Research article

Graded repetitive arm supplementary programme (GRASP) and virtual reality to improve upper limb function in patients with acute stroke - An experimental study

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(Received: September 2022 Revised: January 2023 Accepted: January 2023)

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ABSTRACT

Introduction and Aim: The objective of the study is to improve upper limb function in patients with acute stroke using graded repetitive arm supplementary program (GRASP) and virtual reality. Stroke is described as an sudden neurological outburst brought on by impeded blood flow via the brain's blood vessels. Stroke has an annual mortality rate of 5.5 million which is the 2nd leading cause of mortality.

Materials and Methods: Fourteen patients were randomly split into two groups, Group A and Group B in A.C.S Medical College and Hospital. Inclusion criteria were persons with first ever acute stroke confirmed by CT or MRI, modified Ashworth scale less than 2, Fugl- Meyer score between 10 to 57, age > 18, both genders, eager participants who are willing volunteers for the study. Exclusion criteria were who were mentally unstable, other neurological conditions, any orthopaedic conditions, modified Ashworth scale more than 2, Fugl Meyer score less than 10 or more than 57, age group < 18, patients with TIA were excluded. Group A trained with GRASP program. Group B trained with virtual reality. Both groups consist of 7 patients and training given for 8 weeks, 60 minutes per day for 6 days a week.

Results: This study demonstrates a statistically significant difference between group A and group B in the hand-held dynamometer, Fugl-Meyer evaluation upper extremity, action research arm test, and EMG with a p value of 0.001. However, when compared to group B, group A exhibits greater relevance across the board.

Conclusion: The study concludes that graded repetitive arm supplementary programme in acute stroke patients demonstrates good recovery in upper limb function.

Keywords: Stroke; virtual reality; GRASP; dynamometer.

INTRODUCTION

The World Health Organization defined stroke in 1970 as having promptly manifested clinical indications of a focal disruption of brain function that lasted for more than 24 hours or resulted in death, with no other etiological explanation other than vascular origin (1). With 13 million new cases each year, stroke is the second leading cause of death and disability (2). Nearly 5.87 million stroke deaths occurred worldwide in 2010, up from 4.66 million in 1990, according to the Global Burden of Disease study that was updated with further work. This showed a 26% rise in global stroke mortality over the previous two decades (3).

One of the major causes of illness and mortality worldwide is acute stroke (4). Risk factors are in two categories: modifiable and non-modifiable. Modifiable risk factors include hypertension, diabetes mellitus, cardiac factors, alcohol intake, smoking, inflammation, obesity, hyperlipidaemia, and sedentary behaviour (5). A sudden severe headache, sudden confusion or difficulty speaking or understanding speech, sudden difficulty seeing in one or both eyes, sudden difficulty walking, dizziness or loss of coordination and balance, sudden numbness or weakness on the face, arm, or leg, usually on one side of the body, sudden severe headache, and sudden difficulty with speech are all stroke symptoms (6). Upper limb motor impairment is one of the most prevalent deficits following stroke and has a substantial influence on disability and health. Due to the various recovery patterns of upper limb function, each patient will require a particular approach to rehabilitation (7).

In the field of stroke rehabilitation, novel therapy modalities like virtual reality and interactive video games are emerging. These assignments give the chance to practise skills that cannot or are not practised in a therapeutic setting (8). Virtual reality offers simultaneous feedback, may be customised to a person's abilities, and aids in involving and inspiring the stroke victim to meet his or her therapeutic objectives. People recovering from strokes can benefit from using virtual reality (9). GRASP is a self-directed training programme for the hands that combines strengthening exercises with practise of individual upper-limb movements and upper-body movements as a whole (10). A Canadian researcher created the GRASP hand programme, which has three levels of manual and a graded progression of exercises that include range-of-motion, stretching exercises, functional strengthening exercise, trunk control, weight bearing through the hand, repetitive bilateral arm tasks, and repetitive paretic arm practise (11). The 33 tasks that make up the FMA-UE (Fugl-Meyer assessment of upper extremity) are each given a score on a 3-point ordinal scale (0 = cannot perform, 1 = partially performs, and 2 = fully performs). The overall score might be as low as 0 (hemiplegia) or as high as 66 points. It evaluates coordination, shoulder, elbow, forearm, wrist, and hand reflexes, as well as movement (12).

After stroke, the ARAT (Action Research Arm Test) exhibits strong sensitivity and validity associated to therapy and spontaneous recovery. It has been demonstrated to be helpful in past studies analysing stroke patients with a variety of disabilities. High levels of both intra and inter-rater dependability have been recorded (13). Using portable dynamometry, the paretic upper limb's isometric strength was evaluated (14). Electromyography (EMG) can measure co-contraction and simultaneous activation of agonist and antagonist muscles, but this phenomenon is frequently described qualitatively (15). In order to improve upper limb function in stroke patients who are experiencing an acute stroke, this study will contrast the efficacy of virtual reality with the GRASP programme.

MATERIALS AND METHODS

The research design involved a comparison of pre- and post-testing. Two groups of the 14 samples were created using the random sampling procedure. The study was conducted for 6 months with intervention duration for about 8 weeks in ACS Medical College and Hospital, Physiotherapy Outpatient Department, Velapanchavadi, Chennai. Patients who had first ever stroke, confirmed by CT or MRI, acute stroke between 1 month to 3 months, Modified Ashworth Scale (MAS) score less than 2, Fugl Meyer score between 10 to 57, 10° of active wrist flexion and extension, Age > 18, male and female who were interested in taking part in the study were included. Modified Ashworth scale (MAS) more than 2, Fugl Meyer score less than 10 or more than 57, age group less than 18, patients with transient ischemic stroke, who were mentally unstable, other neurological conditions, upper limb fracture or other orthopaedic conditions were excluded in this study. The outcome measures used are Fugl Meyer assessment upper extremity, action research arm test, hand held dynamometer, electromyography. Materials used in the study includes Samsung M31 Phone, VR headset, VR motion controller, buttoned shirt, target board, tennis ball, wrist weight (0.5-1 lb), hand gripper, knife and fork, towel, cup, various sizes of Lego, blocks of various sizes, paper clips of various sizes, Thera putty and jars of various sizes.

By using the random sampling technique, the 14 samples were split into two groups. Group A received GRASP training and group B received virtual reality for 8 weeks. Regarding the study and the training programme, the samples were completely detailed. The samples signed the consent form to indicate their agreement to take part in the investigation and demographic data such as age, sex, address, height, weight is collected from them ensuring confidentiality of the collected information. Questionnaire were filled by the samples before and after the study.

Group A

GRASP programme consists of 3 levels, progressed based on Fugl- Meyer score Level 1-10- 25, Level 2-26-48, Level 3- 46-58.It consists of 7 patients trained with grasp program, it is given for 8 weeks of 60-minute session for 6 days a week. Exercise includes strengthening of arm and hand, stretching, range of motion and gross and fine motor skills, weight bearing. It can be divided into 2 sets of 30 minutes session. 30 sec breaks between each exercise.

GRASP level 1 exercise manual It consists of total arm stretch Shoulder shrug, The twist, Hand and wrist stretch, Push-ups, Shoulder exercises, Elbow exercises, Wrist exercises, Grip power, Squeeze, Finger power, Waiter – cup, Start the ball rolling with a partner, Start the ball rolling with no partner, Wash cloth.

GRASP level 2 exercise manual consists of total arm stretch, Shoulder shrug, Hand and wrist stretch, One arm push-up, Chair-ups, Shoulder exercises: arm to the front and to the side, Elbow exercises and wrist exercise, Grip power, The twist, Cutting, Waiter – ball, Drop and catch ball, Buttons, Lego, Hanging up clothes, Jars, Drying Off.

GRASP level 3 exercise manual consists of total arm stretch, Shoulder shrug, The twist, Hand and wrist stretch, One arm push-up, Chair-ups, Shoulder exercises: arm to the front and side, Elbow exercises, Wrist exercises, Grip power, Cutting, Advanced waiter – ball, Pouring, Drop and catch, Button, Lego, Paper clips, Jars, Drying off.

Group B

It consists of 7 patients trained with virtual reality. Virtual reality is given for 60-minute session, 6 days a week for 8 weeks. Patients sitting in a chair, VR motion control and VR headset are given to patients, it can be divided into 3 sets of 15 minutes session, 5 minutes rest between each session. The objective of the game is to promote upper limb function.

Three games each played for 15 minutes includes dinosaur VR shoot, ping pong and archery.

Dinosaur VR shooter the participant is a shooter and must stop dinosaur to come near the shooter. This game involves repeated shooting of dinosaur with involved upper limb in all direction. This game results in movement of upper limb in all direction cause shoulder flexion and extension, small degree of abduction, elbow flexion and extension, finger movements. Scores are noted.

Ping pong is a table tennis game. Participant holds the racket and serves the ball. Participant has to hit the ball using the racket with the help of joystick controller, with the involved upper limb in all direction. This game involves moving of hand in all directions in order to hit the ball. Total scores are counted.

In archery participant has to use arrow to hit the target board with involved upper limb with the use of joystick. Points will be based on participant hitting the target. Game overs once he repeatedly missing the target. Scores are noted.

As patient shows moderate degree of changes in movement abilities and games scores, the difficulty level of applications was progressively increased.

Data analysis

Using both descriptive and inferential statistics, the gathered data were tallied and examined. Version 24.0 of the statistical package for social science (SPSS) was used to evaluate all the parameters. To determine the statistical difference between the groups and the statistical difference within the groups, paired t-test and independent t-test were used, respectively.

Table 1: Comparison of Fugl-Meyer assessment and Action Research Arm Test between group A and group B in pre-test and post test

		Group A		Group B			
Scores		Mean	S.D.	Mean	S.D.	t-Test	Significance
	Pre Test						
		46.42	7.72	43.57	6.7	0.739	.474*
FMA	Post Test						
		113.43	1.71	90.28	1.97	23.383	.000**
	Pre Test						
		15.28	1.79	14.71	1.7	0.61	0.553
ARAT	Post Test						
		48.28	2.36	40.42	2.07	6.621	.000**

(*- P > 0.05, **- P ≤ 0.001)

The Fugl-Meyer Assessment and Action Research Arm Test scores for groups A and B are not significantly different from one another in the pre-test values (*P > 0.05), according to this table. The Fugl-Meyer Assessment and Action Research Arm Test post-test results for Groups A and B are significantly different from each other, as shown in this table (**P 0.001).

The post-test means for both groups indicate a considerable gain, but Group A, with a higher mean value, is more successful than (group B).

Table 2: Comparison of hand-held dynamometer score between group A and group B in pre-test and post test

HHD	Group A		Group B			
	Mean	S.D.	Mean	S.D.	t-Test	Significance
Pre Test	1.28	0.48	1.14	0.37	0.612	.552*
Post Test	4.14	0.69	2.28	0.48	5.814	.000**

(*- P > 0.05, **- P ≤ 0.001)

The pre-test hand held dynamometer score between group A and group B does not significantly differ from Group A's pre-test value (*P > 0.05), according to this table. The post-test values of the hand held dynamometer score between Group A & Group B differ significantly, as shown in this table (**P ≤ 0.001).

Both groups exhibit a considerable rise in post-test means, but group A, with a higher mean, performs better than group B.

Table 3: Comparison of electromyography scores between group A and group B in pre-test and post -test

EMG		Group A Mean	Group A S.D.	Group B Mean	Group B S.D.	t-Test	Significance
Extensor Digitorum	Pre Test	315.57	38.66	328.14	40.83	0.591	.565*
	Post Test	636.71	31.8	442.57	47.98	8.923	.000**
Triceps	Pre Test	101.37	16.32	112.17	25.49	0.944	.364*
	Post Test	334.9	45.92	220.63	23.66	5.853	.000**
Biceps	Pre Test	320.57	39.28	351.8	29.94	1.673	.120*
	Post Test	544.14	34.01	428.04	19.43	7.841	.000**

(*- P > 0.05, **- P ≤ 0.001)

According to this table, there is no discernible difference between group A and group B's pre-test EMG levels (*P > 0.05). The post-test EMG readings between group A and group B differ significantly from one another, as seen in this table (**P 0.001).

The post-test means for both groups indicate a considerable gain, but group A, with a higher mean value, is more successful than (Group B).

RESULTS

In Table 1, the Fugl-Meyer and action research arm test comparing the means of groups A and B reveals a highly significant improvement in the post-test mean, but group A demonstrates (FMA-113.43 & ARAT-48.28) higher mean value is more effective than group B (FMA-90.28 & ARAT-40.42) at P≤0.001, thereby denying the null hypothesis.

In Table 2, comparing the means of groups A and B on a hand-held dynamometer reveals a highly significant increase in the post-test mean, while group A exhibits a higher mean value (4.14) and is more effective than group B (2.28) at P≤0.001, denying the null hypothesis.

When group A and group B electromyography mean values are compared, the post-test mean shows a highly significant improvement for both groups, but group A higher mean value is more effective than group B lower mean value (ED -442.57, Triceps - 220.63, Biceps - 428.04) at P≤0.001, denying the null hypothesis.

DISCUSSION

The aim of the study is to enhance upper limb function following acute stroke. Improvement of upper limb function is done with GRASP programme and virtual reality. Both GRASP programme and virtual reality showed a better significant outcome in improving upper limb function and strength. Every year, 15 million people suffer from stroke throughout the world. Motor impairment is the most widely caused impairment by stroke, which cause restriction in function such as muscle movement and mobility.

GRASP is a low-cost self-administered program which involves range of motion, strengthening, weight bearing, trunk control, hand skills and coordination. Virtual reality is task-oriented training which helps in neuroplasticity and CNS reorganization, it is found to activate the mirror neurons to improve functions. Virtual reality tends to cause functional recovery of deficits of upper limb. When compared with virtual reality, GRASP shows better outcome because it concentrates on various disciples including strength of upper limb, range of motion, trunk control, hand skills and coordination with easily available objects. Previous study results support the GRASP program and virtual based game training.

Perez-Marcos *et al*, concluded that the VR system could provide chronic stroke survivors with intense training and substantial rehabilitation doses (16). Stewart *et al*., concluded that the VR system and activities used in this pilot study offered a demanding practise setting that permitted personalised practise advancement (17).

Simpson *et al*., stated that GRASP has been widely used and that studies have shown it to be helpful for improving upper limb function and used during inpatient rehabilitation (18). Sahu *et al*., stated that VR can make deliberate actions more intense, and it dramatically increases neuroplasticity during rehabilitative therapy (19). Ji and Lee stated that the mirror neuron theory provides the neurobiological foundation for the usage of VRT. The mirror neuron was active during VRT pre-motor cortex imaging in monkeys (20).

Harris *et al*., stated that the GRASP procedure was discovered to be a secure, quick, inexpensive, and treatment-effective way to enhance upper limb rehabilitation in the subacute stage of stroke (21). Yang *et al*., stated that using rigorous, repeated, and task-specific practise, the Graded Repetitive Arm Supplementary Program (GRASP) is a self-administered UE rehabilitation therapy for stroke victims (22). Stegeman *et al*., concluded that the EMG as a scientifically founded set of experimental methods in the study of human movement (23).

McDonnell concluded that the ARAT is a useful tool for upper limb rehabilitation and clinical research because it provides an accurate and sensitive measure of functional limitation in the upper limbs. (24). Bohannon concluded that the ease of hand-grip dynamometry supports its use, as any of the dynamometrically assessed motions are sufficient for characterising strength of either side following stroke (25).

GRASP showed a better outcome when compared with virtual reality because GRASP is feasible, inexpensive and safe program to improve upper limb function, it's very easy to perform without any special or expensive equipment and it can be progressed and graded according to patient inability. It is neurorehabilitation intervention which is intensive, specific and task-oriented training. Every protocol of grasp program is goal oriented which provides sensory and visual feedback to patient and make them aware of their abilities. It concentrates on every aspect include ROM, hand skills, strengthening, weight bearing, stretching.

Limitation of the study

The study sample size is modest, and its time span is brief. Only acute stroke patients were included in this study.

CONCLUSION

This study concludes that graded repetitive arm supplementary program (GRASP) and virtual reality shows a good improvement in patients with acute stroke. But when compared with virtual reality, graded repetitive arm supplementary programme (GRASP) showed a great significant outcome in patients with acute stroke. Hand dynamometer showed a better improvement in hand strength in GRASP group when compared with virtual reality group. Both Fugl-Meyer assessment of upper extremity and action research arm test demonstrated an improved result in GRASP group than virtual reality group. EMG amplitude shows increased muscle contraction in GRASP group than in virtual reality group. Therefore, the study concludes that grades repetitive arm supplementary program in acute stroke patients demonstrates good recovery in upper limb function.

CONFLICT OF INTEREST

Authors declare that there is no conflict of interest.

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