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A Study to Investigate the Efficacy of Application -Based Activities on Hand Dexterity Among Individuals with Sub-Acute Stroke: A Pilot Study

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ABSTRACT

Stroke is the sudden loss of neurological functions caused by an interruption of blood flow to the brain. Stroke is more clinically prevalent and it is the second leading cause of disability. Due to impaired dexterity, patient face difficulties with feeding, dressing, and grooming, mainly in performing bimanual activity.

AIM OF THE STUDY: The aim of the study was to investigate the efficacy of application – based activities on hand dexterity among individuals with sub-acute stroke.

METHODOLOGY: A total of 20 patients, aged 42 to 60 years with subacute stroke were undertaken and were divided into two groups. The total duration of the study was one and a half year. Patients meeting inclusion and exclusion criteria were selected in the study and were assessed for hand dexterity, arm and hand function. A pilot study was conducted in which treatment was given using tablet including the game intervention along with conventional physiotherapy for Group A. The conventional physiotherapy treatment for upper limb and hand was given to Group B that is the control group. The treatment was carried out for 5 days per week for 9 weeks. in which first week was for training session for Group A and for Group B the treatment time was 45 minutes per session for 9 weeks; 5 days per week. The data was collected for dependent variables at baseline and at 9-weeks post treatment for both the Groups.

DATA ANALYSIS: The data was analyzed using SPSS Version 16.0 Data was summarized by giving their average and standard deviation. Paired T-test was used to compare the means of the two samples of related data. (pre-post scores). Unpaired T -test was used to compare the means of two independent groups.

RESULTS: Data analysis was performed by SPSS software version 18. The result of the study showed statistically significant improvement in hand dexterity and arm and hand function within the group with a p- value less than 0.001 for hand dexterity for Group A and p-value of 0.0013 for Group B. Statistically non- significant were obtained for between the group difference for hand dexterity component with P value of 0.4391 and 0.3306 for Group A and B respectively at baseline and 9thweek. The score for CAHAI score were also found to be statistically significant with P value less than 0.001 and 0.001 for both the groups.

Statistically non- significant were obtained for between the group difference for hand dexterity component

with P value of 0.4391 and 0.3306 for Group A and B respectively at baseline and 9th week.
CONCLUSION: It is thereby, concluded from the results that the virtuous use of application-based activities aids as a fun based measure along with conventional rehab protocol. Stroke rehab is multi-centered approach and it is of utmost importance to consider all the aspects affecting the patient's capabilities. Using game- based measure for rehabilitation provides clinical insights towards symptoms improvement and consistency.

KEYWORDS: Stroke, Hand dexterity, Grip strength, Active touch

INTRODUCTION

Stroke is one of the leading causes of mortality and disability in India.[1] It is a major global health problem and one of the leading causes of acquired disability in adults.[2] Stroke is clinically the most common and second leading cause of disability. It is a seriously devastating disease for patients.[3] It is responsible for approximately 5.5 million deaths and 44 million years of disability-related life years worldwide each year.[4] Stroke is a term used to refer to an acute injury to the brain from a vascular cause that results in permanent neuronal injury and functional disability.[5] According to the American Stroke Association, a stroke (cerebrovascular accident [CVA]) can be defined as a disease that affects the arteries leading to and in the brain. It causes neurological dysfunction due to interruption of blood flow to the brain. Many focal deficits are possible, including changes in level of consciousness and impairment of sensory, motor, cognitive, perceptual and language functions. Upper extremity disability is more common after stroke, and nearly half of the population is disabled more than three months after stroke. These weaknesses make it quite difficult for patients to perform daily activities, especially those activities that require the use of both hands, ie. two-handed activities. In stroke rehabilitation, the main goal is to perform bimanual activities, regardless of which hand is affected.[5] Skilled finger manipulation is one of the characteristics of motor control systems. Due to biomechanical and neurological limitations, the somewhat limited independent movement and reduced individualization of the fingers and thumb affect many activities, from writing to grasping and carrying objects.[6] In particular, restoration of upper extremity function is critical. factor to determine independence in tasks of daily life. The main signs of physical (pathological synergy) and changes in muscle tone on the side opposite to the stroke. This form of the disease is called hemiparesis, and its severity usually reflects the extent of damage to the corticospinal tract. Neurology. Due to reduced dexterity, they have difficulties to eat, dress and take care of them.[2] Loss of flexibility in stroke is most common in stroke, which requires a long-term recovery. If the inflexibility due to stroke continues for a long time, it leads to improper control of individual movements of the fingers. To improve fine motor skills, the patient should do appropriate finger exercises. An effective rehabilitation program that supports stroke patients through long-term exercise is crucial to increase finger dexterity and improve quality of life and self-care activities.[7] During the first month after a stroke, recovery of the upper limb is maximal. So, this time the rehabilitation is very effective due to the increased plasticity of the brain during this period.[2] Neurorehabilitation is the main part of the treatment of stroke patients, where the improvement of skill is an integral part of the treatment methods.[2] The patient's hand is damaged in many ways that affect his motor skills. This can include decreased strength, inability to control individual fingers, abnormal force control at the finger level, increased muscle tension and stiffness in the wrists and hand flexors, which can exacerbate these problems and make it difficult to open the hand in preparation

for grasping. Atypical reaching and grasping patterns often occur both as a consequence of, and in response to, motor dysfunction.[8] At the same time, rehabilitation of upper extremity impairment proves difficult. Although many treatments (eg, bilateral exercise, restraint-induced therapy, electrical stimulation, task-focused high-intensity programs) have been evaluated in clinical trials, none have demonstrated lasting effects on hand function.[2] Conventional rehabilitation treatments can aid in recovery. motor skills. to work and improve the disability. Recent evidence suggests that repetitive, task-oriented training of the paired limb is beneficial.[3]Recent technologies advances have created new opportunities for and motivational training that may be appropriate for the home rehabilitation programs. The included app for tablets, computers, Android phones and other devices are very portable and affordable. Many people own and use these devices for social, designed for mobile devices can promote vigorous, repetitive finger and hand movements (ie, dexterity). Apps can be useful for upper extremity self-training after a stroke because they can be motivating, fun and challenging, which is an important part of motor learning. In addition, applications can measure an individual's performance in tasks such as movement speed and reaction time and practice these elements.[9] Physical disability, which is mostly caused by brain damage. The incidence of stroke in each age group affects the younger, middle and older age groups of the population. Therefore, manual dexterity is generally impaired in these patients. Therefore, it is important to evaluate the reasons for better neurological rehabilitation to focus on improving manual dexterity.[10] Their fine motor skills are impaired due to stroke. Thus, rehabilitation is necessary for them.[11] The interest of patients has been influenced by rehabilitation systems containing interactive games based on virtual reality.[7] Traditional treatment methods require more effort and time from therapists and patients. and are not motivated, so they do not encourage intensive self-education. Recent advances in touch screen technology can therefore fill this gap and serve as a tool for finger dexterity training.[12].

METHODOLOGY

Patients with subacute stroke were taken in the study. The patients were divided into two groups. Group A was the Experimental Group and Group B was the Control Group. Each group had 10 patients with subacute stroke. Convenient sampling technique was used. The total duration of the study was one and half year. Study was experimental design pilot in nature. The study was conducted in Neuro Outpatient Department of DAV Institute of Physiotherapy and Rehabilitation and its affiliated hospitals. Written consent was taken. Inclusion criteria with age between 42- 60 years both male and female, patients with first ever stroke in past 4 months, accompanied with early to subacute rehabilitation stage, with intact cognitive abilities (MMSE greater than 20), patients with evidence of ischemia and hemorrhagic stroke as ascertain by CT/ MRI head scans. Modified Ashworth Scale (MAS) grade 1+ and grade 1 for wrist and elbow flexors / extensors for affected hand, patients able to extend wrist and fingers at least 10 degrees., patients able to perform 9- hole peg test with duration of more than 19 seconds. patients with Grade **3 / 3-** for flexor digitorum superficialis, flexor digitorum profundus, lumbricals, opponens pollicis, abductor pollicis brevis, abductor digiti minimi according to Medical Council of Research (MRC) Grading with intact visual and auditory abilities and able to comprehend with the instructions. Exclusion criteria include subjects with apraxia (Apraxia Screening of TULIA less than 9), self-reported pain. subjects with seizures or any other neurological function deficits (Alzheimer). subjects with any orthopedic conditions of upper

limb that impairs patients' active participation like subluxated shoulder acute upper limb fracture, Dupuytren's contracture, CTS, tenosynovitis, trigger finger and hand injuries.

VARIABLES:

INDEPENDENT VARIABLES:

- Application Based Games
- Conventional Physiotherapy

DEPENDENT VARIABLES:

- Score of 9 Hole Peg test (secs)
- Score of Chedoke Arm and Hand Activity Inventory (CAHAI)

TOOLS AND INSTRUMENTS

- Lenovo Tablet version t10 android 12
- Nine Hole Peg Board
- Chedoke Arm and Hand Activity Inventory (CAHAI)
- Cotton
- Sharp and blunt pins
- Reflex Hammer
- Tuning Fork
- Half circle goniometer

NINE HOLE PEG TEST-The Nine-Hole Peg Test (9-HPT) is a standardized, quantitative assessment used to measure finger dexterity.[152]

CAHAI SCALE- The CAHAI is a performance test using functional items. It is not designed to measure the client's ability to complete the task using only their unaffected hand, but rather to encourage bilateral function.[151]

PROTOCOL

All the subjects meeting the inclusion criteria selected for the study. A written informed consent was undertaken from each participating subject. The required assessment of the subjects was done. A minimum of 20 patients were undertaken divided into two groups. Group A was interventional Group whereas Group B was control group. Each group will be having 10 patients with sub- acute stroke.

For Group A, the treatment had given for a period of 9 weeks; 5 days per week with total minimum duration of 60 to 65 minutes per day.

For Group B, the treatment had given for a period of 9 weeks, 5 days per week with total minimum duration of 45 minutes per day. Prior to the baseline assessment, All the patients underwent a training session for 5 days in order to acquaint them to the application – based games and the usage of tablet.

The patients had been assessed at baseline and post intervention 9 weeks for Dexterity, Arm and Hand Function using Nine Hole Peg Board, Chedoke Arm and Hand Activity Inventory (CAHAI).

PROCEDURE

Group A

All the patient included in the study for experimental group (Group A) underwent an interactive game based on Lenovo tablet along with standardized physiotherapy intervention the patient is receiving for hand and upper extremity.

A total of 6 games will be used for the intervention.

2	**2**	**2**
Dragging Games	**Tapping Games**	**Stretching Games**

Table No. 4.1- Showing different way of mechanisms in game

Following games was incorporated using tablet and all the app- based games are downloaded from authentic manufactures from android play store:

1. **FRUIT NINJA**

The game was based on dragging activity which was further aid in control of fingers. All the fingers of the affected hand practiced through this game.

2. **KIDS PUZZLE**

The game was based on dragging activity.

3. **POP US**

This game was based on tapping activity which was address finger isolation and co-ordination

4. **TAB TITANS**

This game was based on tapping activity.

5. **ZOOM ART**

This game was based on stretching activity which were enhance Range of Motion.

6. **ZOOM IN**

This game was based on stretching activity.

CONVENTIONAL THERAPY (GROUP A)

After the interactive gaming session, the patient gave the conventional physiotherapy as follows

- Stretching of the affected digits (12 repetition with 10 sec hold)
- Stretchi0ng of flexor and extensor compartment of Forearm (12 repetition with 10 sec hold)
- Lateral and posterior weight bearing (5 to 7 minutes)
- Mobilization of affected hand (dorsal and volar glide,25 oscillations; grade 2 Maitland Mobilization)
- Bilateral arm activity (12 repetition)
- For upper limb – scapular mobilization (25 repetition),
- Elbow flexion and extension with weight cuffs (10 repetition)

CONTROL GROUP (GROUP B)

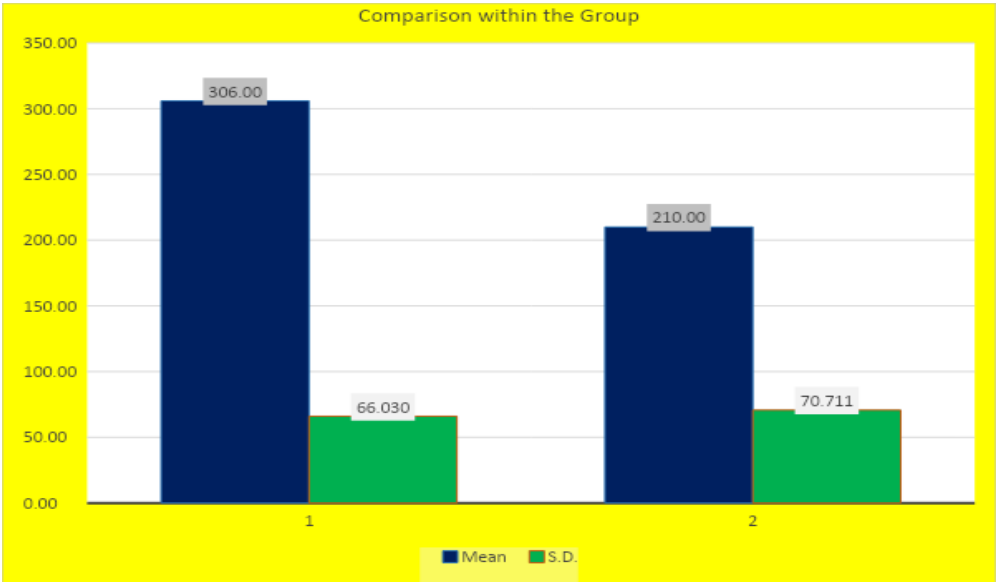
- Stretching of the affected digits (12 repetition with 10 sec hold)
- Stretching of flexor and extensor compartment of Forearm (12 repetition with 10 sec hold)
- Lateral and posterior weight bearing (5 to 7 minutes)
- Mobilization of affected hand (dorsal and volar glide, 25 oscillations Grade 2; Maitland Mobilization)
- Bilateral arm activity (12 repetition)
- For upper limb – scapular mobilization (25 repetition)

- Elbow flexion and extension with weight cuffs (10 repetition)

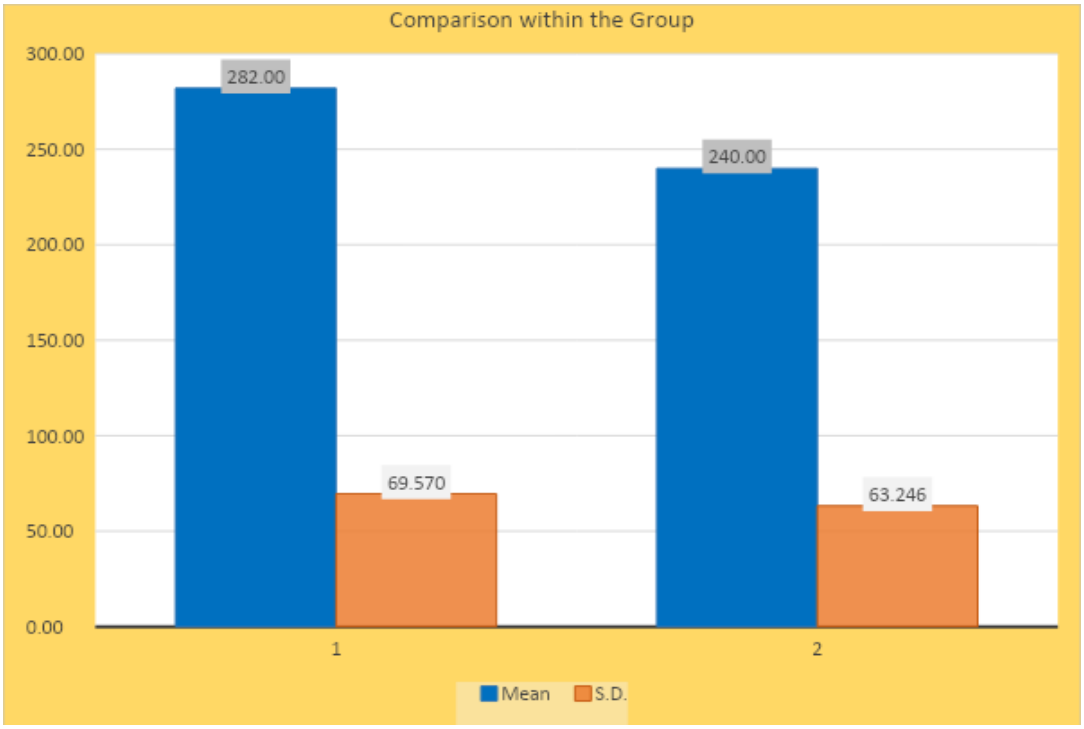
FRUIT NINJA	This app is a free to play game Email: fruitninja@halfbrick.com Address: po box 172, red hill, Queenland4059, Australia
KIDS PUZZLES	This app is a free to play funny game Email: support@cleverbit.net Address: Dmitry skornyakov, office 313, Brodina21 Izhevsk426000, Russia
POP US	This app is free to play game Email: pop-us-android@say.games Address:8010, Cyprus, paphos, tepeleniou13 Court,2 floor
TAP TITANS	This app is best adventure play game app Email: support@gamehive.com Address: suite3940,22 Adelaidest W Toronto
ZOOM ART	This app is free to play game Email: baonguyennd95@gmail.com Address: Song da building,18/165 cau giay road
ZOOM IN	This app if free to play game Email: shlechang406@gamil.com

Table No.4.2 The following games have been downloaded from play store from authentic companies

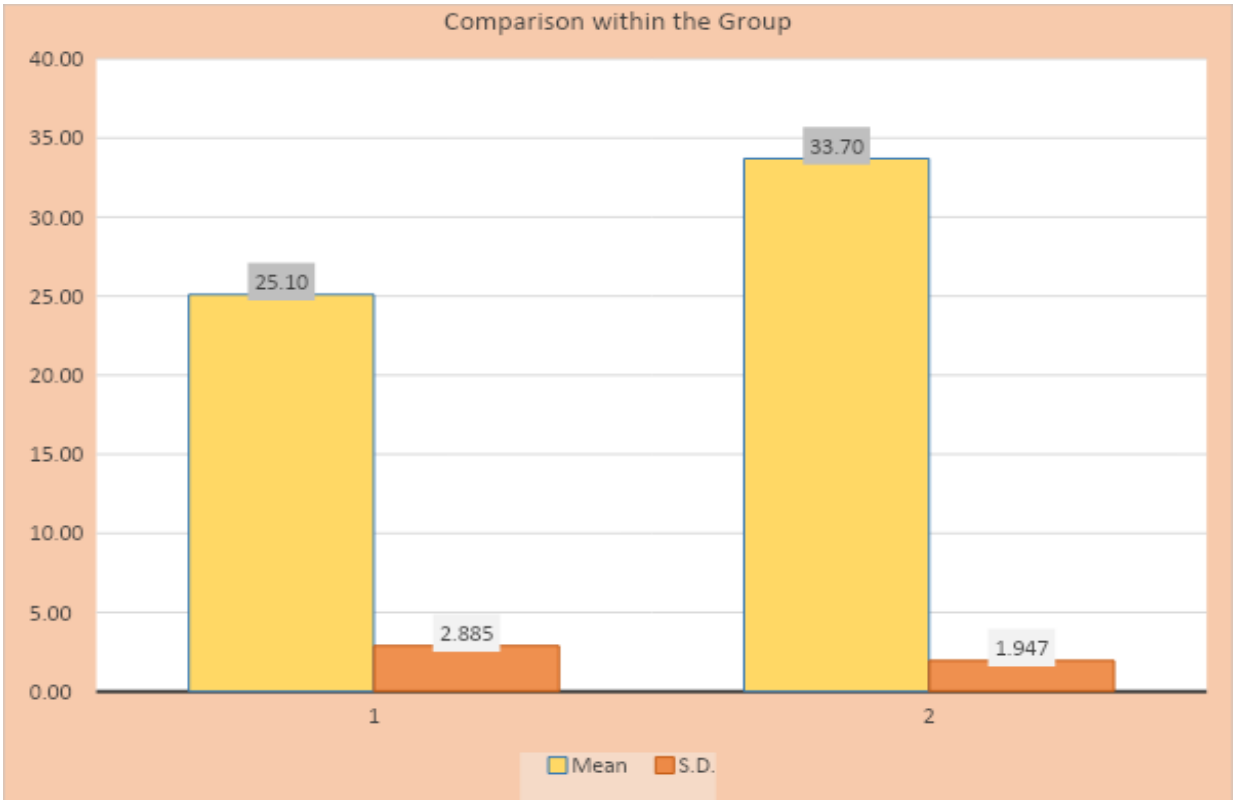
Results



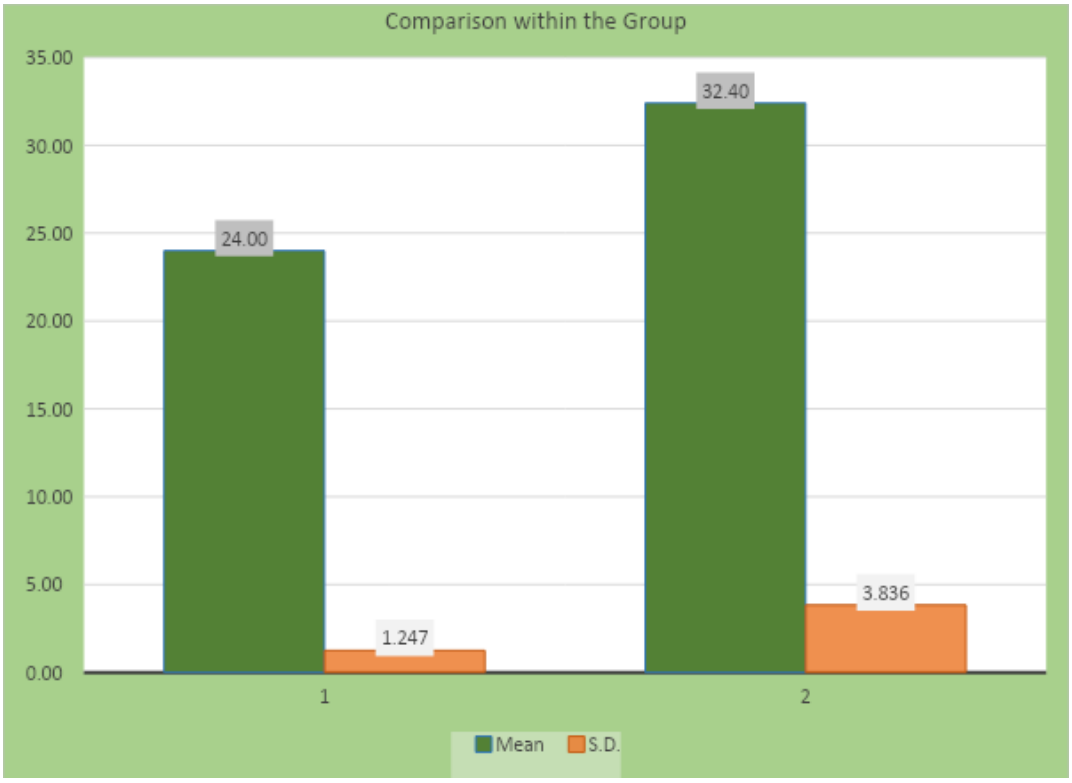
Graph no. 1 Shows within the Group Difference for hand dexterity (in seconds) of subjects for Group A at baseline and at 9 weeks.



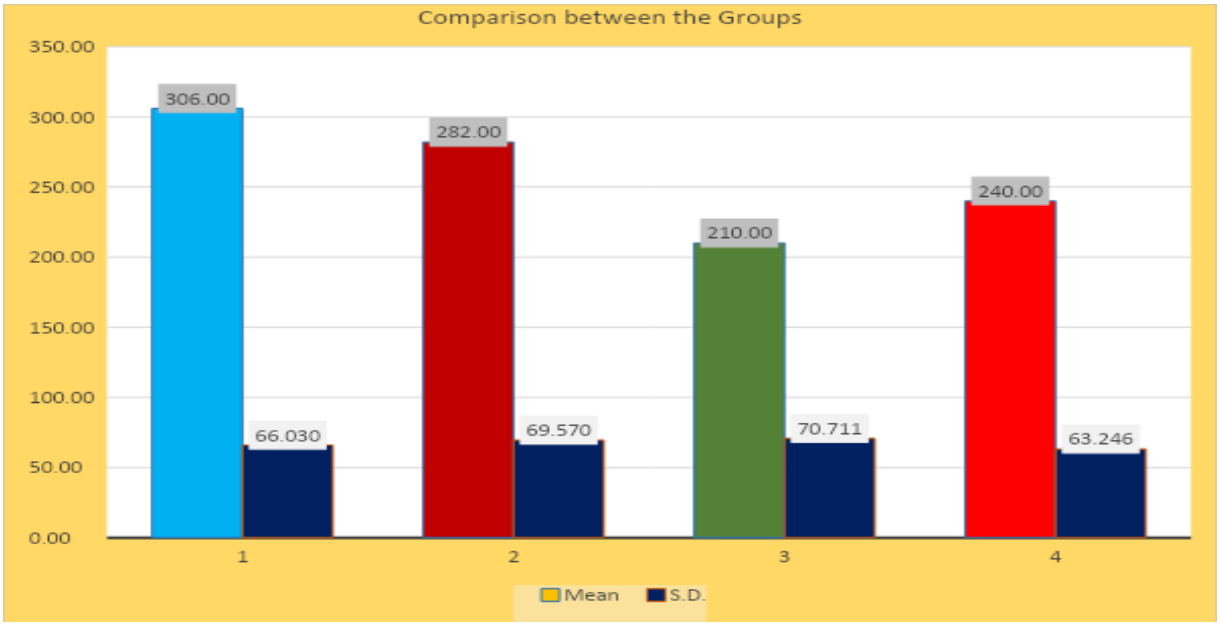
Graph no. 2 - Shows within the Group Difference for hand dexterity (in seconds) of subjects for Group B at baseline and at 9 weeks.



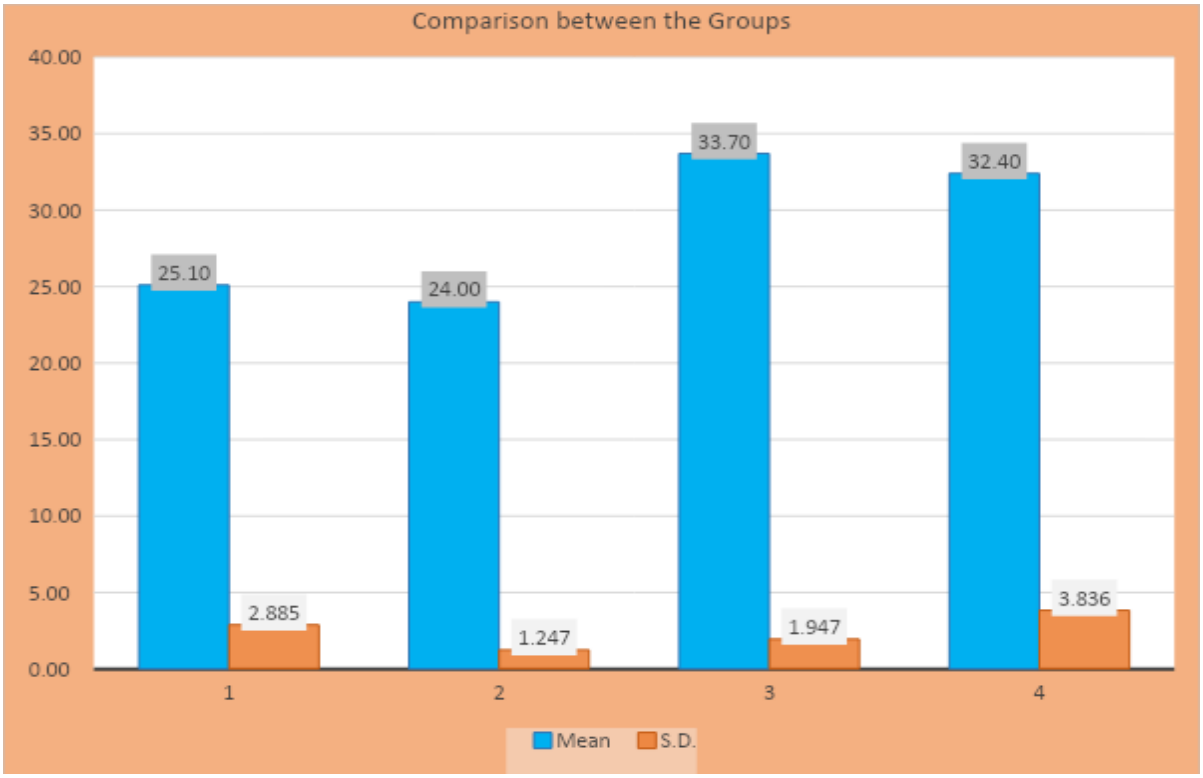
Graph no. 3 – Shows paired T- test scores within the Group Difference for Chedoke Arm and Hand Activity Inventory (CAHAI)of subjects of Group A at baseline and 9th week.



Graph no. 4 – Shows paired T- test scores within the Group Difference for Chedoke Arm Arm and Hand Activity Inventory (CAHAI) of subjects of Group B at baseline and 9th week.



Graph no. 5 – Shows between the group comparison for hand dexterity (in seconds) for group A and Group B at baseline and at 9th week.



Graph no. 6 – Shows between the Group Comparison for Chedoke Arm and Hand Activity inventory (CAHAI) for Group A and Group B at baseline and at 9th week.

DISCUSSION

Stroke manifests as loss of motor abilities which may even lead to permanent loss of function. The long-term repercussions of stroke are determined by which area of brain was afflicted and how severe had been the extend of the journey. Weakness or paralysis of half side of the body, impairment in speech, decreased or diminished physical abilities, impairments with cognition and perception. The functional status of stroke patients recovers with 6 months, marked by fast recovery during first month[13].

One of a classic motor impairment encountered post stroke is loss of hand function. One essential characteristic of human upper limb is a high degree of manual dexterity. Finger timing, kinematics and force all independently control the complex interaction between motor and sensory elements of hand and fingers Stroke frequently results in diminished manual dexterity and impaired hand functions, limiting Activity of Daily Living, and decline quality of life.

Post- stroke, hand recovery can be protracted process interfering with activities. So, rehabilitation activities that are performed consistently boost likelihood of hand recovery. Hand function is frequently the slowest to recover post- stroke. This is because, the hands and feet are distal to the midline of the body and are also distal to the midline of the body and are also furthest from brain and spinal cord. This extends the signal travelling distance to communicate effectively. Post stroke, communication is frequently delayed or impeded resulting in impaired hand function.

Rehabilitation exercise is probably the most important part of fine motor recovery after stroke. Intentional hand movements are essential for regaining lost functions and it is critical to start exercising as soon as feasible.

Traditional protocol focuses on strengthening regimen, whilst prime goal after stroke is associating brain to body through conscious movement. This promotes motor relearning and better ADL performance.

However, the changing paradigm of the rehabilitative sciences, gaming consoles have emerged as a patient's recovery by stimulating their minds, enhancing focus and encouraging social contact. The implication of games or virtual reality is a new avenue for developing new motor connections in the brain and increasing capacity to accomplish the arm movements.

The aim of the present study was to investigate the efficacy of application- based activities on hand dexterity in patients with sub- acute stroke. The variables of the current study were Score of 9 Hole Peg test (secs), Score of Chedoke Arm and Hand Activity Inventory (CAHAI). A total of 20 subjects were enrolled in this study.

The objectives of the study were to evaluate hand dexterity by using application- based hand activities in patients with sub-acute stroke, to evaluate arm and hand function using application-based hand activities in patients with subacute stroke. The subjects were divided into two groups that is Group A and Group B. Group A was Interventional Group and Group B was a Control Group with a total of 10 subjects in both the groups with sub-acute stroke. Both the groups received the treatment for 9 weeks;5 days per week with a total minimum duration of 60 minutes to 65 minutes per day. All the patients underwent a training session for 5 days in order to acquaint them to the application – based games and the usage of tablet. The patients were assessed at baseline and post intervention 9 weeks for Dexterity, and Arm and Hand Function using Nine Hole Peg Board, Chedoke Arm and Hand Activity Inventory (CAHAI).

The analysis was obtained using the SPSS software version 18. Level of significance 0.05 was used to determine the statistical significance. Unpaired t test and paired t test were used as a statical tools in this study. Both within group and between the group analysis was done to analyze the dependent variables (Score of 9 Hole Peg test (secs), Score of Chedoke Arm and H and Activity Inventory (CAHAI).

It was hypothesized that there would have been statistically non-significant and significant differences among Hand Dexterity, and Arm and Hand Function.

The demographic details for the age of the subjects were found to be 55.30±5.755 and 51.20±5.884 for Group A and Group B respectively.

The demographic data for the gender of subjects showed values 60% male and 40% female for Group A and in Group B 70% was under male and 30% under female category.

After analysis, It was found that within group the scores for hand dexterity for Group A showed a mean change of 306.00± 66.030 at baseline and 210.00±70.711 at 9^{th} week. The score for the hand dexterity for Group B showed a mean change of 282.00±69.570 at baseline and 240.00±63.246 at 9^{th} week. In our study, the mean difference for the hand dexterity for Group A From baseline to 9^{th} week is 96.00 while for Group B the mean difference come out to be 42.00 from baseline to 9^{th} week.

The result of mean for CAHAI for Group A was 25.10±2.885 at baseline and 33.70±1.947 at 9^{th} week. For Group B the mean value was 24.00±1.247 at baseline and 32.40±3.836 at 9^{th} week. The mean difference for CAHAI of Group A and Group B was 8.60 and 8.40 respectively.

Between the group analysis was carried using unpaired T test for all the parameters.

Between the group difference for hand dexterity was found to be 306.00±66.030 and 282.00±69.570 for Group A and Group B at baseline and 210.00±70.711 and 240.00±63.246 for Group A and Group B respectively at 9^{th} week.

Between the group difference for arm and hand function CAHAI was found to be 25.10±2.885 and 24.00±1.247 for Group A and Group B at baseline and 33.70±1.947and 32.40±3.836 for Group A and Group B respectively at 9^{th} week.

While analyzing within the group analysis for hand dexterity for Group A and B, the results were found statistically significant wit P value less than 0.001 for Group A and 0.0013 for Group B.
For grip strength it was found that the results were statistically significant for both the groups with a P value of 0.0011 for Group A and P value of 0.0006 for Group B.
The score for CAHAI score were also found to be statistically significant with P value less than 0.001 and 0.001 for both the groups.
Statistically non- significant were obtained for between the group difference for hand dexterity component with P value of 0.4391 and 0.3306 for Group A and B respectively at baseline and 9thweek.
It was found that after between the group analysis for arm and hand function using CAHAI scale the results were also non- significant with P value of 0.2830 and 0.3518 respectively for the groups.
The similar results were shown by a study conducted by **Kizony.R, Zeilig.G, Rand.D**[10]in 2016 which reported that studies done in the past using tablet-based games for dexterity was beneficial. There was total 172 subjects taken without disability. Falling under subjects without disability, young adults, older adults, middle aged and other group taken with stroke and impairment in upper extremity. All subjects played (tap- it game.). Of the 20 individuals with stroke, 15 were able to complete the two trials of the tapping activity, but all participants reported enjoying the experience and believed the apps may have promise for stroke rehabilitation to enhance performance of the stroke-affected hand or Impaired hand dexterity impacted tablet app-based hand activities in both older individuals without disabilities and those with stroke. Tablet apps could help improve hand dexterity and function after stroke by allowing for self-training of repeated, task-oriented movements as well as isolated finger movements.
Vanbellingen T, Filius SJ, Nyffeler T, Van Wegen EE[2] in 2017 The study aims to evaluate the usability of VBT using a Leap Motion Controller (LMC) to train fine manual dexterity in the early rehabilitation of stroke patients as an adjunct to standard care. In addition, this study aimed to assess the feasibility and potential effectiveness of VBT. 64 stroke patients were screened for eligibility. A nine-hole test, skill questionnaire was used. Patients significantly improved manual dexterity. No changes in upper extremity motor impairment (FM-UE) were observed during the intervention. VBT using LMC is a useful rehabilitation tool for skill training in early stroke recovery patients. LMCs were useful in several ways. First, the LMC is a small and light USB power supply that can be connected to any computer. Second, the integrated software installation is easy to use. Third, there is no need for an expert, because the device traces do not need to be attached to the hands. This pilot study is the first to evaluate the utility of VBT and LMC for manual dexterity training early in rehabilitation for stroke patients in addition to standard care.
Rand D, Zeilig G, Kizony R[12] in 2015 similar studies showed touch screen tablet for manual dexterity training in post-stroke patients. : Dexterity impairment in the weaker upper limbs is common after a stroke, and it is recommended that these individuals practice multiple movements to restore function. However, stroke rehabilitation methods do not reach the strength necessary to be effective. Touch screen tablet technology can be used as a motivational tool to train weaker upper limb dexterity after a stroke. All participants are asked to exercise for 60 minutes a day. Rehab-let can be used during subacute rehabilitation to increase treatment intensity and improve accessibility. It is possible that the Rehab-let can be used after hospital discharge and could be ideal for people with mild strokes who are not often referred to formal rehabilitation. Rehab-let has proven to be an effective tool in improving upper limb function, particularly dexterity, self-training protocol adherence (self-training time) and satisfaction.

Sawant. N, Bose.M, Parab.S[14] in 2020 their study revealed that advanced treatment options such as app. therapy provides repetitive practice that can be helpful in improving fine motor skills. The effect of application-based therapy compared with conventional manual therapy on improving stroke skill in 39 people in the first year of stroke in three groups. Group A received conventional hand care; Group B received a statement treatment, while group C received conventional treatment with app therapy All groups showed significant results in hand function. Applied therapy, used as an adjunct to conventional treatment, has been found to be effective in The results of our study are consistent with the results of research carried by **Kottink AI, Prange GB, Krabben T, Rietman JS**[15] in 2014 the study manifest state to compare the effect of reach training achieved using a rehabilitation game designed for the target group with updated standardized post-stroke grip training. The study showed that both arm and hand function improved as much after training with a recovery game as after timed normal training. **Carmeli E, Peleg S, Bartur G, Elbo E, Vatine JJ. HandTutorTM**[16] in 2010 the study an apparent finding that assessed the potential therapeutic benefit of using HandTutorTM in combination with traditional rehabilitation in subacute post-stroke. The study compares an experimental group receiving traditional therapy with Hand Tutor TM therapy to a control group receiving traditional therapy alone. The results of this pilot study support further research into the use of HandTutorTM in combination with traditional occupational therapy and physical therapy during rehabilitation of hand function after stroke.
The results of study carried out by**Afsar SI, Mirzayev I, Yemisci OU, Saracgil SN**.[17] in 2018 also showed the effects of the Microsoft Xbox 360 Kinect video game system on upper extremity motor function in subacute stroke patients and it was found that kinect-based gaming system may have additional benefits for stroke patients in addition to conventional treatment. However, virtual reality gaming systems were routinely used in stroke rehabilitation.
Choi JH, Han EY, Kim BR, Kim SM, Im SH, Lee SY, Hyun CW [18] in 2014 manifests the use of commercial game-based virtual reality (VR) therapy for paretic upper limb rehabilitation in subacute stroke patients showed that grip strength improved significantly only in the case group. There were no significant differences between groups before and after treatment. The results suggest that commercial game-based VR therapy was as effective as traditional OT therapy in restoring upper extremity motor and daily activities in subacute stroke patients. commercial game programs were designed for healthy people and feedback was given based on the movement itself. There were no significant differences between groups before and after treatment which matches with our study results for the component of Hand Dexterity, Grip Strength, Three Jaw Chuck and Arm and Hand function. Only Pad to Pad Pinch Strength and Pad to side Pinch strength have showed statistically significant observations for between the group differences in our study.
A study conducted by **Subramanian et al**[19] supported that the clinical outcomes for the patients who are affected moderately to severely have shown improvement with a usability of virtual training. **Bao et al**[20]which evaluated a use of X vox Kinect on five sub-acute stroke patients. The results of the study stated that there were a significant improvement in Fugl- Meyer scores. However, this study differed from ours with respect to taking functional resonance imaging.
A study carried out by **Lee**,[21] also advocated the use of game-based rehab (X vox Kinect) for improvisation of strength and tone of upper extremity muscles and ADLs in patients with chronic stroke. The results of their study stated that the functional Independence Measure scores improve significantly in the training group with no differences between the groups.
The possible mechanism behind incorporating virtual training post stroke can be contributed to cortico-

motor reorganization when the affected side is used. frequently.[22] Long term performance results in plasticity that have been linked to muscular actions and rewiring and rearrangement which enhances the functionality.

Various inferences have been documented for planned rehabilitation post stroke. It has been significantly noted that higher levels of severity with regard to disabilities and lack of functional capacities area major contributing factor for less active exercises during rehabilitation. A structured evaluation for the factors determining the patient participation should be incorporated in clinical practice, thereby promoting patient's recovery

CHAPTER 7
LIMITATION AND FUTURE SCOPE
LIMITATIONS OF THE STUDY

- In our study the patient did not have a follow- up protocol.
- The duration of the gaming program should have been of longer duration for more precise functional outcomes.
- The study lacked randomization component.
- The time taken for the patients to complete the gaming task was not taken into consideration

FUTURE SCOPE OF THE STUDY

- A comparative study for assessing the outcomes for hand function at different stages of stroke (acute, sub-acute, chronic) using gaming technology can be undertaken.
- In order to establish the practicability of tablets and virtual training, larger samples should be incorporated.
- The pertinence of self-training program using game-based measures should be considered into the rehab process as an evidence base practice.

CHAPTER 8
CONCLUSION

To summarize, it can be concluded that from the findings of our study that substantial employability of gaming technology along with the conventional rehabilitation for management of post stroke hand function for ameliorating decease dexterity and strength should be encompassed.

As per the tablet-based games included in our study, it was noticed that the patients were found to perform dragging (Fruit ninja, puzzles), tapping (Tap titans, Pop us), games easily. Whereas it was found that the stretching games (, Zoom art, Super zoom),) were perceived as being difficult.

It could be thereby concluded that incorporating game-based rehabilitation along with conventional protocol is attainable and admissible at patients' perspective.

It is indeed relevant to mention that gaming helps the population reach their health objectives.

It is worth mentioning that dwelling technological aspects and virtual environment in rehabilitation promotes novelty, is fun based, diminishes the boredom associated with conventional measures. It has been noticed in our study clinically that the participation level among game-based group was better when compared to control.

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