# Notes on Papers Read As research for my FYP

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## Serious games for upper limb rehabilitation after stroke: a meta-analysis

<https://jneuroengrehab.biomedcentral.com/articles/10.1186/s12984-021-00889-1>

List of Neurorehabilitation principles with description established by Maier et al.

Massed practice – tasks aiming to increase the number of repetitions performed

Dosage – Intensive training: more than a daily session of 60 min on every weekday

Structured practice – training that includes periods of rest

Task-specific practice – functional training relevant to ADL

Variable practice – training that includes different types of tasks

Multisensory stimulation – training that provides more than two types of sensory feedback

Increasing difficulty – Complexity of tasks changes depending on participants’ ability, performance or time

Explicit feedback – Training that provides information about the patient’s performance at the end of the task

Implicit feedback – Training that delivers information about the performance in real time such as visualization of movement or other kinematic properties

Avatar representation – Embodied training by representation of a human or body part

Use of the paretic limb – promoting the use of the paretic limb

When studying the efficacy of serious games in stroke rehabilitation, serious games where compared against existing methodologies and the fulfilment of each of the neurorehabilitation principles. The serious games saw more fulfilment in most of the principles. Hower some principles were more fulfilled by existing treatments. Those principles along with how much they exceeded the serious games fulfilment presented in the format Principle (difference in fulfilment) are as follows: Massed practice (6%), Variable practice (3%), Increasing difficulty (4), use of the paretic limb (4%)

Therefore, it is possible that the serious games are less effective at increasing the number of repetitions performed, offer a wide range of different types of tasks, increase in difficulty and effectively make use of the paretic limb.

The conclusion of this study was that serious games designed for neurorehabilitation showed an increased efficacy than their traditional therapy counterparts.

Another key take away from the same study is the emphasis on the importance of complying with more than 8 out of 11 of the neurorehabilitation principles.

“Results illustrated that, when compared to conventional therapy, interventions specifcally designed based on elements enhancing neural plasticity led to signifcantly better results”

Providing feedback during therapy is important, (implicit feedback)

Curious to see if implementing addictive game elements seen in mobile gaming could help someone’s willingness to do the therapy and for how long.

Or maybe seeing if multiplayer can be used to achieve more willingness to play with the patients.

Subacute, chronic

## Serious Game Design and Clinical Improvement in Physical Rehabilitation: Systematic Review

This systematic review aims to identify, evaluate, and summarize the features of SG design (GG, GN, and GDS) that significantly improve patient outcomes in physical rehabilitation

Keywords:

SG – Serious Game

GG – Game Genre

GN – Game Nature

GDS – Game development strategy

Custom made, casual games that resort to the first-person perspective with no visible player character, played in a singleplayer mode using nonimmersive virtual reality attain the best results in terms of positive clinical outcomes.

Custom made games offer most clinical results but off the shelf games are perceived as more motivating and engaging.

Nonimmersive meaning games played on a computer screen.

Simulation and puzzle games are the most popular game genres used

According to this paper there are no studys which analyse the game design elements (GG, GN, GDS) in serious games in healthcare where the intended user is the patient.

The predominant genres are puzzle, casual games, and simulation

Video game characteristics included in the study:

Health and wellness, fitness, exergaming – video games that are also a form of exercise and that rely on technology that tracks body movement and (or) gestures.

Casual games – This category includes games that feature simple game play and objectives, including drag-and-drop games or point-and-click games.

Simulation – Games that aim to closely simulate aspects of a real or fictional reality. They seek to provide enjoyment through re-enactment.

Sports – Games that simulate the sporting experience. They focus on the experience of playing the sport or on the strategy behind the sport.

Game perspective (1pp/3pp) – The player camera angle/perspective. Games can be presented to the user either in 1pp or 3pp. In 1pp, the player experiences and interacts with the game through the playable character/avatar’s eyes, that is, the game action is observed the same way the user would experience the real world, which gives the player a sense of “being” the character (eg. Overwatch). In 3pp, the player is distanced from the game’s action by allowing them to control a playable character or avater that they can see (eg, new Super Mario Bros).

Game-Play mode (single player/multiplayer) – Refers to whether the game is single-player (only one user can play the game at a time) or multi-player (allows for different users to play the game at the same time and interact with each other).

Presence of visible player characters (yes/no) – Refers to whether the user has to control an avatar or character in order to play the game. Playable characters are often linked to the game perspective. When a game presents a first-person approach, the playable characters/avatars are often omitted – they are there, but since the player is seeing the game world through their eyes, the actual characters are not seen. However, third-person point-of-view (POV) games generally allow the player to control a specific character/avatar that they can keep track of at all times.

Presence of a story (yes/no) – Whether the game play invites the player to follow a story.

Type of scenery/in-game environment (realistic/fantasy/simple) – Refers to the aesthetics of the background image/3D setting used in the game. Realistic sceneries depict situations, locations, etc, that can be found in the real world. Fantasy determines that the scenery represents locations that are not an imitation of direct reality. Simple environments denote that there is no actual scenery, and the game takes place on top of single-color backgrounds with no associated imagery, often relying on geometric shapes, hence without any specific sense of aesthetic.

Level of immersion applied to the use of VR (immersive/ nonimmersive) – Immersion can be described as the sensation the player experiences as being part of the virtual world promoted by the game, that is, the involving nature of game play. In this specific context (applied to VR), nonimmersive VR denotes a system where the interaction between environment and player is achieved through the use of a mouse or joystick, putting some distance between player and game, while immersive VR implies the use of tools that are connected to the human body (eg, head-mounted display) in order to interact with the game.

Of the genres included in the review, casual games obtained the best clinical outcomes, first person games and games with no visible player character were behind in in clinical outcomes. However, this is under the assumption that generally first person games do not have a visible player character.

All studys featured physical therapy sessions with durations varying from 25 minuets to 1 hour.

Weekly frequency ranged from twice a week to every day.

5 to 42 sessions

Ways to test efficacy of therapy.

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| --- | --- | --- |
| Title | Description | Relevant to UL function |
| The Six minute walk test | Entirely self-paced, a patient will be asked to walk between two cones set 20 meters apart with one complete lap equalling 40 metres. The aim is to complete as many laps as possible within the six minutes |  |
| The Wolf motor function test | Quantifies upper extremity motor ability through timed and functional tasks |  |
| The box and block test | Measures unilateral gross manual dexterity. Quick simple and inexpensive test.    Patients are asked to move the 150 blocks from the starting container to the other container, one by one. |  |
| The nine hole peg test | Used to measure finger dexterity in patients with various neurological diagnoses  Nine-Hole Peg Test - Physiopedia |  |
| The 10 meter walk test | Measure the patients walking speed over ten meters. The patients should be aked to walk at a comfortable pace and/or at a faster pace. The therapist will walk at least a half step behind the patient |  |
| The Tinetti test | Assesses a persons perception of balance and stability during activities of daily living and their fear of falling. It is a very good indicator of the fall risk of an individual. |  |
| The timed up and go test | Most used test worldwide. Measures dynamic balance and functional mobility. Patients gets up from chair into bipedal position, walks three meters, returning and sitting on the chair again. The variable measured is the time taken by the test. |  |
| The dynamic gait index | Assesses an individual’s ability to modify balance while walking in the presence of external demands. |  |
| The berg balance scale | Used to objectively determine a patients ability (or inability) to safely balance during a series of predetermined tasks. |  |
| The Fugl-Meyer Assessment-Upper extremity scale | Widely used outcome measure for quantifying motor impairment in stroke recovery. Used in clinical and research settings. Has a series of movements for the different parts of the upper limb. The patient can achieve none partial and full for each of these movements |  |
| Timed chair stands | Tests leg strength and endurance, how many times can the patient sit then stand in 30 seconds on a fold out chair with no arms |  |
| Purdue pegboard test | Tests fingertip dexterity and gross movement of the hand, fingers and arm in patients with UL impairment.  <https://www.youtube.com/watch?v=xXT9E4OY9tw>  There is a series of pegs and holes, place the pegs in the holes with right hand. Reset, then left hand, reset then both. Then using both hands put a peg in a hole a washer on the peg a sleeve on the washer and a washer on the sleeve then move onto the next peg |  |
| The Action research arm test | The action research arm test is a 19-iten measure aimed at assessing functional performance of the upper extremity through observational means. Costs $875 |  |

Tests that seem to be for Upper Limb:

Box and block test, nine hole peg test, Fugl-Meyer Assessment-Upper extremity scale, Purdue pegboard test, the Action research arm test.

Interesting fact of the 12 games analysed in this study none invited the player to follow a story during the playthrough.

Custom made games more effective.

Casual games seen as the most effective

First person, single player, nonimmersive seems to be more effective

Found no linkes to visual aesthetic and clinical impreovement

1st person increases immersion and enjoyment

Something very interesting, patients perceive more improvements when playing Wii games (Commercial off the shelf) than when playing games specifically designed for therapy (even if clinically that did not turn out to be the case).

Making a serious game which interests the patients in the way a COTS (commercial off the shelf) game would is a commercially viable thing to do.

Serious Games are designed in a way where you have to do the correct movements and arnt as hard to cheat those movements as COTS games.

Conclusion;

“Of the genres featured in the papers included in this review, casual games obtained the best clinical outcomes in terms of significance (6 of 8, 75%, attained significant results). If we delve even deeper and take a look at how GN features may influence outcomes, both 1PP video games as well as video games that did not feature a visible playable character were behind in significant clinical outcomes. As previously explored, these two features generally go hand-in-hand: if a game is played from the user’s point of view, then it is to be expected that the player does not “see” the character/avatar they are controlling. Likewise, this contributes toward reducing production costs and development time, making this approach feasible not only from a clinical outcomes’ perspective but also from an economic point of view”

## Development of a 3D, networked multi-user virtual reality environment for home therapy after stroke

Does not use immersive vr headset. Reasons as follows. Limited field-of-view and, especially, involuntary coupling between neck and arm motion. The latter may lead to complications with moving the arm while keeping the head steady.

In the US 50 million Americans live rurally and 90% of physical and occupational therapists live in urban areas. Rural areas have higher stroke rates, this is a problem as accessing the therapy for many people can be very difficult.

Uses xbox connect to get inputs.

First person was seen as better. Helps establish a sense of presence for the user in the scene.

Environments created: dining room and kitchen

Player model: A screenshot of a cartoon of a person

Description automatically generated

Exercises: Ball Bump, Food Fight, Trajectory chase

Ball Bump is played on the table of the dining room. The goal is to hit a ball back and forth across the table while avoiding the objects on the table. Collision between ball and avatars hand redirects the ball. Ball is able to be redirected by obstacles on the table, or be knocked off the table by one of the avatars. Pressing a red napkin located to the side will produce a new ball. Pressing this napkin encourages participants to reach away from their bodies. Same is true for reaching for the ball.

Game can be played competitively or collaboratively. (try to hit ball past other player, or see how many bounces we can get together). This is good as different users will have different preferences for collaborative or competitive exercises.

Food Fight takes place in the kitchen environment. Participants grab different food items and throw them at other avatars. The user grabs on object by placing the avatars hand close to a food item and clicking a button on a wireless optical pen mouse. Then releasing the button throws the food. The velocity determined by the velocity of the hand at the time of release. Once all food items have been thrown they can hit a reset button to continue play.

Trajectory trace, one participant draws a 3D trajectory in the air. This trajectory is then passed to another participant who attempts to erase it by retracing.

Did a Pilot study to examine feasibility of the system for use by stroke survivors.

One big factor that influences a patients desire to keep using a system is how quickly and easily the system is to understand.

This study focuses on arm movement.

Using their system the patients moved their arm more than they would have in conventional therapy.

During training sessions patients spent most the time with their arm extended at least 70% of full range.

Also spent a considerable portion of time with the hand raised In an upper level of the work space.

Two thrds of patients chose HEP (not the game created for the study) as the easiest to use.

Reasons for this:

Trajectory trace game was too complicated as it meant actively cycling through a sequence of discrete states for each round. (Draw, Claim, Trace, Reset) while coordinating with another player.

No patients listed trajectory trace as their favourite.

Trajectory trace also had less than 50% of the movement during the ball bump exercise.

Only 1 user said the game was the easiest to understand.

Big problem with trajectory trace was that it didn’t give users feedback on the state of play. This was added in following the feedback. And the game lacked objective feedback to be given to the player. Unable to measure long term gains.

Multiplayer aspect did cause more motivation to use the game. This is increased if the other player is a friend or family member.

Need to ensure onboarding experience is fast and easy to understand.

Coming in to do the therapy may have increased the compliance rates which may be lower if the therapy was done at home.

Over 66% responded that they would definitely be willing to continue therapy at home.

100% responded that they would do training at least 2-3 times per week. Two thirds said they would do home-based training 6-7 times a week.

Multi user environments definitely hold promise for maintaining engagement in therapy and providing feedback of performance for home users.

Home therapy study currently underway with the system.