaluate its effectiveness. Additionally, incorporating the Smart Music Boxing Machine into regular rehabilitation programs may enhance patient engagement and motivation. Healthcare providers are also encouraged to explore innovative and technology-based interventions that combine physical activity with sensory stimulation to improve rehabilitation outcomes. Further research may also investigate its effects on other aspects such as balance, cognition, and functional independence.

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