RE - A PLATFORM FOR MOTOR SKILLS REHABILITATION THROUGH GAMES

INTERACTION DESIGN PROJECT II
IN II - 88

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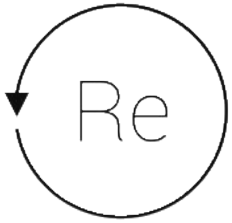

Re

A platform for motor skills rehabilitation through games

Semester III Project report

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November 16, 2015

Approval sheet

The project titled *Re - A platform for motor skills rehabilitation through games* by Dileep M, is approved for partial fulfilment of the requirement for the degree of 'Master of Design' in Interaction Design.

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Internal examiner	:	
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Contents

Abstract

Stroke, also known as cerebrovascular accident (CVA), cerebrovascular insult (CVI), or brain attack, is when, poor blood flow to the brain results in cell death. Stroke survivors are often left with residual effects ranging from physical and emotional to cognitive limitations. Severity of these conditions can be minimized if proper rehabilitation is followed from early stages of diagnosis. More often people suffer from hemiparesis, weakness of the entire left or right side of the body due to stroke. This limits their fine motor skills in terms of muscle strength, range of motion and coordination. Fine motor control disorders can dramatically reduce the ability of a person to perform daily activities like eating, dressing, taking bath, grooming and even returning to productive work [3].

The rehabilitation program is extensive and often requires regular practice. The existing facilities for motor skills rehabilitation are not accessible to a large part of the community due to inadequate health care systems and poor affordability. People tends to discontinue the therapy soon after hospital care due to lack of motivation and the expenses involved. Absence of facilities to continue rehabilitation outside a hospital environment is also a major factor in forcing the patients to drop out of the rehabilitation therapy.

This project titled *Re - A platform for motor skills rehabilitation through games* proposes a platform for motor skills rehabilitation through games. The objective of gamifying the rehabilitation routine is to keep the participants engaged and motivated to continue the routine and benefit from it. The platform uses a smartphone as controller and a computer to run the game.

This enables accessibility and affordability to the participants since they can assemble the platform without investing and/or acquiring in any dedicated devices.

The game adjusts itself to the participant's skills and records various data such as length of each gameplay session, frequency of session throughout a week and range of motion. This data is made available to the therapist through a web portal, where the participant's progress can be reviewed with greater accuracy and in a systematic manner.

Introduction

Any structural or biological abnormalities to the body nervous system consisting of the spinal cord, brain and nerves is known as Neurological disorder. A person having a neural disorder might be suffering from impairments ranging from paralysis, loss of cognitive abilities to seizures and altered level of consciousness. Among the disorders, stroke and traumatic brain injuries are the most common [2]. According to the UN, one in six people in the world suffer from neurological disorders and there are over 600 known neurological disorders and many doesn't even have a cure[5][6].

A study, conducted by the St. John's Medical College (SJMC), on 11,000 stroke patients across the country showed only 7% received rehabilitation care while the rest 93% were taken care by their families alone. Majority are left with residual disabilities even after 6 months of care in the hospital. Almost 60% of the survivors could return to only part-time jobs or became unemployed [4].

The advancements in technology, made the rehabilitation process far more effective, but they are accessible and affordable to only middle and upper class people. Unavailability of effective methods lead to slow progress or even incomplete recovery. Participant's lack of motivation to continue, socio-economic and psychological problems adds to the slow progress of recovery.

The participant's motivation is a critical factor in the rehabilitation process. This often drops as soon as the participant is relieved of the existing discomfort and pain. This is because rehabilitation process is lifelong, the extremely repetitive and monotonous routines have to be followed throughout life.

The participants are not able to assess any visible improvement and hence lose confidence in continuing laborious routines.

Existing methods utilise equipment similar to as seen in a gym and high end health care systems demanding supervision from a therapist. There is no element that can keep the participant engaged or motivated while performing the exercises. They have to entirely depend on the therapist for counselling, assessment of improvement and even access to any equipment for practice.

Background research

Rehabilitation is a complex process. It involves cognitive, psychological and physical rehabilitation therapies. The domain of was carefully studied to understand the process, its timeline and where the opportunities lie.

What is Neuroreahabilitation?

Neurorehabilitation is a series of therapies to facilitate recovery from a neurological disorder or injury to minimize any functional alterations [7]. The goals of rehabilitation is to not to "cure" or reverse any effect of stroke, but to help the survivors become as independent as possible in terms of performing activities. Neurorehabilitation works on the neuroplasticity of the brain, where it has to relearn the skills that were lost as a part of the disorder or adapt to new ways of doing the activities to compensate for the lost skills. Hence the process of rehabilitation usually continue throughout life.

Characteristics of Neuroreahabilitation

Holistic – The process should consider the physical, psychological, cognitive and social dimensions of the participant as well as their family.

Inclusive – Neurorehabilitation requires a multidisciplinary team consisting of dietician, neuro physiotherapist, neurologist, occupational therapist and other specialists to cater to the rehabilitation plans

Participatory – Cooperation of the patient and their family is necessary for the process to be effective.

Lifelong – Rehabilitation is a lifelong process which aims to make the participant attain highest possible level of independence to perform various daily activities. Many needs would arise throughout their life, which must be catered to, including further medical complications or illness [7].

Therapies in Neuroreahabilitation

Neurorehabilitation consists of four main domains –

Physiotherapy – Which is aims to strengthen muscles and improve fine motor functions.

Occupational therapy – Treatment to develop, recover or maintain the skills of participants to perform daily living activities.

Psychological – Use of psychological methods to help the participant regain or improve their mental health – including behaviour, emotions, confidence.

Speech and language therapy – Focused on improving understanding and processing language by reducing receptive and expressive disorders. Also minimize any effects of Dysphagia (oral feeding disorders) which includes difficulties with drooling, eating and swallowing[1][5].

Stages of Neurophysiotherapy

There are three main stages in Neurophysiotherapy.

Aggressive – As soon as a person is diagnosed with a neural disorder, rehabilitation process is started along with the treatment. Following rehabilitation plan from the early stage helps in minimizing the post disorder conditions. This phase lasts till the person is cognitively healthy – able to understand and follow instructions.

Activities of Daily Living training – Once the person is regained cognitive abilities, then they are given real life tasks such as eating using a fork and spoon, wearing shirt by themselves. These activities are to be repeated till they are able to perform them without any help.

Maintenance – When the person is able to perform the basic ADL, rehabilitation plan to be followed at home is chartered out and provided to them. The care plan is supposed to be continued throughout life for maximum recovery. This phases is started usually after 60-90 days of ADL training [5].

Current scenario of Neurophysiotherapy

The current techniques for neurophysiotheraphy incorporates very sophisticated and complex instruments. Methods such as Gait analysis, which studies and measures the motion of human body with the help of augmented instruments , Vestibular rehabilitation and balance retraining requires close supervision from a trained personnel. For example Gait analysis involves visual motor assessment measured by infrared video goggles and balance assessment measured by a computerized force-plate. This can be done only under proper supervision and are not accessible to a majority of the survivors as well as therapists.

Despite the existence of health care systems, only a few receive rehabilitation care. Reasons for non-availability of care include non-accessibility of the health care systems, lack of trained personnel or the ability to afford such therapies. Most of the participants have access to only primary care, where the doctors use low-technology interventions.

The current methods deploy physical exercise routines for upper and lower body using gym equipment such as dumbbells, treadmill and ropes. Task oriented exercises are also designed such that the participants will be benefited in real life as soon as they begin rehabilitation. These methods involve monotonous repetition of the exercise or task, till it becomes an activity which can be triggered by muscle memory. This leads to loss of coordination skills and sensitivity of control of muscles. After the pain is subsided, participants tend to lose motivation to continue the monotonous exercise routine and discontinues the therapy. This leads to slow progress or incomplete recovery.

To keep the participants motivated, counselling sessions are included in the therapy. Also, experiments were carried out to measure the engagement and motivation level of the participants by gamifying the exercise routines, which proved to be effective.

Game therapy

Game therapy is a form of psychotherapy that uses games to perform activities that are necessary for rehabilitation. Research has demonstrated that game-based therapy can keep the participants motivated to continue the therapy in an effective manner[3]. Constraint-induced movement therapy (CI therapy) is an intense treatment to improve fine motor functions of individuals. By mapping the tasks involved in the therapy to a game, researchers were able to hold the engagement level of participants and improve or maintain their motivational levels[8]. Individuals focus is on the game while performing the exercise routines and the challenges in the game are designed to push the limits of the participants.

Various physical as well as digital games are designed and evaluated their effect on participants by a number of researchers. The following are the ones that are widely used.

Existing therapeutic games

Physical

A number of tasks involved in the Constraint Induced movement therapy have been gamified into physical games. These games focus more

Figure 3.1 - Box and block test

on measuring the progress of an individual by regular assessments rather than keeping them merely engaged in the therapy itself. For example - Box and block test (figure 3.1) – which requires the participant to pick and drop small cubical blocks from one half of a box container to the other over a separation wall. The number of blocks dropped on the other side within a limited amount of time is recorded for assessment. Similar games were designed to test various parameters such as dexterity – Minnesota Manual Dexterity test (figure 3.2), where the participants has to arrange pegs on the pegboard as fast as possible. Grooved Pegboard tests (figure 3.3) motor abilities and visual coordination. The participant has to arrange pegs on the pegboard as fast as possible, where each peg will fit into a peg hole only at certain angle.

The above examples of activities or games that were primarily designed as a test, to measure and assess the progress of an individual. They lack game-play and are useful only at particular stage of rehabilitation. They are not adaptive to the participant's skills and demands supervision. Self-assessment is not possible, the participant is entirely dependent on the therapist for feedback and assessment. Without supervision, there is no error compensation also. The participant could be performing the activity not in the recommended format, which can yield undesired assessment.

Video games

According to Gazihan Alankus et al. therapeutic games must balance the goals of enabling rehabilitation through games and cater to the needs of the participants. Current research tend to focus on any one

Figure 3.3- Grooved pegboard test

Figure 3.3 - Minnesota Manual Dexterity test

of the goals, instead of both [3].

Many researchers have designed or used existing technology to facilitate rehabilitation through games. But the major focus was on either evaluating the game alone or the effectiveness of game therapy. There is a lack of focus on the unique needs of the participant and their abilities. Use of commercial products like Nintentdo Wii, PlayStation, Xbox Kinect for rehabilitation found that the requirements to operate the technology was often beyond the capability of the participant [3]. An example of a more personalised rehabilitation game is that of Gazihan Alankus et al research, used Wii remotes and color tracking as the controller for the games (figure 3.4) and recorded angles of rotation and axis which was helpful in tweaking the game settings to cater to the unique needs of the participant. Their work also talks about how the system could catalyse the rehabilitation process if the game enables the individual to set and meet their own personalized goals.

Taeko Fukamoto's approach was different from the above method of motion tracking. He explored an implementation of a controller using muscle based electrical impulses to detect motion. Existing games were modified to enable play with the new controller implementation, which involved EMG and other sensors to sense electrical pulses, bends, muscle strength and tension to trigger events in the game (figure 3.5). Motion capturing technology has a minimum movement threshold to detect motion, whereas EMG can detect even the slightest electrical pulses, even though the participant doesn't feel any sensation. This provides a meaningful feedback to the therapist and the participant regarding progress. However, Biofeedback mechanisms need sophisticated calibration process, which often requires

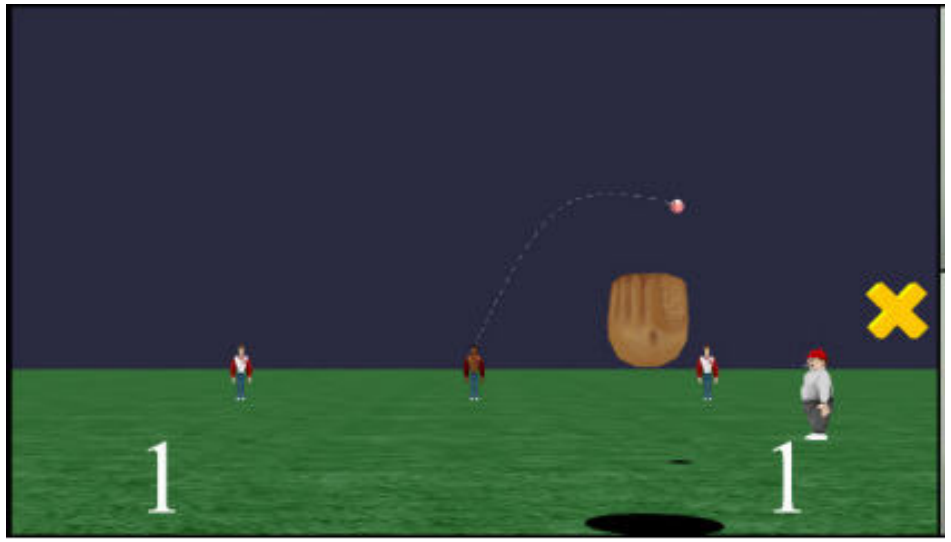


Figure 3.4 - Baseball catch game using Wii remote strapped to the patient's hand.

supervision of a therapist and EMG being an invasive technology, it can be effective to only a few [9].

Gustavo Cuberos Urbano et al. came up with a low-tech intervention which consists of a heart rate monitor to find the emotional level of patients. The exercise routines are practiced in therapists' supervision which are video recorded using a mobile application. Later the video playback can be used as a reference for the patient to mimic the routines at home, which is again captured by the mobile application. These videos are then compared by the therapist through a web portal to assess progress. Even though the platform is low cost and easy to operate, there is no element to motivate the participant to practice the exercises at home. Also, the therapist has to compare the videos manually, which is a laborious process.

An immersive system based on virtual reality (figure 3.7) was designed by Osvaldo Gervasi et al. The system has two games – utilising an elevator to reach a given floor and second, to cross a road using the traffic lights. Participants are presented with real life scenarios in a safe and controlled mode. This allows participant to relate to the rehabilitative program and real life. The system also has virtual tasks that simulates activities of daily living such as pouring water from glass, using hammer and posting an envelope. Their work talk about how critical is the contextual environment while performing the actions and why they have designed the activities in relation to real life scenarios. The system allows remote monitoring of data recorded through different sensors and camera by the medical staff. Modularity of the system enables the participants as well as medical staff to interact remotely, making the process convenient to both parties and

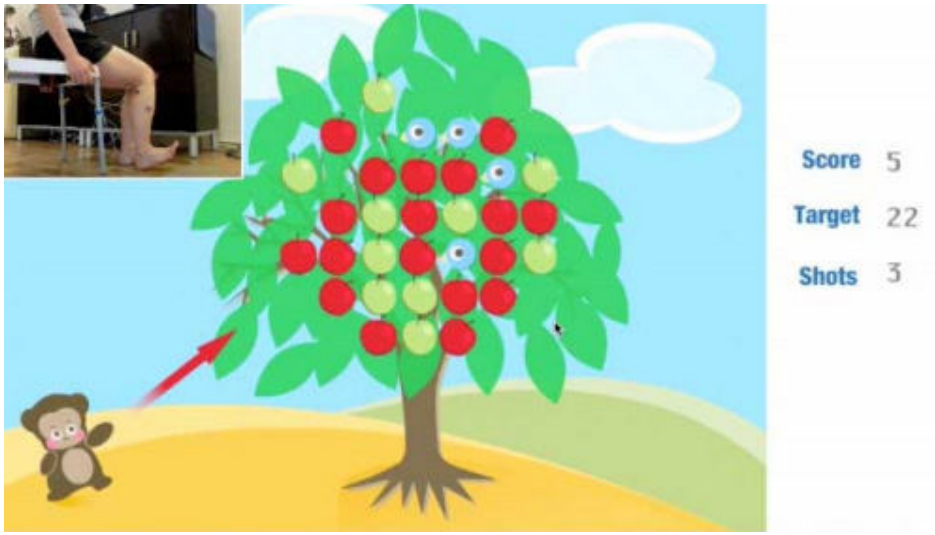


Figure 3.5 - Controlling the power and direction using EMG sensors.

Figure 3.6 - Application divided into live recording of participant's action with reference to the pre-recorded video at the bottom.

saves time. The system being bulky and expensive raises accessibility concerns [10].

An immersive system using Kinect, Oculus Rift and haptic gloves was evaluated by Conor Kaminer et al. The system captures movement with Kinect, finger movement and pressure sensitivity through haptic gloves. They designed two games – one to pack cylinders from the shelf to a box and another where instructions are delivered through Oculus rift and the participant has to follow them to perform the exercises. Kinect records x,y,z coordinates and angle data of each joint in the participant's body. This data along with periodical snapshots are sent to the therapist for review. The evaluation found that immersive systems has a high level of engagement, but the participants found the system to be too "geeky" and sophisticated. Also, the games lacked elements of game such as challenges, feedback and fun factors [11].

A web based serious game interface (figure 3.8) that uses non-invasive method to track the participant's movement was presented by Md. Abdur Rahman et al. They incorporated Kinect to record inverse kinematic joints and a LEAP motion controller to collect data from wrist, fingers and thumb. Therapists are enabled with option to create custom exercise routines which can be shared with other therapists. Once a participant completes a session, the report is generated and displayed to the therapist. Data collection and representation in the most meaningful manner to the therapist is essential. The custom routines and shareable feature makes the system more flexible. Although the system is feature rich, the game, where the participant interact lacked focus, which was a bottleneck to the other

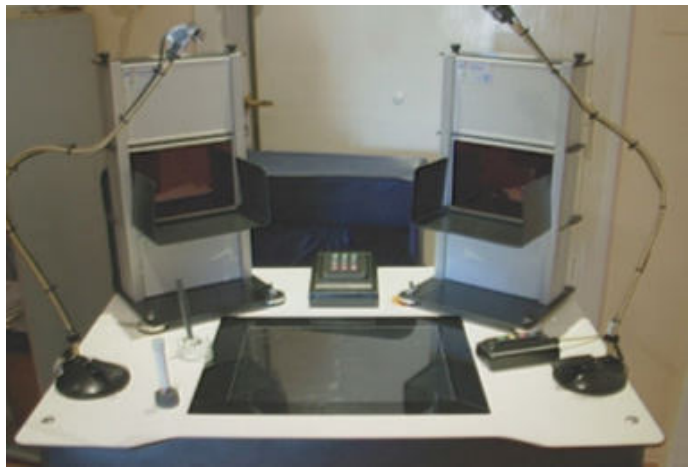


Figure 3.7 - The Nu!Reha desk (full installation)

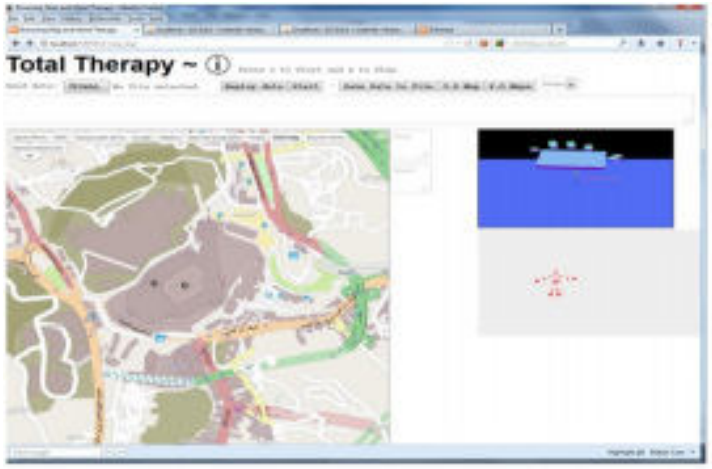


Figure 3.8 - User interface of map browsing serious game.

features [12].

Participants often tend to use other body parts while performing activities for rehabilitation. While playing games, if the hand movement is restricted, they aid the movement by changing body posture, tilting or leaning, compensating for the restriction. This impede recovery. Gazihan Alankus and Caitlin Kelleher talks about their method to reduce compensatory motions in video games for rehabilitation (figure 3.9). Experiment was carried out in the context of shoulder exercises by individuals who survived stroke. Operant conditioning strategies for games that aim to reduce compensatory motion was evaluated. They employed pressure sensors to restrict trunk motion and provided audible feedback. Compensation feedback was associated with incentives and disincentives in the game, which significantly reduced compensatory motion by 21%.

The researchers suggest that for better compensation, the game must capture motion range and a compensation profile, since compensation motion is different for different individuals. Designs that consider compensation motion will minimize error in data collection as well as in the way individuals perform the exercises.[13]

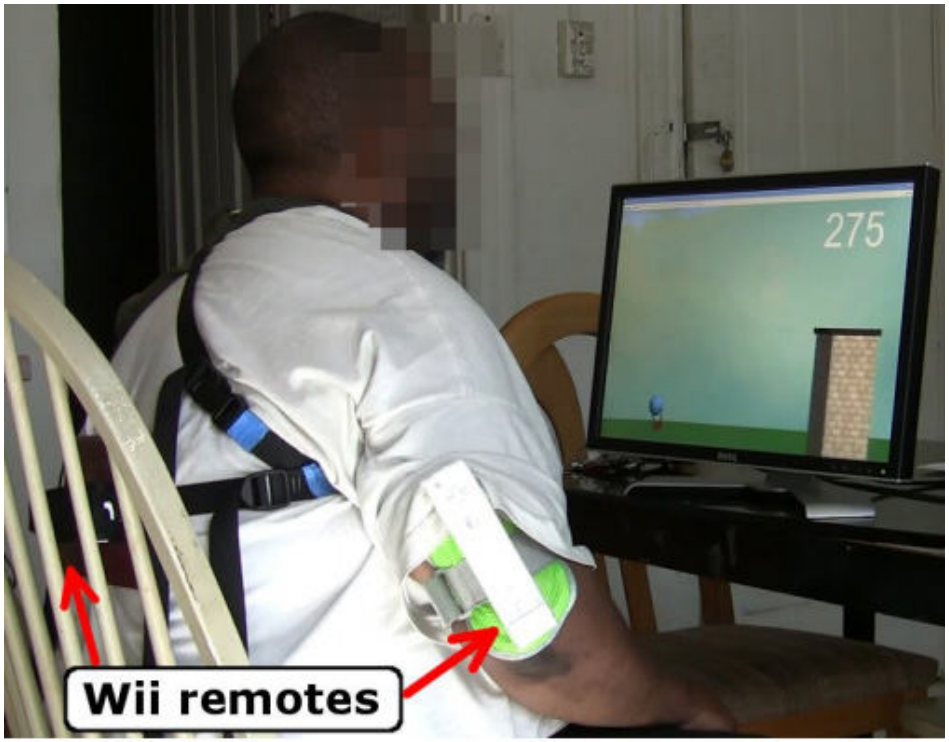


Figure 3.9 - Participant playing the game with multiple Wii remotes strapped to arm and back to detect compensatory motion.

User studies

Current work in using games for rehabilitation lacks focus on the goals defined by Gazihan Alankus et al. in their case study. Majority of the works either evaluated features of the system or effectiveness of the game. A user centric approach is essential to design a platform that can meet both the goals. Users were studied

Primary research was carried out with stroke survivors and therapists to understand the rehabilitation process, stages of rehabilitation, exercises or routines that the patients has to follow for recovery. Which all tests are performed to assess the progress of recovery and what all data are necessary for it.

The primary focus of the study was to understand the behaviour and attitude of participants towards the rehabilitation process. To understand if is there is any pattern in drop outs, why is the care not accessible to a majority of the patients, what are the reasons for the success rate of rehabilitation being very less and how does the individual's condition affects themselves and their surroundings.

User criteria

A semi structured interview was conducted with people who have survived stroke and were still undergoing neurophysiotherapy. During the course of the project, 7 Neurophysiotherpists and 6 stroke survivors. The patients interviewed were from urban settings, aged between 30-40 years and have used a computer or mobile phone with smart features in their life. One Neurophysiotherapist and 2 patients were chosen from Kerala and the rest were from Mumbai.

Insights

Accessibility of rehabilitation care is low.

The number of hospitals or therapists that offer neuro-rehabilitation is less. Adding to that, only a few hospitals has health care systems and equipment that makes the rehabilitation process more effective. Only middle class and upper middle class can afford to utilise such technology based therapies. Although some people can afford to undergo therapies, they are not aware of technologies such as Gait analysis, Isokinetic exercises and Game therapy. Participant 1 had to travel 12Km one way, daily to a neurophysiotherapist to practice exercises, because the hospital that treated for stroke did not had neurophysiotherapy.

Figure 4.1 - Sophisticated equipment are only available in high end hospitals.

People discontinue the course after a period.

According to Doctor 1, the rehabilitation process typically last for 6 months and care plans differ from patients to patient. Since it is a long process, people tend to discontinue the course. The main reasons being de-motivation and surroundings, which include family and work. The existing methods of neurophysiotherapy utilise low-tech interventions to facilitate patients to perform tasks. These are extremely repetitive and monotonous. Participants tend to discontinue as soon as the pain is relieved. Also they often lose faith in the process since they are not able to measure the progress by themselves.

Figure 4.2 - Gait analysis technology is expensive and available only in limited number of hospitals.

All the activities are performed under supervision and only a trained personnel can assess their improvement. Here, feedback is almost nil to the participants which is a major demotivating factor. This affects

course and sometimes even stop catering to their needs. This leads to psychological and social conditions like isolation and depression.

Therapists try different techniques to motivate the participants including counselling to the individuals as well as their families, group therapies and short activities with rewards.

But another gripping factor for dropouts is affordability. Majority of the patients are not able to afford to goto a clinic or a hospital daily to pursue the exercise routines. They have to visit the clinic because there are no affordable equipment to practice the routines at home. If the patient is an earning member of the family, there is pressure from the family also to go back to productive work for earning. P1 discontinued after 21 days of neurophysiotherapy due to affordability.

Existing home based therapies are limited.

Some hospitals and clinics offer home based therapies. But they are limited to either printed out manuals on how to perform the exercises or doctors visiting the patient at their house. Such methods do not have any error prevention and requires a laborious task from the therapists' side. There is no way to validate whether the participant is following the therapy routine until and unless the person visits the facility for assessment typically after 3-4 weeks.

These factors affect the maintenance stage of the participant. Once they leave hospital care, the rehabilitation process becomes slow and eventually stops. An affordable intervention that can keep the participants motivated and persuade them to continue the course is necessary.

Project brief

From the primary and secondary research insights, the characteristics of the design can be defined as - should be affordable, accessible and useful for both participants as well as therapists. The focus should be on keeping the participants engaged in the exercise routines and motivate them by providing appropriate feedback.

The objective of the project is as follows –

To design and develop a platform by which rehabilitation of motor skills can be made engaging through games with minimum error and supervision.

The primary objective of the project is supported by the following goals -

Motivate the participants to continue the rehabilitation process.
- Making exercises engaging and rewarding.
- Feedback for even the slightest improvement.

Help them build confidence and aid in community reintegration.
- Familiarize with ADL and real life scenarios.

Enable access to neuro-rehabilitation process to a larger community.
- Affordable and simple systems.

Minimize supervision and make rehabilitation more effective.
- Timely feedback
- Custom therapy routines

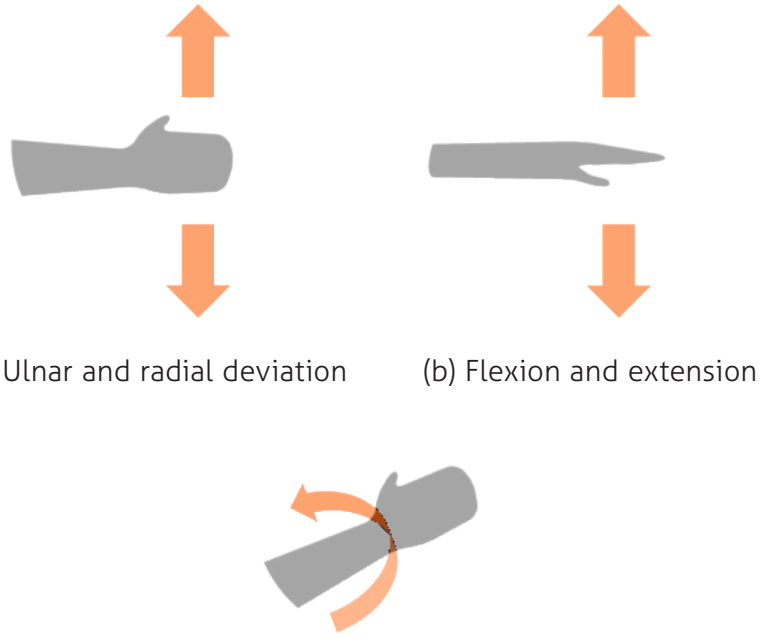
Design ideas

Insights from primary and secondary research provided a better understanding about the process of motors skills rehabilitation. Neurophysiotherapy for fine motor control begins with the thumb. Once the individual is able to flex their thumb, therapy continues to fingers, then wrist and henceforth, till the shoulders. Most of the Activities of Daily Living (ADL) is associated with wrist movement – eating, grooming, picking and placing objects. Despite being a high priority motor function, wrist exercises lack dedicated equipment. Current methods largely use gym dumbbells with the help of a therapist. This limits the practice of exercises to a clinic or hospital environment.

To address these primary issues of accessibility and motivation, we thought about a system that would enable the participants to practice exercise routines through video games. Currently, India does not have a video game culture. Video games are extermely expensive and hence participation is very low. This affects the awareness about video games among people and is limited to games on Facebook, Google plus and such social media platforms [16]. Also, parents in India believe video games do not teach any life skills like leadership, patience, how to maintain relationships and cognitive learning. The fear of their children being addicted to video games adds to the poor condition of video game culuture in India [15].

Considering the above arguments there were concerns regarding the acceptance of games as a medium for rehabilitation. Primary and secondary research revealed that even though serious games are being recognized and employed by many health care service providers like National Institute of Mental Health and Neurosciences (NIMHANS) and Manipal College Of Allied Health Sciences in India, participants are often not convinced about the effectiveness of the medium and are reluctant to try it. A patient from primary research asked *"Mein game kyu khelu?"*, which confirmed the earlier concerns.

To further validate the findings, an early prototype game was designed by mapping the game controls to wrist exercise movements. The following are the wrist exercises -



(a) Ulnar and radial deviation (b) Flexion and extension

(b) Pronation and supination

Figure 6.1 - Exercises for wrist

Initial prototype

The prototype was developed to test the feasibility of the project. The goals of evaluation were to understand the attitude of people towards serious games and their familiarity with the hardware.

In this prototype, a computer was used to run the game and a smart-phone with inbuilt sensors as the controller. A third party Android application – SensoDuino communicates the sensor values from the phone to the computer through Bluetooth.

Pilot 1 - Paper plane

In this game, the player had to control the movement of a paper plane on the screen. The horizontal movement of the plane was mapped onto pronation-supination (figure 6.1 c) and vertical movement to flexion-extension (figure 6.1 b) of the wrist. The game continued till the player hits more than three red spikes. Distance travelled by the plane was given as the score metric (figure 6.2).

Since the movement were tracked using sensors, we also collected range of motion of the participant's wrist. The maximum and mini-mum achievable angle of rotation during flexion-extension were accurately captured.

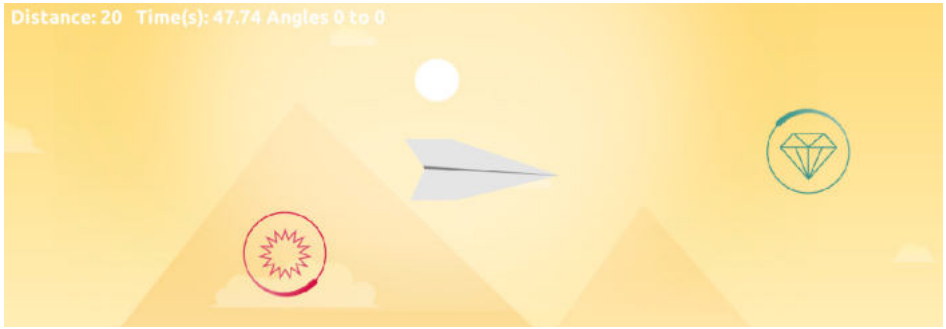


Figure 6.2 - Paper plane - collect the diamonds and avoid the red spikes.

The prototype was evaluated with two patients and two therapists. Participants were asked to play the game for 5 minutes continuously. The following are the insights from observations and semi-structured interview with the participants.

Insights

The participants were able to use the phone as controller. There was no confusion or difficulty in using the phone to play the game. There were no physical movement restrictions for the patient because of the controller.

One of the two patients, were reluctant to participate, until the therapist convinced him. All the others readily complied. This helped us understand why information about the game and its purpose is important to be shown to the participant. Unless and until the participant is convinced, they won't try. The aim of the game and how it works should be clear to them.

Later, we found out that the problems are beyond accessibility and affordability. People tend to lose interest and practice the exercises very loosely, often in an incorrect manner. This usually leads to more complexities later in their life. This tendency was observed more among patients who were in the maintenance stage or those who had to travel long distances to reach a rehabilitation facility. Lack of supervision while participants perform the routine is a major cause for incorrect or incomplete rehabilitation. Usually, reviews happen every two weeks. These two weeks the therapist is unable to supervise the participants' exercise routine.

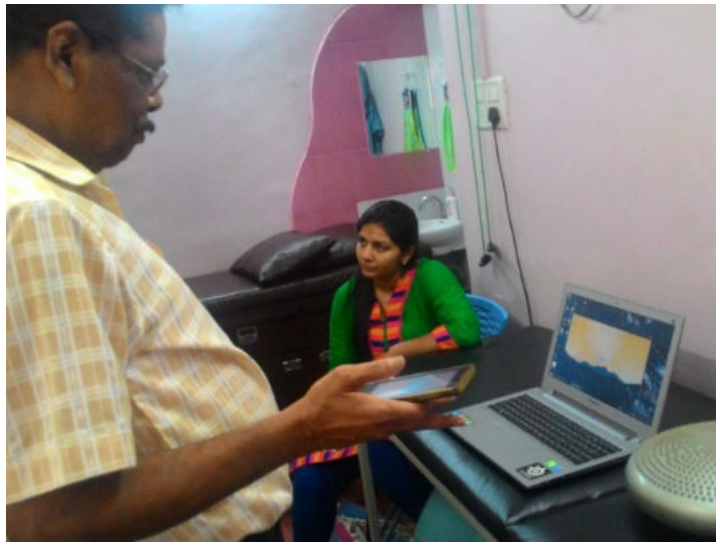


Figure 6.3 - Initial pilot evaluation

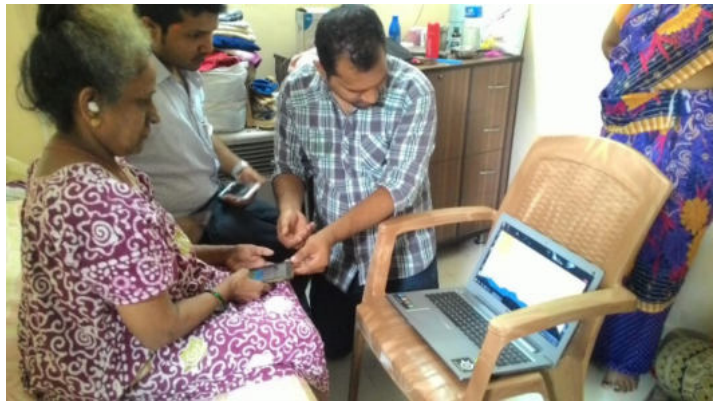


Figure 6.4 - Initial pilot evaluation

The review sessions helps therapist to make an informed decision, changes in the routine and customize it to meet individual goals. But many people cannot afford a clinic therapy or travel frequently to a therapist for a prolonged period. Hence, they discontinue the therapy.

This lead to the idea of tele-rehabilitation. If the review sessions were done remotely, patients need not travel to a therapist. Tele-rehabilitation also enables patients to pursue the exercise routines at any place, any time. But such a system also require a feedback system that can collect and represent the patient's progress to the therapist.

The prototype could already collect range of motion of the participant's wrist in degree angles. With the therapists, a list of parameters that help to assess progress of an individual was made. It included - exercise session length, number of sessions per day and range of motion of the wrist joint.

Feedback to the participant is also critical. If the review sessions are largely done remotely, in between the review period, the patient might lose faith and confidence because they are not able to assess their progress. Currently, only a therapist or a trained personnel is able to assess the progress.

Therapy sessions were observed to understand which is the most sensible form of representing the feedback to both therapists and patients. Therapists often explained the status of the patient's recovery in relation to real life scenarios - such as *"Now you will be able to hold a pen", "You can use the rails on the stairs now"* and such. At the therapist's end, specifics considered valuable. Details like current and previous range of motion, how many times the patient is repeating the exercises? What is the average session length? For athletes or individuals who participate in sports, specific details are critical. These vital data if collected, could be benchmarked against the expected or ideal conditions that the recovery should aim to achieve.

To minimize error and supervision, the prototype was modified to collect data about gameplay session lengths, frequency of sessions and range of motion.

It was also observed that even though the game do not respond to incorrect exercise movements, patients tend to take aid of gravity to ease the effort of doing the exercise. While performing flexion-extention, patients loosen their list to come to flexion after extention. Compensatory motion affects recovery and can be signficantly reduced by penalising such motions in-game [13].

The theme of the game was kept minimal to flatten the learning curve. The concept of a paper plane were familiar to all the participants, but did not appeal to them.

The pilot evaluation helped us to understand that accessibility and feedback are the major concerns for both participants as well as therapists. Types of data and feedback that would be meaningful to both the parties were narrowed down and three games were designed, with different mechanics, theme and therapeutic goals.

Games

Shapes

Most of the Activities of Daily Living requires an individual to move their wrist against the plane of gravity. While observing the participants performing the exercises, it was found that the participants tend to let the gravity act on and aid their performance. For example, after extension, they let the wrist joint loose so that flexion will be aided by gravity. This limits the effectiveness of the exercise.

Shapes (figure 6.5) is an abstract balance game incorporating pronation-supination (figure 6.1 c) movement. The player has to sort different coloured shapes into different portals. The game has four shapes – triangle, square, circle and hexagon. All of them have different friction values. These shapes either coloured red or blue drops from the top, onto the platform at the center. The player can rotate the platform to keep the shapes on the platform until a portal appears. Once the portals appear, shapes are to be slid off to correspondingly coloured portals. This is achieved by tilting the platform. Different friction values for different shapes requires the player to vary the tilt angle to slide off the shapes. The goal is to survive in the game as long as possible. A time bomb mechanic is incorporated to prevent players from accumulating shapes on the platform.

The focus of the game was on reducing compensatory motion and increase the control over movement of muscles. The visuals were kept abstract to understand the preferences of the target group.

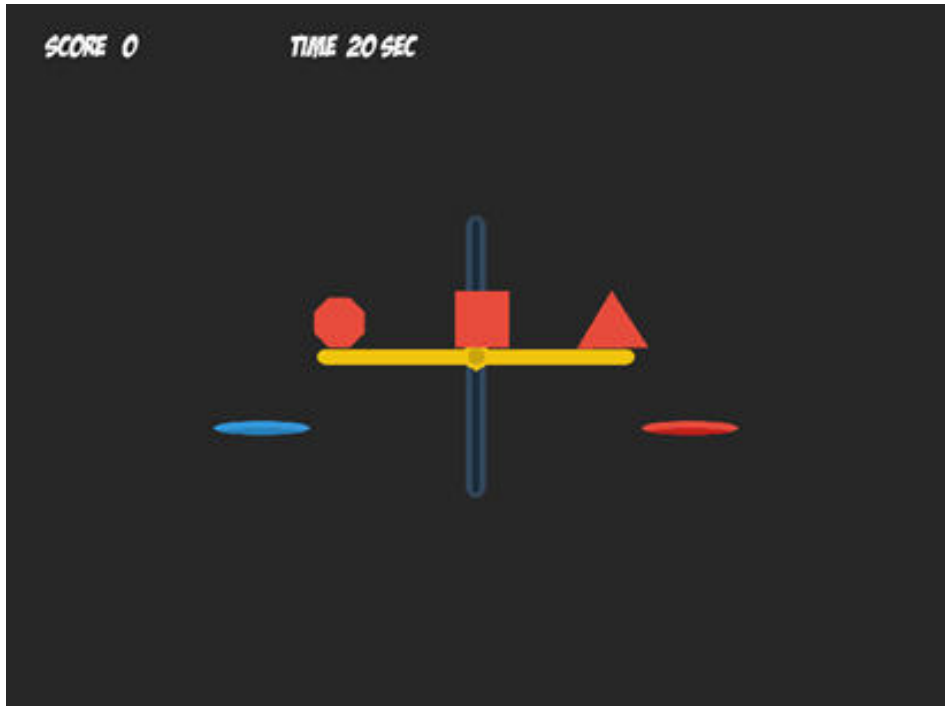


Figure 6.5 - Red coloured shapes on the platform. Red and blue portals are opened.

Kites

Kites (figure 6.6) involves repetition of flexion-extension (figure 6.1 b) and pronation-supination (figure 6.1 c) . The game requires the player to repeat the exercises to stay away from other kites and fly as high as possible. Thread bundles are incentives that speeds up the kite, increasing the difficulty.

The enemy kites and thread bundles are positioned in such a manner that the participant repeats the two sets of exercises individually and in combination. Switching between the two sets of exercises in-game aids in improving hand and eye coordination.

The kite theme is aimed to allow players empathize with the game to a greater extent as they are familiar to kite and kite festivals. Empathy leads to more level of engagement and motivation .

Kites' focus was on making the participant repeat the exercises. More repetition means more strength in muscles.

Figure 6.6 - Red colored shapes on the platform. Red and blue portals are opened.

Fort defense

Fort defense (figure 6.7) do not require the player to follow exercise in any particular order, rather has the freedom to perform any of the exercise to proceed through the game. The game responds to flex-ion-extension and pronation-supination movements.

The player plays as a king trying to defend his fort from demons. The wide screen area and careful positioning of the enemy requires the player to move and stop the crosshair at particular points.

Eventually the number of demons increase and the player needs to be quick in aiming. If the fort takes damage beyond a certain threshold, it breaks and game will be over.

The game enables honing of hand and eye coordination. Visuals and narrative of a king and fort was to evaluate the benefits of contextu-alisation of a game according to the location. The king character was inspired from legends surrounding Pune and Mumbai.

A second pilot evaluation was conducted with the three games. The goal was to evaluate the engagement potential of the games and to get an idea regarding the participants' preference on narrative or theme.

Figure 6.7 - Align the crosshair on the enemies to shoot them. Enemies are spawned at different positions to maximize wrist movement.

Second pilot evaluation

Engagement level is expressed in terms of *Immersion, Presence, Flow, and Absorption* [14].

Immersion is used to describe the experience of becoming engaged in the game, while being aware of their surroundings to an extent. It is also defined in terms of how much a game can induce of the feeling of 'being inside the game [14].

Presence is defined as the experience of being inside the game, while retaining the normal state of consciousness. Experience of presence lets the players feel like integrated to a virtual environment while they are conscious about the fact that it is a virtual environment [14].

Flow is the satisfaction and enjoyment that the player enjoys when they accomplish any activity that is challenging and rewarding enough. Flow include feeling of being in control and players experience time distortions [14].

Absorption aggregates all the above parameters and describes the total engagement. In common with flow, absorption results in an altered state where everyday thoughts, feelings and experiences are less accessible by the consciousness [14].

Evaluation was within subjects with three patients and three doctors. Each of them were asked to play all the three games, one by one for 10 minutes without any pause.

Figure 6.8 - P2 playing Shapes game.

After each gameplay session, they were given a questionnaire *(Appendix 2)* to fill. Some of the questions were on Likert scale out of 10 – samples include, *"You wanted continue playing without distracting yourself", "Were you eager to know what next is going to happen in the game?".* Others were open ended questions – samples include *"How long do you think you played the game?", "Did you get confused while playing the game?".*

Insights

Players had no confusion on how to proceed in any game. All the three games were analysed using the Likert scale scores *(Appendix 3).* The mean score of four categories of all the games were not significantly different. Kites game came to be slightly better in terms of flow and absorption, followed by Shapes and Fort defense.

Kites game proved to be more intuitive, players understood the game mechanics quickly and did not made any mistake in-game. Participants could empathize more with the Fort defense game, which concludes that localization of game affects engagement levels. But the learning curve of the game was steeper comparing to the others.

As per the analysis and therapist's recommendation that repetition of exercises is of high priority followed by muscle control and finally coordination, Kites game was chosen to develop further and add details.

Figure 6.9 - P3 playing Kites game.

Final concept

Insights from pilot evaluations confirmed that by enabling the participants to pursue therapy routines whenever and wherever they want in an affordable manner, the longevity of motivation is more. Also they tend to continue the therapy when it was made fun through video games. To allow the freedom of anywhere, anytime to the patients, without compromising the therapists time and effort, the concept need to be more than a game.

Tele-rehabilitation is the best possible approach to achieve this freedom. It requires many interconnected systems such as feedback mechanism, game configuration and customization and personalization.

Hence, we propose a platform - Re (figure 7.1), inclusive of all the systems required to employ tele-rehabilitation in the most effective manner.

The name is inspired from the Latin prefix 're', indicating return to a previous condition, restoration etc. It also indicates repetition of any action.

Platform details

The platform consists of three components – a game, computer with a controller and a feedback system.

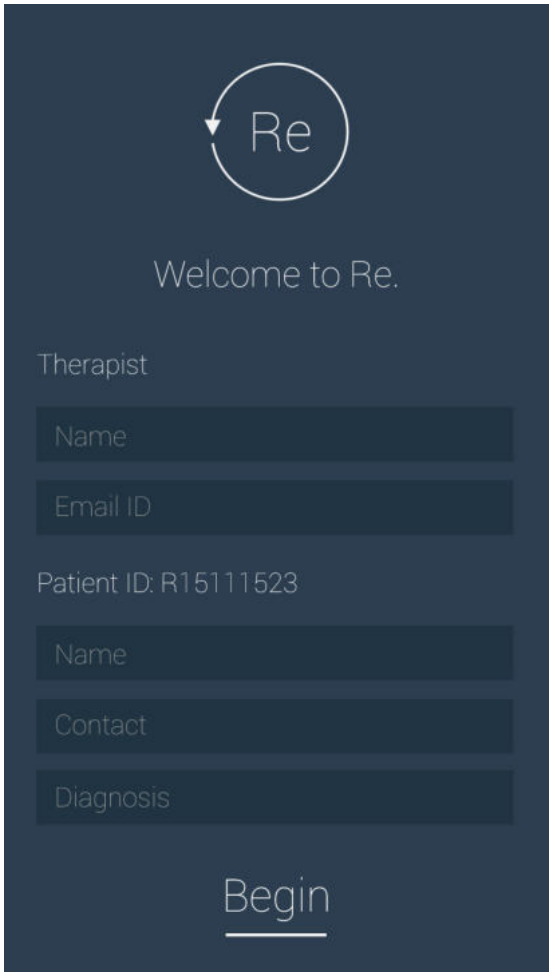


Figure 7.1 - Re registration (initial run)

Game

The core loop of the games make the participants perform the exercise routines by playing the game. Since the game controls are mapped onto the exercises, any other movement would not be reflected in the game, thereby reducing compensatory motions. Incorrect exercises wouldn't be recognized, minimizing error while practicing without any supervision.

Existing systems needs the therapist to acquire the system and configure the game settings. They had to be familiar with the system to modify it, which is an unnecessary load. To tackle this, the games designed were made adaptive. After each gameplay session, the data collected by the game will be used to assess the participant's current skill level and adjust the game accordingly for the next session – from game mechanics, control sensitivity to difficulty. By making the games self-learning, therapists are relieved from configuring and tweaking the game again and again. Games are automatically personalized depending upon the participant. After a few sessions, the same game will be different in terms of difficulty, controls and mechanics for different participants. The levels are automatically generated and is tweaked separately for each participant (figure 7.2).

The data collected are forwarded to the feedback mechanism.

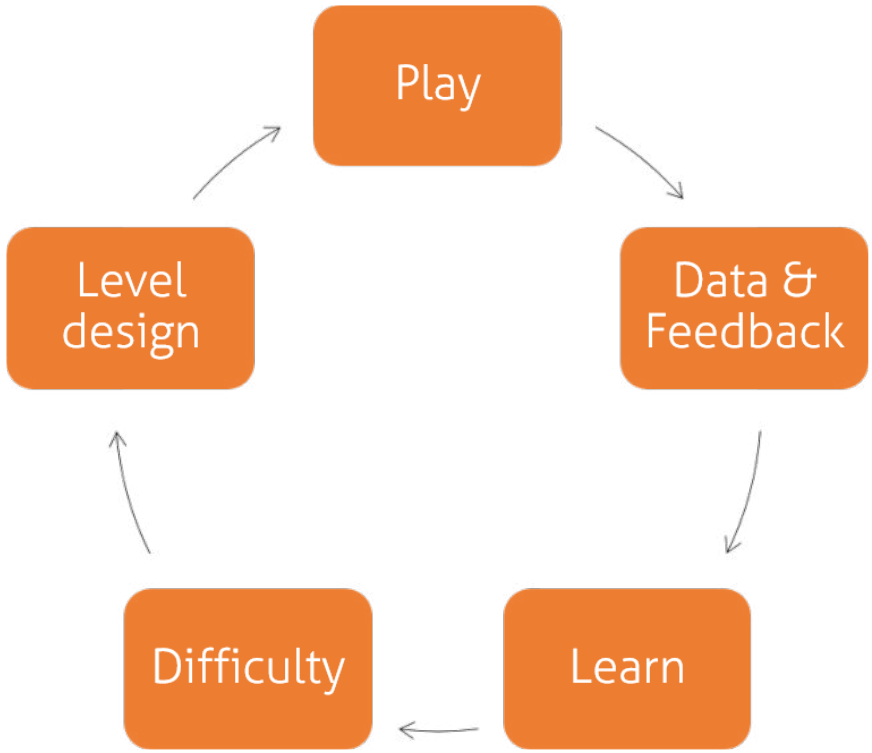


Figure 7.2- Core loop of all the games in the platform.

System and controller

A computer which can run the games becomes the system. Among the commercial products available in the market such as Microsoft Kinect, Nintendo Wii remote and LEAP motion to track movement, Nintendo Wii remote and LEAP controller were evaluated against their reliability, ease of use and form factor. Set up and troubleshooting of the controllers required a certain level of familiarity with technology. Also, they had to be calibrated before play and whenever the connection between the controller and system is lost. If the controllers are not calibrated properly, it will affect the gameplay, leading to wrong data collected.

Considering the affordability factor and from observations during the pilot testing, about how participants handle the hardware, it was concluded that a smartphone (figure 7.3) will be the best possible alternative in the current context. It does not have calibration issues and participants are often familiar with the technology.

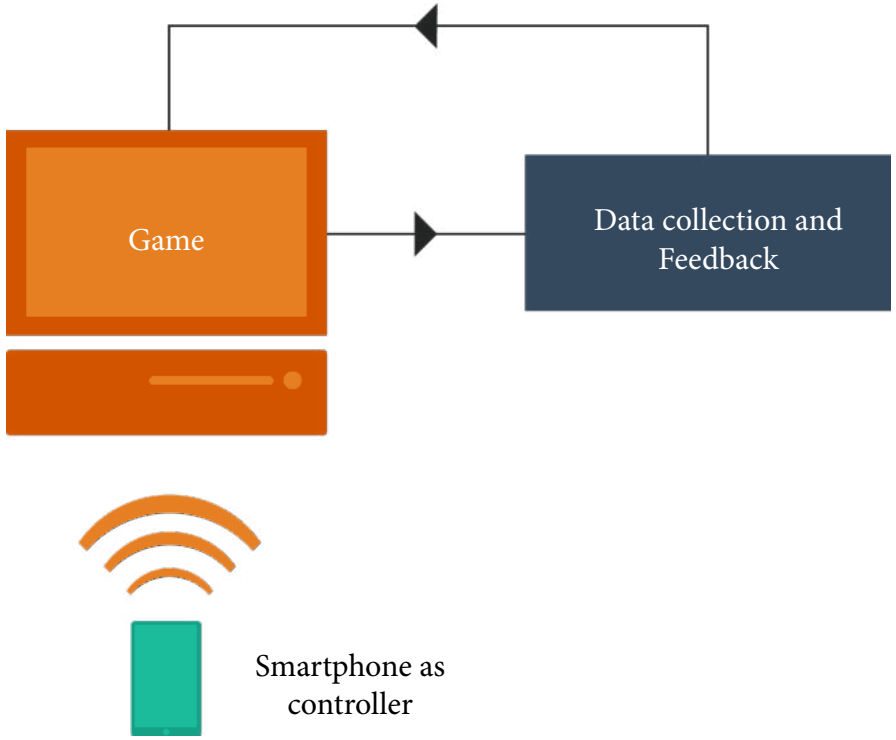


Figure 7.3 - Platform overview

Data collection and feedback

Feedback is vital for motivation and improvising the rehabilitation course. As evident from the user studies and pilot evaluation, the frequency of review meetings helped the participants to stay in the rehabilitation course for longer period. But the kind of feedback that the participant receives from the therapist might not be meaningful to them. Feedback should enable them to self-assess their progress and gain confidence. Re prvoides two kinds of feedback - while performing the exercises and on every minute progress that the participant makes.

For therapists, participant's gameplay sessions are rich in data. The controller sensors can provide accurate and reliable data regarding Gameplay session length, frequency of sessions and the range of motion of joints. This data can be used to assess the progress of participants (figure 7.4). The data collected during gameplay sessions are sent to a web portal which can be accessed by therapists to review the participant's progress.

Detailed view is available on each participant, including demographics, gameplay session length, frequency of sessions per day and range of motion in terms of angles for individual set of exercises (figure 7.5). Therapists can review progress across days, also easily locate undesired results from the spikes in the graph. Session length is represented in minutes and range of motion in degrees. The system reports and represents even the slightest improvement. This aid the therapist to provide more comprehensive feedback to the participants.

Figure 7.4 - Patient, along with details like Ulnar and radial deviation measurements and their progress.

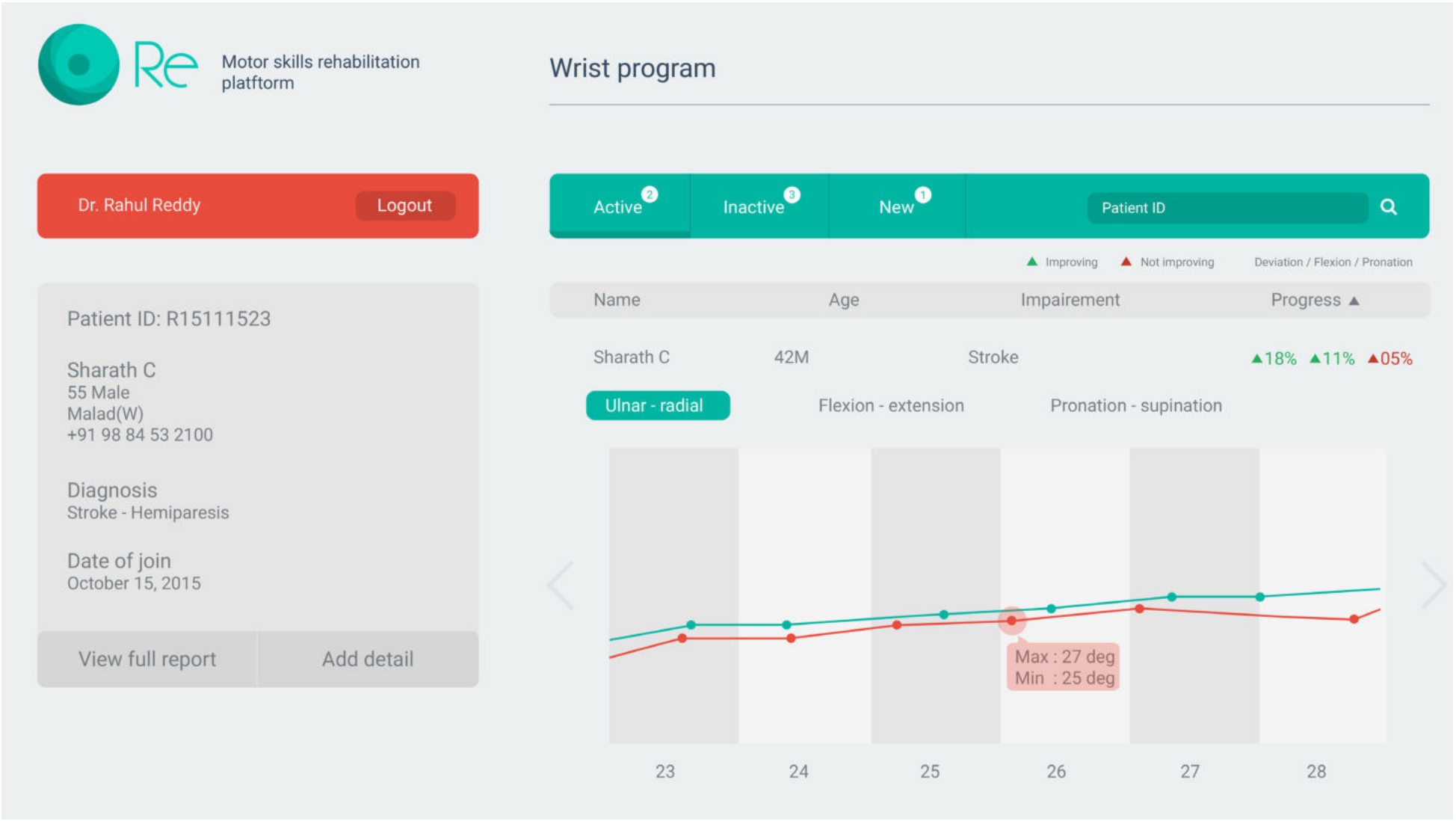


Figure 7.5 - Therapist's portal. Date-wise details of angles achieved by the participants.

Therapists can view who all are actively participating in the routine, who all joined new and who all are not at all engaging with the system. A graph representation helps to get a holistic idea and variations in parameters easily. These data, collectively provides the feedback on an individual's progress.

For the participants, data like session length, frequency and range of motion do not make sense. Analysis of these parameters need therapeutic level of understanding about the domain. For them, feedback is provided in terms of real life challenges. A list of Activities of Daily Living were created in ascending order of difficulty in performing, which includes - "Write 5 sentences with a pen on a paper", "Try drinking water from a mug today" and so on. With each substantial progress that the participant make, corresponding challenges are put forward to the patients by the game to try (figure 7.6) . They also vary in difficulty.

Since, the exercise movements are mapped to game movements, any sort of compensatory motion is prevented. Even if the participants do incorrect exercises, it will not be reflected in the game, restraining them from progressing through the levels. Thereby, feedback for doing proper movement is provided to the users.

In this manner, the participants are able to assess their progress on their own by relating their ability to perform real life tasks to the exercises. They feel more confident and benefited from the rehabilitation. This further motivates the participants to continue the therapy. From the platform design, user journey was sketched to position the intervention in the rehabilitation time-line.

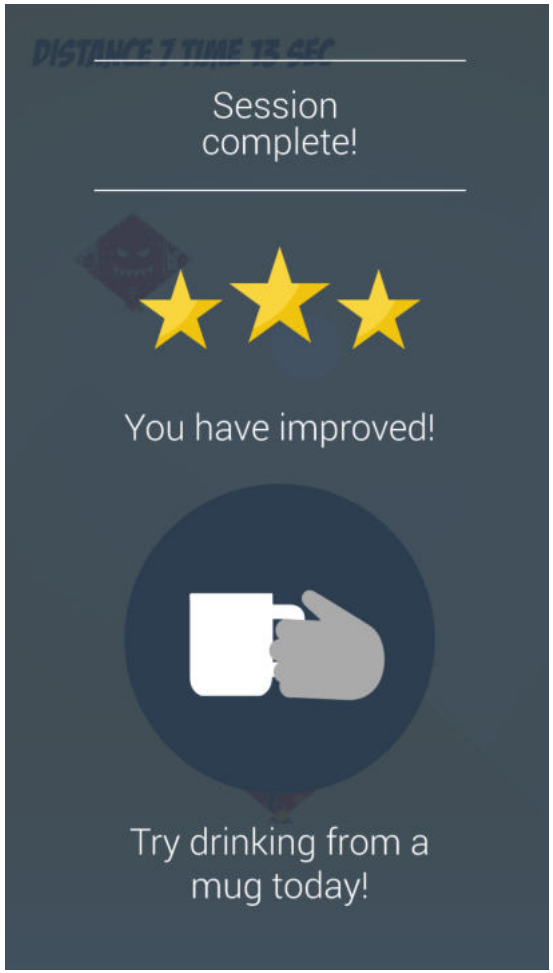


Figure 7.6 - Real life challenges for the participant

User journey

Once the patient has recovered cognitively – able to understand and follow instructions, the platform can be employed to perform the exercises. This can be in a hospital environment or at home or at a community centre.

Details of the participant and therapist are fed into the system by any one of the parties. Participants can configure the game settings according to the therapist's recommendations.

Once the platform is configured, participants can play (figure 8.1) and proceed through the game by performing the recommended exercises. The data for each session is recorded and made available at the therapist's end in graph format. Therapist can then review the progress, locate undesired results and can follow up with the patient more frequently. The participant need not rely upon the therapist for feedback on progress, the game detects even the slightest improvement in range of motion and suggests real life challenges like drinking water from a mug, wearing shirt by themselves, comb hair, for the participant to try and accomplish.

After each gameplay session, the data recorded is used by the game to adjust settings automatically to suit the participant's skills and therapy requirements, easing therapist's, as well as participant's concerns over configuring and tweaking the game settings. The same game might be different for people with different impairment, allowing personalization of games.

Figure 8.1 - User journey from diagnosis to feedback.

Evaluation

The platform was taken to participants and therapists for their feedback. The goal was to evaluate the game against traditional methods of motor skills rehabilitation exercise routines. Evaluation criteria were based on psychological absorption, flow, immersion and presence.

A within-subjects experiment was designed to understand the same. Two participants and two therapists participated in the experiment. The protocol was to play the game and do the exercise for a period equal to the participant's current therapy session length. At the end, fill in the self-report survey for both the methods.

Traps were designed to reduce any sort of bias in the survey. These included general talk with others in the room, to test the level of presence of the participant. The topic of discussion had specific details like numbers, names etc. to understand how deep the level of presence is. If the participant is able to recall all the minute details of the conversation, then the game failed to engage the participant. This was verified again by talking to the participant about anything, except the game itself. If he/she is able to converse fluently while playing, then the level of engagement is less.

Qualitative and quantitative evaluation were performed to evaluate the effectiveness of the platform against traditional methods of rehabilitation care. The evaluation was designed to collect Likert (scale of 10) data within subjects. Sample questions for games included -

Did you get confused while playing the game?

Did playing seemed automatic?

You didn't have to look at the controller every time to proceed in the game?

For traditional method -

Did you get confused while doing the exercises?

Did doing the exercises seemed automatic? You didn't have to look at the equipment every time to see if you were doing it properly?

Demographic information along with suggestions were recorded to draw inferences about the engagement level and effectiveness of the platform.

Insights

The quantitative data collected showed significant difference in the level of engagement achieved by the game against traditional exercising methods. The results show immense potential of the platform to enable tele-rehabilitation care in an effective manner. The levels of absorption, presence and flow in the game were higher than traditional exercises *(Appendix 4)*.

By contextualizing the game for the location, playing became intuitive and relate-able to the participants. One of the users said - *"This is the first time I am flying a kite".* She enjoyed the game thoroughly and doing exercises seemed automatic through games.

There were no confusions regarding the correctness of the movement or what next is to be done. Everything was embedded inside the game without bothering the user. For example, the enemy kites spawns at the center to make the player repeat pronation-supination exercise to drive the kite left and right.

Participants readily understood that compensatory motion won't be reflected in the game. Hence, they were following the right movement to progress through the game involuntarily. It was also found that the participants were unable to gauge the level of pain after the game session, affirming the effect of absorption in the game. The game also helped them to relieve any tension in their mind and helped them to relax. While playing, participants did not feel any stress or tension from everyday thoughts.

Some of the participants even remembered the details of the game and gave suggestions like -

"The thread bundle comes only very few times, makes it difficult to survive long in the game".

Such comments displays the level of engagement of participants to the game.

Therapists found the visualization of data collected, very useful to make quick and informative decisions. One therapist commented -

"Now I can follow-up with patients who don't practice the way I taught them."

Details such as ideal angles for every joint were appreciated by therapists, since they are very critical for participants who are active in sports. Such data will help therapists to customize the rehabilitation routine accordingly.

Therapists were also able to attend to others while the participants practice the exercise in the platform. The supervision needed was minimal and observations are recorded for later retrieval. This gave a lot of convenience to the therapists to manage their schedule without compromising on the therapy.

On the quantitative data collected, cumulative mean were calculated to understand the nature of data collected. The cumulative mean of absorption, presence, flow and immersion for the Re platform was 29.0, significantly higher than traditional methods which scored 17.5.

Both qualitative and quantitative data showed positive results towards the proposed design. Suggestions from therapists and patients were very detailed, showing their understanding of the system. Such kind of participation from the stake-holders also proves their interest and positive attitude towards the platform.

Conclusion

The positive results of qualitative and quantitative tests show the potential of the platform as a tele-rehabilitation medium. The familiarity of the hardware, contextual design of the game encouraged users to try the system and become experts in handling the hardware within a few sessions.

By gamifying the exercise routines, the participants are exposed to a different kind of experience which kept them motivated to continue the rehabilitation routine. The challenges in real-life were redefined as challenges inside the game. This helped in personalizing the game for every individual, to meet their own goals. With each milestone they reach inside the game, they were able to perform real-life activities, which boosted their confidence and morale. Contextualization of game also helped to reduce the gap in preferences regarding games across genders.

It was concluded that motor skills rehabilitation through games, based on familiar technology like a smartphone and computer is very much a feasible, effective, and inexpensive option. It offers participants a more engaging alternative to the current methods of rehabilitation. It also widens the availability of rehabilitation across people.

Even though the project was only the preliminary stage to explore whether games could enhance the rehabilitation experience, the successful development of this platform opens the door to a variety of ideas which could expand the project in the vertical.

Future scope

The system can be improved by including more games, including other body joints such as elbows, shoulders and/or the knees. Further, create multiplayer online leaderboards to encourage the participants to engage with the system and continue rehabilitation. By enabling the participants to connect to similar people online, to reduce social isolation and allow mutual motivation. Design haptic feedback for the participants to improve their overall experience and provide meaningful feedback.

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Annexure

1. Key questions of user studies

1a. Therapists

1. How long is the period of rehabilitation process?

2. Which are the general exercises/activities recommended for fine motor skills rehabilitation?

3. Is there any common exercises or every routines is different for different individuals?

4. What are the stages of rehabilitation process?

5. Do you recommend doing the rehabilitation routines at home with minimal or no supervision?

6. Does patients show enough motivation towards rehabilitation process? If not, what could be the reasons?

7. Does the patient prefer clinic over home-based therapy?

8. How is the progress evaluated? Is there any metrics to measure the progress scientifically?

9. Is there any particular parameter which are tracked to assess the progress of the patient?

10. Do you have any motivational programs or counselling?

1b. Patients

1. How do you feel the rehabilitation sessions to be? long or short?

2. Do you practice the routines at home? if yes, does family members help in doing them?

3. What are the routines that you do?

4. Do you prefer clinic or home to do the exercises?

5. What are your opinions about free exercises and with equipments?

6. How do you assess your own progress or improvement?

7. What do you do when you are not in rehabilitation routine?

1c. Care takers and family members

1. Does the patient show enough motivation to continue the rehabilitation process?

2. Is there any difference in attitude and personality of the patient before and after the impairment? If yes, what could be the reasons?

3. What do you do to motivate them?

4. Do you help the patient in doing the exercise routines or activities of daily living?

3. Pilot evaluation protocol

3a. Evaluation goals

Evaluating the prototypes on *psychological absorption, flow, immersion and presence* to narrow down on developing one concept.

3b. Protocol

Test task :

1. Play the game Roll balls into the hole for 2 minutes.
2. Unstructured intervie~~w to get fe~~edback on
    1. Smartphone as a controller
    2. Input sensitivity
    3. Ease of control / playing

Task:

1. Record the length of play session.
2. Fill the questionnaire.
3. Take a break for 5 minutes.
4. Repeat steps 1 - 3 for game B and C.

Traps:

1. General talk with others in the room, to test the presence level of the participant.
    1. No specific details to remember
    2. Specific details to remember (like numbers, names etc.)
2. Talk to the participant about anything except the game.

3c. Analysis

Hypothesis – There is no significant difference in engagement among the three pilot games

2. Self survey questionnaire

(for games)

(0 - extremely disagree, 10 - extremely agree)

1. Name :
   Age :
   Gender :

2. How long do you think you played the game?

3. How engrossed were you in the game?

   1 2 3 4 5 6 7 8 9 10

4. Did you get confused while playing the game?

5. Did you felt like continue playing without distracting yourself?

   1 2 3 4 5 6 7 8 9 10

6. Were you able to empathize with the game?

   1 2 3 4 5 6 7 8 9 10

7. Were you eager to know what next is going to happen in the game?

   1 2 3 4 5 6 7 8 9 10

8. Were you concerned whether you would win or lose the game?

9. Were the game visuals and sound enjoyable? Why?

10. Did you feel like playing seems automatic, you didn't had to look at the controller every time to proceed in the game?

11. Everyday thoughts and concerns were not in your mind while playing the game.

    1 2 3 4 5 6 7 8 9 10

12. Does the game demand a lot of effort?

    1 2 3 4 5 6 7 8 9 10

13. If someone talks to you while playing, Do you find it difficult to pay attention to them?

14. Did you felt as if you were inside the game world?

15. You did not notice what is happening around you while you were playing the game?

    1 2 3 4 5 6 7 8 9 10

16. Did you like the game, yes or no? Why?

17. Any comments / suggestions?

5. Self survey questionnaire

(for traditional exercises)

(0 - extremely disagree, 10 - extremely agree)

1. Name :
   Age :
   Gender :

2. How long do you think you did the exercise?

3. How engrossed were you in doing the exercises?

   1 2 3 4 5 6 7 8 9 10

4. Did you get confused while doing the exercises?

5. Did you felt like continue doing the exercises without distracting yourself?

   1 2 3 4 5 6 7 8 9 10

6. Were the exercises fun to do? Why?

7. Did you feel like doing exercises seems automatic, you became unaware of any equipment that was being used?

8. Everyday thoughts and concerns were not in your mind while doing the exercises.

   1 2 3 4 5 6 7 8 9 10

9. Does exercises demand a lot of effort?

   1 2 3 4 5 6 7 8 9 10

10. While doing exercise if someone talks to you, Do you find it difficult to pay attention to them?

11. You did not notice what is happening around you while you were doing the exercise?

    1 2 3 4 5 6 7 8 9 10

16. Do you like doing the exercises, yes or no? Why?

17. Any comments / suggestions?

Pilot evaluation data

Questions	Abstract Shapes game			
	P1	P2	P3	P1
Name, age, gender	40 M	33 F	34 F	40 M
How long do you think you played the game?	5-10min	5-6min	10-15min	5min
How engrossed were you in the game?	6	7	5	8
Did you get confused while playing the game?	No	Haan, woh bomb niche girne ke baad bhi foot raha tha	different shapes were confusing	No
Did you felt like continue playing without distracting yourself?	7	6	6	7
Were you able to empathize with the game?	6	7	5	7
Were you eager to know what next is going to happen in the game?	6	7	7	5
Were you concerned whether you would win or lose the game?	No	No	No	Yes
Were the game visuals and sound enjoyable? Why?	Yes, simple and plain, no confusion	Music acha tha	Yes, sirf shapes tha	Yes, music acha laga, simple hai
Did you feel like playing seems automatic, you didn't had to look at the controller every time to proceed in the game?	Yes	Yes	Yes	Yes
Everyday thoughts and concerns were not in your mind while playing the game. Your thoughts were about the game	5	5	4	7
Does the game demand a lot of effort?	5	5	5	5
If someone talks to you while playing, Do you find it difficult to pay attention to them?	No	No	No	No
Did you felt as if you were inside the game world?	Not really	No	Aisa kuch nahi hai	Yes, to an extend
You did not notice what is happening around you while you were playing the game?	8-Didn't pay attention	5-Haan, Mujhe sunai de raha tha	6	6
Did you like the game, yes or no? Why?	Yes, simple game, not much confusion to play	Yes, sirf shapes tha	Easy to play, simple	Yes, visually rich, liked the music
Any comments / Consolidated feedback	Need goals in the game	Distinguising between shapes and bomb	-	Needs to be challenging

Kites		Fort defense		
P2	P3	P1	P2	P3
33 F	34 F	40 M	33 F	34 F
5min	5-10min	10min	10min	10min
6	7	6	6	7
Kuch bhi nahi	No confusion	No	Yes, Woh point nahi dikh raha tha	No
6	8	5	5	5
7	7	6	7	8
5	7	6	6	7
No	No	No	No	No
Yes, alag alag patang hai, colors hai	Yes,Easy, simple	Yes, could relate to Ramayana	Yes, Liked king shooting with bow and arrow	Yes, liked the music and playing as a king
Yes	Yes	Yes	Yes	Yes
6	7	5	6	6
6	6	4	3	3
No	No	No	No	No
Not much	No	Yes	Yes	Yes
7	6-Could hear, but not the details	5	5	5
Yes, first time playing game. Simple hai	Had fun, will play more	Really liked the game, relate to the game since I am an Indian	Yes, Aaawaj acha hai. Aur woh maarne me maaja aaya	Liked playing as a king
Option to configure for specific exercises	-	Sometimes the aim is not showing	Difficult to aim, takes time to aim properly	-

Pilot evaluation analysis

Parameter (questions)	Shapes	Kites	Fort defense
Absorption (15)(2,14)	6.3	6.3	5.0
Presence (11,12)(2)	4.8	6.2	4.5
Flow (5)(3,4,10)	6.3	7.0	6.3
Immersion (3,6)(8,9)	6.0	7.0	6.7
TOTAL	**23.5**	**26.5**	**22.5**

Remarks

Priority: Strength > Sensitivity > Coordination. Repetition of exercise is the best during initial stages.
Intuitive play: Kites > Shapes > Fort defense

Kites was less stressing and needed less effort to play. Presence and Absorption score indicates more level of engagement comparing to Shapes and Fort defense.

Players had no confusion while playing all the three games, but Kites was intuitive and players didn't made any mistake. It was easy to learn and start playing. Players were unaware of any controller and tend to continue play for longer period in case of Kites.

Players could empathize more with Fort defense than Kites, least being Shapes.

From the mean value, doctor's (3 nos) recommendation Kites was chosen as the final concept on the basis of absorption, presence, flow and immersion. Kites is more intuitive, simple and had the player empathize with the game with rich visuals.

4. Final evaluation protocol

4a. Evaluation goals

Evaluating the game against the traditional methods of motor skills rehabilitation exercise routines based on *psychological absorption, flow, immersion and presence.*

4b. Protocol

Test task :

1. Play the game Roll balls into the hole for 2 minutes.
2. Unstructured interview to get feedback on
    1. Smartphone as a controller
    2. Input sensitivity
    3. Ease of control / playing

Task for experimental group:

1. Play the game for a period equal to the participant's current session length.
2. Fill in the self-report survey for the game (Appendix 2).

Task for control group:

1. Do one session of exercise.
2. Fill in the self-report survey for exercises (Appendix 5).

Traps:

1. General talk with others in the room, to test the presence level of the participant.
    1. No specific details to remember
    2. Specific details to remember (like numbers, names etc.)
2. Talk to the participant about anything except the game.

Break times, if occurs, will be subtracted from overall time.

4c. Analysis

Hypothesis – There is no significant difference in motivation level between traditional methods of exercising and exercising through games.

Evaluation data

Questions		Fly high		Traditiona
		P1	P2	P1
Name, age, gender	1	33 F	34F	33 F
For how long did you play the game?	2	10-15min	10-15min	30min
Did you get confused while playing the game?	3	No confusion, no pain	No	No confusion, but was paining
You wanted to continue playing without distracting yourself.	4	10	8	5
You were eager to know what next is going to happen in the game.	5	7	7	4 Haan, sochna tha
Were you concerned about winning or losing the game?	6	No	No	Haan, after exercise.
Did you like the game art, sound and music? Why?	7	Yes, colorful and flying kite is fun	yes, different kites, khelne mein maja aatha hai	yes, machine is comfortable
Did playing seemed automatic? You didn't had to look at the controller every time to proceed in the game?	8	Yes	Yes	No focus was on the machine
You did not had everyday thoughts and concerns in your mind while playing the game	9	8 No, game mein tha	7 Nhi	2-Haan, I have school going children
The game does not demand a lot of effort to play.	10	8 No pain	8	5-dard hota hai
If someone talks to you while playing, You find it difficult to pay attention to them?	11	6 Not difficult	7 Dhyaan rahta hai	6
You felt as if you were inside the game world?	12	7	7	4
You did not notice what is happening around you while you were playing the game.	13	5	6	5
Did you like the game? Why?	14	Kite flying is fun. First time feeling of flying kite	Acha hai, khelne mein maja aatha hai	No, karna padtha hai
Any suggestions or comments?	15	Thread bundle comes very few times		

Evaluation analysis

Parameter (questions)	Fly high	Traditional exercise
Absorption (2,8)(11,12)	6.8	4.8
Presence (9)	7.5	3.0
Flow (3,6)(4,5)	8.0	4.8
Immersion (7)(10,13)	6.8	5.0
TOTAL	**29.0**	**17.5**

Remarks
Games have better engagement - Patients doesn't have everyday thoughts, doing the exercises seemed automatic, had no confusion, was intuitive.
Has fun while playing the game. Contextualization matters.