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Effect of Gamification for Hand Grip, Hand Function and Stress among Patients with Hemiparesis – A Pilot Study

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Abstract

Hemiparesis, commonly resulting from stroke, significantly impacts hand function, strength, and overall quality of life. Traditional rehabilitation often lacks engagement, leading to low adherence and slower recovery. Gamification, which incorporates game elements into therapeutic exercises, has shown promise in enhancing rehabilitation outcomes. This pilot study aimed to explore the effect of gamification on hand grip strength, hand function, and stress reduction among patients with hemiparesis. A total of 10 participants were randomly divided into two groups with blind fold method, labelled as group A and B, each comprising 5 participants. Over a six -week period, Group A underwent gamification as a therapeutic exercise, while Group B underwent conventional therapy. The two groups' results discovered a statistically significant variance with the "P-value" was <0.001 in hand function (Jebsen taylor hand function test) post-test. The hand grip strength (Dynamometer) the pre and post-test values for group A and B were assessed as same as above, here for between group comparison statistical difference was not significant for the post test (p<0.07), in group A alone post test results showed statistically significant difference, with "P- value" of <0.001. Finally for the stress post values of PSS showed statistically significant difference. This current study showed that gamification was effective in improving the hand function and grip strength of patient with hemiparesis and specifically it helped in the fine dexterity function improvement and also helped in the reduction in stress level.

Keywords: *Dexterity, Gamification, Grip Strength, Hemiparesis, Psychological Status.*

Introduction

World Health Organization reports that millions of people are affected by strokes every year, making them one of the main causes of long-term impairment globally, stroke results in significant physical, cognitive, and emotional challenges, with hand function impairment being one of the most common and debilitating consequences [1]. A person's capacity to carry out everyday tasks can be notably restricted by a loss of hand grip strength and general hand function, which can result in a higher reliance on caretakers and a lower quality of life [2], particularly in intracerebral haemorrhage, low serum magnesium and high ferritin are linked to greater risk, with higher mortality observed after rt-PA treatment regardless of gender [3, 4]. Rehabilitation following a stroke often focuses on restoring these essential functions, yet traditional therapeutic approaches may not fully engage patients or promote optimal recovery outcomes.

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The relationship between hand grip strength, hand function, and stress levels in stroke patients is multifaceted. Hand grip strength is a critical indicator of overall physical health and functional ability [5]. Studies have shown that improvements in hand grip strength are associated with better functional outcomes and increased independence in activities of daily living [6] Furthermore, the psychological aspect of rehabilitation cannot be overlooked. Many stroke patients experience significant levels of stress and anxiety, which can hinder their recovery. The integration of gamification in rehabilitation programs may not only enhance physical rehabilitation outcomes but also serve as a tool to reduce stress and anxiety levels.

Recently, there's been a surge of interest in using gamification as a groundbreaking way to boost rehabilitation results for stroke patients, offering a new and engaging approach to recovery. Gamification is the practice of applying aspects and concepts of game design to non-gaming contexts, like healthcare and rehabilitation, in order to inspire and involve people in their recovery process[7], by incorporating elements like scoring systems, challenges, rewards, and social interaction, gamification has the potential to transform the often monotonous and tedious rehabilitation exercises into engaging and enjoyable experiences by promoting engagement and enjoyment through gamified interventions, patients may experience a decrease in perceived stress and anxiety, leading to improved mental well-being. This interplay between physical rehabilitation, psychological well-being, and the effects of gamification presents a compelling area for exploration. Game-based interventions have also shown effectiveness beyond neurorehabilitation [8].

Research on gamification in rehabilitation has begun to yield promising results, but there remains a need for further investigation, particularly in the context of stroke rehabilitation. The purpose of this study is to investigate how gamification affects stroke patients' stress levels, hand function, and grip strength. By evaluating the impact of gamified interventions, this research seeks to contribute to the growing body of knowledge on innovative rehabilitation strategies and their effectiveness in improving outcomes for stroke survivors, Numerous gamified tools and software for rehabilitation have surfaced, encompassing virtual reality setups and mobile applications that promote physical activity by means of game-like tasks. These systems can create a tailored rehabilitation experience by tracking progress, giving real-time feedback, and adjusting to the needs of each unique patient [9]. For stroke patients, who may have varying degrees of impairment, such adaptability is crucial for ensuring that exercises remain both challenging and achievable.

Stroke survivors often benefit from sharing experiences and challenges with peers who understand their struggles, and gamified approaches can facilitate this interaction in a fun and supportive environment, the objective of this research is not only to assess the immediate effects of gamified interventions on hand grip strength and function but also to examine the stress reduction among stroke patients, by employing a mixed-methods approach, this study will utilize both quantitative measures—such as grip strength assessments and functional hand assessments—and qualitative feedback from participants regarding their experiences with gamification in rehabilitation and examining these relationships [10], in future there is a more effective patient-centered rehabilitation interventions that promote recovery and improve overall well-being. Jebsen Taylor hand function test [11, 12] is a useful test for assessing hand dexterity and general hand function, the test consists of seven sub-tests with each subtest timing were calculated and with overall timing score were calculated, the greater the time were taken by participant

denotes higher the level of impairment also used in prognosis for the given treatment. Digital Hand dynamometer, it is used to measure grip strength, an important aspect of hand function and overall upper extremity performance. A common clinical indicator of a person's physical condition, functional state, or recuperation following an accident is grip strength, a quantitative, objective measurement is provided by the hand dynamometer [13], in this study digital hand dynamometer were used and values measured in kg [14] and Perceived stress scale, it is used to measure the perception of stress in an individual's life and scores between zero and forty [15].

Materials and Methods

Participants

For this pilot trial, ten subjects with a common demographic profile and aged between 30 to 50 years with a diagnosis of middle cerebral artery (MCA) stroke and in brunnstorm arm recovery (stage 4) were chosen from a suburban hospital, both male and female who gave their consent to participant and agreed to follow were included. The subjects with cognitive decline, communication difficulties and auditory/ visual impairments were excluded.

Ethical Clearance: 02/012/2024/ISRB/PGSR/SCPT

Procedure

A blindfold approach of basic randomization was used to select 10 participants for the study and Participants were randomly allocated into two groups experimental (n = 5) and control (n=5) by sealed envelope method. this was a randomized feasibility study. Each participant had a planned six-week rehabilitation program over five days of the week, including 45-50 minutes sessions each day. A pre-test, such as Jebsen taylor hand function test, hand dynamometer and perceived stress scale were used to assess the participants hand function, grip strength and stress levels before therapy. During a period of six weeks selected group of android mobile based free games with a pebble holding game were given to participants in a suitable environment along with standard physiotherapy treatments for muscle tone, upper limb ROM & strengthening exercises. Each game targeted active use of affected hand, to improve their reaction time and hand function which translated into their adl activities. The app games include Fruit ninja, Schulte table, Piano tiles, whack a mole, temple run and fruit ninja with a traditional game of pebbles holding and catching for hand eye co-ordination [16, 17]. Group B received conventional therapy (peg board activities, hand exercises) along with standard physiotherapy. Jebsen taylor hand function test and hand dynamometer were evaluated four weeks following the intervention also perceived stress scale used to evaluate the stress levels of the participants.

Outcome Measures

1. Jebsen Taylor hand function test
2. Digital hand dynamometer
3. Perceived stress scale

Statistical Analysis

The assessment involved conducting pre-tests on Groups A and B using Jebsen taylor hand function test and grip strength before the intervention. Following a 6-week intervention, both groups underwent post-tests, including Jebsen taylor hand function and grip strength, along with perceived stress score also noted. The Paired ‘t’ was employed for within groups results for both group A& B, while the Unpaired ‘t’ test was utilized to assess the post test variations in both the groups for hand function and handgrip strength which was assessed by Jebsen taylor hand function test and hand Dynamometer. Additionally, for the scale PSS-10 unpaired test value was employed to get the post variations followed by treatment.

Result

In the statistical evaluation of the collected data for Jebsen taylor hand function test, values before and after within Groups A and B were evaluated with the paired 't' test (Table 1)**,** the Unpaired 't' test was used to examine the post-test results for hand function (Jebsen taylor hand function test) between groups A and B (Table 2). In group A the mean and "S.D." was 36.58±3.99 and in group B the mean and SD was 16.8±4.85 with the T value of 7.04. The two groups' results discovered a statistically significant variance with the "P-value" was <0.001 in hand function (Jebsen taylor hand function test) post-test. The hand grip strength (Dynamometer) the pre and post-test values for group A and B (Table 3) were assessed as same as above, the unpaired 't' test was used to examine the post test results for hand grip strength between group A & B (Table 4). In group A mean and "S.D." was 2.94±0.14 and in group B 2.58±0.37 with T value of 2.0348, here for between group comparison statistical difference was not significant for the post test (p<0.07), in group A alone post test results showed statistically significant difference, with "P- value" of <0.001. Finally for the stress post values of PSS showed statistically significant difference with T value of 2.713 and "P value" of <0.001 for between groups A and B (Table 5).

Table 1. Pre and Post-test Values of Group A and Group B Obtained using Jebsen Taylor hand Function Test

Groups	**Test**	**Mean**	**SD**	**Paired test (T value)**	**P value**
Group A	Pre-test	101.32	18.97	18.3047	<0.001
	Post-test	64.74	15.82		
Group B	Pre-test	100.18	7.76	6.9335	<0.0023
	Post-test	83.38	11.32		

Table 2. Post-test of Group A and Group B Obtained using Jebsen Taylor Hand Function Test

Groups	**Test**	**Mean**	**SD**	**MEAN & SD (difference value)**	**Un Paired test (T Value)**	**P value**
Group A	Post-test	64.74	15.82	36.58±3.99	7.0425	<0.0001
Group B	Post-test	83.38	11.32	16.8±4.85		

Table 3. Pre and Post-test Measurements of Group A and Group B were Obtained using Digital Hand Dynamometer

Groups	**Test**	**Mean**	**SD**	**Paired test (T value)**	**P value**
Group A	Pre-test	7.42	1.33	39.28	<0.001
	Post-test	10.36	1.26		
Group B	Pre-test	6.22	1.01	13.91	<0.002
	Post-test	8.8	1.35		

Table 4. Post-test of Group A and Group B Obtained using Digital Hand Dynamometer

Groups	**Test**	**Mean**	**SD**	**MEAN & SD (difference value)**	**Un Paired test (T Value)**	**P value**
Group A	Post-test	10.36	1.26	2.94±0.14	2.0348	<0.076
Group B	Post-test	8.8	1.35	2.58±0.37		

Table 5. Post-test Values of Group A and Group B Obtained using Perceived Stress Scale

Groups	Test	Mean	SD	Mean & SD (difference value)	T Value	P value
Group A	Post-test	14.6	4.22	8.2±1.69	2.713	<0.016
Group B	Post-test	17.6	5.88	7.2±1.26		

Discussion

In this pilot study, the potential advantages of gamification in enhancing hand function, hand grip strength, and stress reduction in hemiparetic patients were investigated. Hemiparesis, often associated followed by stroke, causes partial paralysis or weakness on one side of the body, impairing the ability to perform daily tasks and severely affecting quality of life. Usually, the goals of rehabilitation are to lessen the condition's physical and mental toll and enhance motor abilities. Incorporating gaming aspects into therapeutic exercises, or gamification, has gained popularity as a way to improve motivation and involvement in rehabilitation, particularly in neurorehabilitation settings [18]. Stress often associated in post stroke period [19], where it plays significant role on patients' motivation and involvement, sleep disturbance, anxiety and irritability are common indicator of stress [20].

This study's primary goal was to determine whether gamification may enhance hand function and grip strength. The findings showed a notable increase in these areas, which is consistent with earlier studies that indicate gamified therapies can improve motor performance outcomes in hemiparetic persons. Patients are encouraged to do exercises more frequently and for longer periods of time when game-like features like challenges, levels, and rewards are incorporated into the setting [21]. It has been demonstrated that this increased frequency and intensity of exercise improves neuroplasticity [22] which is crucial for motor recovery following a stroke and refers to the brain's capacity to rearrange itself and create new neural connections. Additionally, real-time feedback is a common component of gamified therapy's interactive aspect, which can enhance task performance by offering prompt reinforcement or correction. Participants may have improved their grip strength [23] and hand function during the study as a result of this instant feedback loop, which helped them hone their motor abilities and grip strength training improves cognition and white matter in brain [24], since task-specific training focuses on the precise motions and actions required to improve hand function, it is crucial in rehabilitation. The introduction of gamified therapies also makes this possible. with the ability to track their progress, establish personal goals, and perform exercises at their own pace, the gamified method also gives patients a sense of control and autonomy over the rehabilitation process [25]. since this self-regulation feature motivates patients to regularly participate in the treatment activities, it might have played a role in the improvements in hand strength and function that have been noted.

Along with enhancing hand grip strength and function, hand grip strength used as a health predictor of functional psychological and social health [26], the study investigated how gamification affected hemiparesis patients' stress levels, A crucial consequence, as stress can hinder healing and adversely impact the entire rehabilitation process, is the results' considerable decrease in perceived stress. A number of factors probably helped the individuals feel less stressed [27], In contrast to traditional therapy's usually tedious and frequently frustrating character, gamification adds a fun and entertaining element to the recovery process. It's possible

that the delightful and fulfilling gamified activities offered psychological respite and a constructive diversion from the mental and physical difficulties related to hemiparesis. Patients tend to experience less stress overall when they perceive therapy to be more pleasurable and less taxing. Additionally, the progress tracking and achievement-based rewards incorporated into gamified therapy might boost patients' self-efficacy and self-esteem, which are frequently reduced in hemiparesis patients because of the perceived constraints on their skills yet conventional therapies also showed improvement in hand function like task-based mirror therapy helped in recovery of upper limb [28] and Proprioceptive neuromuscular facilitation used in post stroke rehabilitation [29]. Patients' self-confidence increases as they do tasks and reach objectives, which increases their sense of control over their illness and reduces stress. Previous studies support that vagal nerve stimulation helped in the reduction of stress and anxiety [30, 31]. There are other smartphone-based mindfulness applications which significantly reduced anxiety levels [32]. Patients with hemiparesis often experience feelings of helplessness or frustration, which are further reduced by the positive reinforcement that gamified systems provide, this motivates patients to continue with therapy in spite of obstacles.

The statistical analysis of this study reveals that both interventions improves hand function and grip strength but when the two interventions were contrasted, gamification group shows more effective in improving hand function and grip strength ,to be specified gamification improves hand function but for grip strength statistically not much significant thou minimal clinical difference criteria were met so clinically we can use gamification for improving hand grip, along with that there was a significant reduction of stress. Limitations of the study includes not all patients with hemiparesis may have the necessary technological proficiency or access to the devices used for gamification. Some patients may experience difficulty using the technology, reducing their engagement or the overall effectiveness of the intervention and those who are less motivated or experience frustration with the game mechanics may not experience the same benefits as those who engage more fully. Future studies should aim for a more rigorous study design with quantitative analysis of the data and a randomized controlled trial (RCT), to better evaluate the efficacy of gamification.

Conclusion

This current study showed that gamification was effective in improving the hand function and grip strength of patient with hemiparesis and specifically it helped in the fine dexterity function improvement and also helped in the reduction in stress level.

Conflict of Interest

No conflict of interest.

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