# Nintendo Wii: An Alternative Method in Improving Shoulder and Elbow Range of Motion, Motor Performance and Strength in Post-Stroke Patients

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**Abstract:** Stroke is a sudden loss of neurologic functions attributed to an interruption of blood flow to the brain and is considered the leading cause of disability. It greatly affects the shoulder and elbow regions which contribute to most of upper extremity's function. Since there is no cure, the only means of promoting functional recovery is through rehabilitation including physical therapy. However, there is no standard protocol for post-stroke treatment. Virtual gaming using Nintendo Wii is also being integrated in rehabilitation because of its capability to sustain interest and motivation to the patient. This study assessed the effectiveness of Nintendo Wii in improving shoulder and elbow range of motion, motor performance and strength and compared it with conventional therapy among post-stroke patients using experimental design. Twelve participants were purposely recruited and were divided into 2 groups- control group treated with conventional therapy and treatment group treated with Nintendo Wii therapy. Each group were treated 3 times a week for 4 weeks. Descriptive statistics such as mean and Standard Error of Measurement (SEM) were used to show significant differences between the groups. Among the results, shoulder external rotation (p-value = 0.030) using Nintendo Wii therapy shows significant difference in the improvement of strength whereas, no significant difference was found in terms of range of motion and motor performance. Through this study, it is found out that the Nintendo Wii therapy is comparable to conventional therapy and is a good alternative in the improvement of shoulder and elbow range of motion, motor performance and strength.

**Key words:** *stroke, shoulder and elbow regions, conventional therapy, virtual gaming, Nintendo Wii therapy*


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**INTRODUCTION**

Stroke is a sudden loss of neurologic functions attributed to an interruption of blood flow to the brain and is considered the leading cause of disability. Roughly 55% and 75% of its survivors continue to experience motor deficits associated with diminished quality of life (Saposnik, Teasell, Mamdani, Hall, Mcllroy, Cheun et al., 2011). It is also known to be the fifth largest cause of acquired disability worldwide (Mouawad, Doust, Max & McNulty, 2011). It is the third most common cause of death in developed countries with China having one of the highest rates of mortality with 19.9% of deaths in the entire population, along with Africa and parts of South America. In the United States, the prevalence of stroke is about 7 million accounting to 3% of its general population (Roger, Go, Lloyd-James, Adams, Berry et al., 2011). In the Philippines, stroke is known to be the second leading cause of death which accounts to 0.9% of its population; 70% of which suffer from ischemic stroke and 30% of the patients suffer from hemorrhagic type of stroke (Navarro, Baroque, Lokin & Narayanaswamy, 2014). Both of the categories aforementioned could lead to a serious cause of disability of the upper extremity including the shoulder and elbow regions. According to the study of Harris and Eng (2007), approximately 70% - 80% of its survivors suffer from upper extremity impairment which include paresis, impaired dexterity and incoordination. Since stroke is not curable, one means of improving the integrity of the affected extremity is through rehabilitation which includes physical therapy. The conventional therapy involves different therapeutic approaches which are intended to improve functional impairments of a patient. The Philippine Association of Rehabilitation Medicine (PARM) Clinical Practice Guidelines enumerated different treatment approaches for stroke rehabilitation which include the following: constraint induced movement therapy, mental practice or mental imagery, electromyographical, robotic devices or robot- assisted therapy or mechanical-assisted training, repetitive task training, routine electromyographic biofeedback, bilateral practice, neurodevelopmental techniques, mirror therapy, virtual therapy and the upper extremity strengthening and stretching exercises which are widely-used in stroke rehabilitation nowadays. In the previous study by Huang, Lee and Chen (2013), conventional therapy of the upper extremity, which includes the shoulder and elbow, is mostly static and provides delayed feedback to the patients. The patients easily feel uninterested and bored during the treatment process due to repeated similar activities over time which eventually gives them negative attitude towards the course of the treatment. This has led to growing use of virtual reality therapy. Some limitations which could be reasons of patient attrition upon conducting


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conventional therapy are as follows: time-consuming, labor- and resource- intensive, dependent on patient compliance, limited availability depending on geography, modest and delayed effects in some patients, initially underappreciated benefits by stroke survivors and requires costs or insurance coverage after the initial phase of treatment (Wolf, Winstein, Miller, Taub, Uswatte et al., 2006). The return of upper extremity function particularly the shoulder and elbow regions has been identified as an important part of the rehabilitation goal (Harris & Eng, 2007). According to a study by Saposnik et al., (2010), the improvement and recovery after stroke of the impaired extremity strength and motor performance is achieved through challenging, repetitive, task-specific and motivating activities. In 2011, Mouawad et al. described that the Nintendo Wii, through its capacity to develop a wide range of skills and task-specific techniques while playing, is now starting to be integrated in the rehabilitation of post-stroke patients who wanted to regain their function and return to their normal activities of daily living. It is believed that this will not only result in better outcomes of mobility, but also will help in minimizing the problems with compliance that could be met with the conventional method. It also offers a simple yet affordable mode of virtual reality therapy which is being used increasingly in stroke rehabilitation worldwide; however, only few studies of its efficacy have been published. There has been limited studies encompassing the use of virtual reality gaming systems including the Nintendo Wii in the neurorehabilitation programs particularly in stroke and conclusions about the effects of virtual reality on upper limb function including the shoulder and elbow regions after stroke incidence cannot be made.

In this regard, this study aimed to assess the effectiveness of Nintendo Wii therapy in improving shoulder and elbow strength, range of motion and motor performance and compare it with conventional therapy among post-stroke patients. If found significant, this method will aid in the rehabilitation of post-stroke patients who suffer from shoulder and elbow impairments in a more motivating and interesting way. The Nintendo Wii could also help these patients focus more on the gameplay rather than his or her impairments which could result in more pleasurable exercise and better devotion to the rehabilitation itself.

## MATERIALS AND METHODS


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**Design**

Experimental design was utilized to evaluate if the Nintendo Wii therapy is an effective method in improving shoulder and elbow strength, range of motion, and motor performance.

**Participants**

A total of thirty post-stroke patients from different barangays in Batangas City were purposively recruited to participate in the study. Only participants with age ranging from 18 to 80 years (Saposnik et al., 2011), at least 6 months post-stroke (Hijmans, Hale, Satherley, McMillan & King, 2011) and cognitively competent (Hurkmans, Ribbers, Streur-Kranenburg, Stam & Berg-Emon, 2011) were included in the study. Upon the approval of the panel of experts about the safety and risks concerning the utilization of the conventional techniques and the device, participants who passed the criteria were instructed to read and sign an informed consent. They were divided into two groups-control group treated with conventional therapy and treatment group treated with Nintendo Wii therapy. Equal distribution was observed as to gender, age and length of stroke affliction.

Potential participants were excluded due to the following reasons: unable to understand and follow instructions, with uncontrolled hypertension, with medical co-morbidities and complications such as cardiopulmonary, seizures and shoulder subluxation (Saposnik et al., 2010).

**Device**

According to a study by Taylor, McCormick, Shawis, Impson & Griffin (2011), the Nintendo Wii offers a simple form of virtual reality therapy that is being used increasingly in stroke rehabilitation globally. Through a motion detection system, this wireless controller interacts with the player and allows participants to interact with the games while performing shoulder, elbow, and wrist and hand movement. The feedback is provided by a TV screen. A chance to observe their own movements while playing produces positive reinforcement; therefore, facilitates training and task improvement. The movements are controlled by the Wii remote and nunchuck as shown in Figure 1. The Wii remote is similar in size with a television remote control and uses a three-axis accelerometer to convert bodily movements into onscreen movements. Up to four controllers can be connected to the console, which could allow group play or interaction with other players. It also provides basic audio and vibration feedback. The nunchuck is the secondary controller and also incorporates motion-sensing technology and gives additional control. The sensor bar


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receives signal from the controller. The console comes with Wii sports (Nintendo), a game package for the Wii remote and nunchuck with the following: tennis, baseball, boxing and bowling which are entertaining and pleasurable so the participants will focus on the gameplay rather than his or her impairments.

**Assessment Tools**

The researchers were guided by the following assessment tools:

**I. Shoulder and Elbow Manual Muscle Testing (MMT).** MMT was used to measure the strength of shoulder and elbow muscle groups. Manual resistance is applied to the body part after it has completed its range of movement or after it has been placed at end range by the examiner. Grading system is shown in Table 1 (Hislop & Montgomery, 2007)

**Table 1**
**Manual Muscle Testing**

| Grade | Definition |
|---|---|
| 0 | "Zero"; Muscle is in complete quiescence on palpation or visual inspection |
| 1 | "Trace"; No muscle movement but can detect some contractile activity visually or by palpation |
| 2 | "Poor"; Muscle or muscle group is able to complete full Range of Motion (ROM) in gravity eliminated position |
| 3 | "Fair"; Muscle or muscle group can complete a full ROM in anti-gravity position without resistance |
| 4 | "Good"; Muscle or muscle group can complete a full ROM in anti-gravity position and can tolerate strong resistance but yield to some extent at the end range |
| 5 | "Normal"; Muscle or muscle group completes full ROM or maintain end-point range against maximal resistance |

**II. Shoulder and Elbow range-of-motion (ROM) assessment.**

It was used to measure the active range of motion (AROM) where the participant voluntarily moves the involved extremity and passive range of motion (PROM) where the examiner alone moves the participant's involved extremity prior and after therapy sessions. Full range of motion will result to: shoulder flexion (0-180º), shoulder abduction (0-180º), shoulder external rotation (ER) (0-90º), shoulder internal rotation (IR) (0-70º) and, elbow flexion (0-150º).


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**III. Fugl-Meyer Assessment upper-limb section (FMA-UL).**

FMA was rated on a three-point ordinal scale (2 points if being performed completely, 1 point if being performed partially, and 0 if not being performed). This was used only for comparison of pre- and post-measurements of motor performance.

**PROCEDURE**

The researchers conducted a feasibility study in selected barangays in Batangas City and gathered information with relevance to the research. The participants were divided into 2 groups: control group and treatment group. Baseline assessments in range of motion (ROM), strength and motor performance were taken before the experiment and were repeated at its conclusion.

The control group received conventional physical therapy including therapeutic exercises such as stretching and strengthening exercises following a standard protocol of maximum of 1 hour treatment session; 15 seconds hold with 10 repetitions for stretching and 10 repetitions per set for strengthening exercises. The participants participated thrice a week for one month. On the other hand, the treatment group was under the Wii therapy wherein the participants in this group strictly used the more-affected arm to control play. Sports games of bowling, boxing, baseball and tennis were introduced and varied according to participant's ability to prevent unwanted overuse syndrome (Mouawad et al., 2011). Each session was approximately one hour in duration. A few users required some assistance to don and doff the apparatus. On the first week of the 1 month treatment plan, the participants were tasked to play virtual bowling to stimulate the proximal muscles of the shoulder and elbow regions. The second week focused on the participants' capabilities on bringing their involved arm on higher degrees of movement by playing virtual boxing. Following the achievement of the previous goal, the researchers asked the participants to play baseball to introduce a less aggressive overhead throwing activities by experiencing to be both a batter and a pitcher. On the last week, participants were tasked to play tennis which requires a more aggressive gameplay by targeting the virtual tennis ball overhead more frequently. The tasks were sequenced as such to encourage the participants to achieve each goal within the allotted treatment sessions given. Patients were encouraged to take rest breaks as necessary. A trained researcher supervised the treatment sessions (Mouawad et al., 2011).

**DATA ANALYSIS**

Descriptive statistics such as mean and SEM and inferential


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statistics such as independent sample T-test were used to analyze and correlate effects of Wii therapy and conventional therapy.

## RESULTS AND DISCUSSION

This study shows the effectiveness of Wii therapy in the neurorehabilitation of post-stroke patients with upper extremity impairment which started to be integrated nowadays and compared it with conventional therapy which is the traditional and widely-known approach in rehabilitation of the same population. The control group received conventional therapy which are purely exercises for 1 month (1 hour/day, thrice/week). The treatment group was under the Wii therapy wherein the patients in this group will strictly use the more-affected arm to control play for 1 month (1 hour/day, thrice/week). Pre- and post-values of assessment of both groups were recorded and compared to observe if there were significant differences.

Since the field of post-stroke rehabilitation is evolving, the patterns of stroke rehabilitation schemes also improve. As it was described in the study by Saposnik et al. (2011), the Nintendo Wii represents a safe, feasible and potentially effective alternative to facilitate rehabilitation therapy. Moreover, in the study conducted by Mouawad et al. in 2011, participants reported frequent involvement of their more affected arm, including the shoulder and elbow regions, in more activities than they previously thought possible after their participation in the study.

**Table 1**
**Comparison of Outcome Measures on Wii and Conventional Groups as to Range of Motion**

| Joint | Wii Group (in degrees) | | | | Conventional Group (in degrees) | | | |
|---|---|---|---|---|---|---|---|---|
| | Pre-test | | Post-test | | Pre-test | | Post-test | |
| | AROM | PROM | AROM | PROM | AROM | PROM | AROM | PROM |
| Shoulder flexion | 166.67 | 176.67 | 176.67 | 80 | 154.17 | 167.5 | 166.67 | 180 |
| Abduction | 160 | 176.67 | 174.17 | 180 | 157 | 175.83 | 160 | 180 |
| ER | 76.67 | 90 | 86.67 | 90 | 73.67 | 88.33 | 80.83 | 90 |
| IR | 59.17 | 68.33 | 86.67 | 70 | 60.83 | 70 | 64.17 | 70 |
| Elbow flexion | 131.67 | 144.17 | 146.67 | 150 | 128.33 | 145 | 140.83 | 150 |

Legend: AROM=active range of motion, PROM=passive range of motion

Average results of shoulder and elbow regions as to active and passive range of motion are shown in Table 1. Under the Wii group, in terms of active range of motion (AROM), shoulder flexion pre-test


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resulted to an average of 166.67˚ and 176.67˚ in post-test. This means that there was an increase of 10˚ in joint movement. In shoulder abduction, pre-test resulted to an average of 160˚ and 174.17˚ in post-test. This means that there was an increase of 14.17˚. In terms of shoulder external rotation (ER), pre-test resulted to an average of 76.67˚ and 86.67˚ in post-test.

This means that there was an increase of 10˚. In addition, shoulder internal rotation (IR) pre-test resulted to an average of 59.17˚ and post-test resulted to 86.67˚. This means that there was an increase of 27.5˚. Finally in terms of elbow flexion, pre-test resulted to an average of 131.67˚ and an average of 146.67˚ in post-test. This means that there was an increase of 15˚. Whereas in terms of passive range of motion (PROM) under the same group, pre-tests for shoulder flexion resulted to an average of 176.67˚, 176.67˚ for shoulder abduction, $90^0$ for shoulder ER, $68.33^0$ for shoulder IR and $144.17^0$ for elbow flexion. All PROM post-tests resulted to full ROM of the joints tested. Results have shown an increase of 3.33˚ both in shoulder flexion and shoulder abduction, 0˚ in shoulder ER, 1.67˚ in IR and 5.83˚ in elbow flexion.

Under the conventional group, in terms of shoulder flexion pre-test resulted to an average of 154.17° and 166.67° in post-treatment. This means that there was an increase of 12.5°. For shoulder abduction, pre-test resulted to an average of 157° and 160° in post-treatment. This means that there was an increase of 3°. In terms of shoulder ER, pre-test resulted to an average of 73.67° and 80.83° in post-treatment. This means that there was an increase of 7.16°. In terms of shoulder IR pre-test resulted to an average of 60.83° and 64.17° in post-treatment. This means that there was an increase of 3.34°. Lastly in terms of elbow flexion, pre-test resulted to an average of 128.33° and 140.83° in post-treatment. This means that there was an increase of 12.5°. On the other hand in terms of PROM under the same group, pre-test for shoulder flexion resulted to an average of $167.5^0$, 175.83˚ for shoulder abduction, 88.33˚ for shoulder ER, 70˚ for shoulder IR and 145˚ for elbow flexion. Whereas, post-tests resulted to full ROM on all joints tested, results have shown an increase of 12.5˚ for shoulder flexion, 4.17˚ for shoulder abduction, 1.67˚ for shoulder ER, 0˚ for shoulder IR and an average of 5˚ for elbow flexion. This showed that both methods were effective in improving range of motion.

This implies that the Nintendo Wii is equally effective as the conventional therapy in improving shoulder and elbow range of motion. The increase in range of motion may be due to the obligatory use of the affected arm in playing Nintendo Wii Sports which was supported by the study of Mouawad et al. (2011).


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**Table 2**
**Comparison of Outcome Measures on Wii and Conventional Groups as to Motor Performance (Shoulder and Elbow Regions only)**

| | Pre-test | Post-test |
|---|---|---|
| Wii | 22.5 | 26.5 |
| Conventional | 21.5 | 28.7 |

Table 2 shows the pre- and post values as to motor performance of the shoulder and elbow regions. The Wii group pre-test showed an average of 22.5 points and 26.5 points in post treatment. This means that there was an increase of 4 points in motor performance using Nintendo Wii. However, in conventional group, pre-test resulted to an average of 21.5 points and 28.7 points in post-treatment. This means that there was an increase of 7.2 points. This showed that the two methods were effective in improving upper extremity motor performance. The effects may be attributed to the stretching and strengthening of tight and weak muscles, hence allowing an increase joint play. The results were in line with the study of Saposnik et al. (2011) that recovery of function, both spontaneous and secondary to intense rehabilitative treatments, is sustained by plasticity and rewiring in the injured brain in adults.

**Table 3**
**Comparison of Outcome Measures on Wii and Conventional Groups as to Muscle Strength**

| | Wii Group | | Conventional Group | |
|---|---|---|---|---|
| | Pre-test | Post-test | Pre-test | Post-test |
| **Muscle group** | | | | |
| Shoulder flexor | 2.33 | 3.66 | 2.50 | 3.50 |
| Abductor | 2.50 | 3.66 | 2.50 | 3.33 |
| ER | 3 | 4.33 | 2.83 | 3.33 |
| IR | 2.66 | 3.83 | 3 | 3.50 |
| Elbow Flexor | 2.66 | 4.17 | 2.33 | 4.17 |
| Extensor | 2.50 | 4.17 | 2.66 | 3.83 |

Table 3 reveals the average results of shoulder and elbow regions as to muscle strength. Under the Wii group, shoulder flexors pre-test resulted to an average of 2.33 and of 3.66 in post- treatment. This means that there was an increase of 1.33. Shoulder abductors pre-test resulted to an average of 2.50 and 3.66 in post-treatment. This means that there was an increase of 1.16. Shoulder ER pre-test resulted to an average of 3 and 4.33 in post-treatment. This means that there was an increase of 1.33. Shoulder IR pre-test resulted to


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an average of 2.66 and 3.83 in post- treatment. This means that there was an increase of 1.17. In terms of elbow flexors pre-test showed an average result of 2.66 and 4.17 in post- treatment. This means that there was an increase of 1.51. Elbow extensors pre-test resulted to an average of 2.50 and 4.17 in post-treatment. This means that there was an increase of 1.67.

Under the conventional group, shoulder flexors pre-test resulted to an average of 2.5 and 3.5 in post-treatment. This means that there was an increase of 1. Shoulder abductors pre-test resulted to an average of 2.5 and 3.33 in post- treatment. This means that there was an increase of 0.83. Pre-test of shoulder ER showed an average result of 2.83 and 3.33 in post treatment. This means that there was an increase of 0.5. Shoulder IR pre-test resulted to an average of 3 and 3.5 in post treatment. This means that there was an increase of 0.5. Elbow flexors pre-test showed an average result of 2.33 and 4.17 in post- treatment. This means that there was an increase of 1.84. Finally, elbow extensors pre-test resulted to an average of 2.66 and 3.83 in post-treatment. This means that there was an increase of 1.17. This showed that both Nintendo Wii therapy and conventional therapy were effective in improving muscle strength which may be due to the voluntary movements performed against gravity by the participants. This implies that the Nintendo Wii is equally effective in improving the muscle strength of the patients during sub-acute post-stroke. The observable increase in muscle strength is in line with the study of Saposnik et al. (2011) which considered the beneficial effect of repetitive, task-oriented training of the paretic extremity.

**Table 4**
**Comparison on the Effects of Wii and Conventional Group on Range of Motion**

| | Test | p-value | Interpretation |
|---|---|---|---|
| Post1(AROM) | Wii<br>Conventional | 1.000 | Not Significant |
| Post2 (PROM) | Wii<br>Conventional | .341 | Not Significant |

Table 4 presents the comparison between Nintendo Wii therapy and conventional therapy in improving shoulder and elbow range of motion (ROM). The results show no significant differences since the obtained p-value on AROM (1.000) and on PROM (.341) are both higher than the level of significance (p-value < 0.05). This means that both methods had the same effect in increasing shoulder and elbow range of motion. The effects may be due to active engagement during therapy. This implies that the Nintendo Wii therapy is comparable to


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conventional therapy in improving shoulder and elbow range of motion. This supports the study of Hijmans, Hale, Satherley, McMillan, and King (2011) that recovery after stroke correlates with the frequency and intensity of exercise, focus on task-oriented movement and practice in a challenging, engaging, functional, and meaningful way.

**Table 5**
**Comparison on the Effect of Motor Performance using Wii and Conventional Method**

| | Test | p-value | Interpretation |
|---|---|---|---|
| Post motor performance | Wii<br>Conventional | 0.631 | Not Significant |

*Legend: Significant at p-value < 0.05*

Table 5 presents the comparison between Nintendo Wii therapy and conventional therapy in improving motor performance of shoulder and elbow regions. The result shows no significant difference since the obtained p-value (0.631) is greater than the level of significance (p-value < 0.05). This means that both methods had the same effect in improving motor performance of shoulder and elbow regions. This may be due to movement practice and repetition and improvement in motor control. This implies that the two methods are both effective in improving motor performance among post-stroke patients. This correlates with the study of Hijmans et al. (2011) that in order to improve motor performance, both motor (re)learning and compensatory strategies are required. Motor (re)learning and recovery are mainly possible because of plasticity of the brain, and the changes caused by plasticity in the lesioned hemisphere coincide with motor function improvement after activity-based rehabilitation.

Table 6 presents the comparison between Nintendo Wii therapy and conventional therapy in improving muscle strength of shoulder and elbow regions. Shoulder ER shows significant difference however, no significant differences were noted in the following: shoulder flexion (0.687), shoulder abduction (0.290), shoulder IR (0.541), elbow flexion (1.00) and elbow extension (0.461). This means that both methods had the same effect in improving muscle strength of muscle groups except for shoulder ER. This can be due to repeated forceful use, challenging voluntary movements performed against gravity by the participants on the Wii therapy group. This implies that Wii method is more effective than conventional method in improving shoulder ER. This supports the study of Harris and Eng (2010) that sufficient strength in the upper limb is related to the ability to adequately perform many activities of daily living (ADLs).


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Through this study, the researchers found out that the Nintendo Wii therapy is effective in improving shoulder and elbow range of motion, motor performance and strength in post-stroke patients with upper extremity impairments.

**Table 6**
**Comparison on the Effects of Wii and Conventional Group on Muscle Strength**

| | Test | p-value | Interpretation |
|---|---|---|---|
| Post-shoulder flexion | Wii<br>Conventional | .687 | Not Significant |
| Post_shoulder abduction | Wii<br>Conventional | .290 | Not Significant |
| Post-shoulder ER | Wii<br>Conventional | .030 | Significant |
| Post- shoulder IR | Wii<br>Conventional | .541 | Not Significant |
| Post-elbow flexion | Wii<br>Conventional | 1.000 | Not Significant |
| Post-elbow extension | Wii<br>Conventional | .461 | Not Significant |

*Legend: Significant at p-value < 0.05*

## CONCLUSION

The Nintendo Wii is a virtual reality gaming device that may be an appropriate intervention for the improvement of upper extremity's function. This study investigated the effectiveness of the Nintendo Wii in improving shoulder and elbow range of motion, motor performance and strength. The study revealed that using the Nintendo Wii could improve shoulder external rotation (ER) in terms of strength whereas, no significant difference was found in terms of range of motion and motor performance. Hence, it can be concluded that Nintendo Wii therapy is comparable and can be a good alternative method in the improvement of shoulder and elbow regions in improving shoulder and elbow range of motion, motor performance and strength.

## RECOMMENDATION

Based on the results and conclusions, the researchers recommend the use of larger population in conducting this study and the use of Nintendo Wii in other conditions involving the upper


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extremity not only stroke. It is also important to assess the endurance of participants who underwent Nintendo Wii therapy. Assessment and determination of participant's level of satisfaction using the Nintendo Wii as a therapeutic modality including their compliance towards the rehabilitation program using the virtual gaming device must also be done.

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