Design Guidelines for Game-Based Physical Rehabilitation System: A Focus Group Study

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Abstract

Background: Incorporating serious games and ICT advancements into physical rehabilitation can substantially enhance the process, provide unique benefits, and improve its effectiveness and efficiency. While recent literature highlights various game-based interventions for physical rehabilitation, there is a lack of comprehensive guidance on how to design and develop systems that effectively address the actual needs of therapists, practitioners, and individuals with physical disabilities.

Objective: Since therapists and other healthcare practitioners play crucial roles in both patient recovery and the establishment of an effective game-based therapy, thus, the objective of this study is to explore the intentions, needs, and desires of therapists and other practitioners, as well as to examine the factors and determinants influencing the effectiveness and efficacy of game-based physical rehabilitation.

Methods: A Design Science approach was adopted to achieve this research objective. To gather feedback, explore the needs and desires for a serious game, and understand the requirements for game-based physical rehabilitation, a focus group of 27 participants was conducted. The group first tested commercially available games and then evaluated the game prototype mockups created.

Results: The research provides essential design insights and guidelines for designers and researchers, focusing on the practical needs and requirements of game-based physical rehabilitation systems.

Conclusions: Therefore, as proof of concept, these guidelines will be used in the next phase of our research, which involves designing and developing a game-based physical rehabilitation system.

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Abstract: Incorporating serious games and ICT advancements into physical rehabilitation can substantially enhance the process, provide unique benefits, and improve its effectiveness and efficiency. While recent literature highlights various game-based interventions for physical rehabilitation, there is a lack of comprehensive guidance on how to design and develop systems that effectively address the actual needs of therapists, practitioners, and individuals with physical disabilities. Since therapists and other healthcare practitioners play crucial roles in both patient recovery and the establishment of an effective game-based therapy, thus, the objective of this study is to explore the intentions, needs, and desires of therapists and other practitioners, as well as to examine the factors and determinants influencing the effectiveness and efficacy of game-based physical rehabilitation. A Design Science approach was adopted to achieve this research objective. To gather feedback, explore the needs and desires for a serious game, and understand the requirements for game-based physical rehabilitation, a focus group of 27 participants was conducted. The group first tested commercially available games and then evaluated the game prototype mockups created. The research provides essential design insights and guidelines for designers and researchers, focusing on the practical needs and requirements of game-based physical rehabilitation systems. Therefore, as proof of concept, these guidelines will be used in the next phase of our research, which involves designing and developing a game-based physical rehabilitation system.

Keywords: Serious Games, Physical Rehabilitation, Game Design, Brain Damage, Kinect

1. Introduction

The application of technology in rehabilitation is experiencing significant and rapid expansion [1]. The integration of serious games and technological advancements enhances the rehabilitation process, creating new opportunities to address stakeholders' needs and expectations by (1) enhancing the quality and efficacy of rehabilitation; (2) offering alternatives that sustain patient motivation by mitigating the repetitive nature of traditional rehabilitation; (3) providing tailored therapy levels; and (4) overcoming limitations in resources and facilities associated with conventional rehabilitation methods [2-9]. For example, Individuals who have experienced a stroke are motivated to use technologies and games to facilitate their functional recovery [10]. Moreover, The study [11] revealed that commercial gaming consoles and off-the-shelf games are more affordable and offer numerous options and variations, which could facilitate the implementation of virtual reality games in clinical practice. However, the usability of virtual reality games is a crucial factor to consider in the design of these interventions. The study [12] introduced a game-based rehabilitation system that includes three exercises and a computerized assessment method.

This system evaluates the accuracy of right arm movements during gameplay by analyzing tracking data collected from a Kinect sensor. The study [13] discussed several barriers to the seamless integration of technological solutions into clinical care, including issues with accessibility to quality rehabilitation, adaptability to individual patient differences, compliance, and engagement with the rehabilitation process. In recent years, the implementation of diverse technologies has strengthened telerehabilitation, enhancing rehabilitation processes and ensuring patients receive the necessary services [14, 15]. Integrating physiotherapy with technologies such as virtual reality and video games enhances the rehabilitation of post-stroke patients compared to physiotherapy alone. This approach offers an immersive and interactive platform that boosts patient engagement and motivation during rehabilitation, while also providing a safe environment for practicing and improving physical abilities [2, 16, 17]. Evidence from a range of studies highlights its potential to improve outcomes for individuals with various physical impairments [2]. Takei et al. [18] assess the safety, feasibility, and acceptability of using the Nintendo Switch video game Ring Fit Adventure for upper and lower limb strength training in older adults with musculoskeletal conditions, alongside conventional physiotherapy over six sessions. The authors concluded that this approach is a safe and feasible adjunct to a rehabilitation program, as long as it is supervised, particularly in the initial stages.

In [19], the game "Meteors" was introduced, which involves a virtual robotic arm that replicates the player's arm movements to catch meteors falling onto a planet. In [20], the game "Slingshot" was employed to enhance arm coordination and improve the precision of aiming and extending arm movements. This game focuses on exercising the flexion and extension of the elbow. In this game, scoring is based on performance, and the difficulty level can be dynamically adjusted to maintain the patient's motivation and commitment. In [21], they developed four video games aimed at arm rehabilitation. One game involved competitive play, where the patient competes against another individual (such as a friend, relative, or therapist). Additionally, there were also two cooperative games, where the patient and another player cooperatively played against the computer, and one individual game where patients played alone against the computer. The study revealed that competitive games significantly enhanced functional recovery and improved patients' quality of life more than conventional rehabilitation exercises. In [22], developed a full-body rehabilitation video game utilizing Kinect V2 as an input device. The game accommodates both sitting and standing positions, supporting various movements such as gross motor actions (steps, jumps, squats) and fine motor gestures (handshakes, palm rotations, hand opening and closing). This system tracks the player in three-dimensional space and registers real-time data, demonstrating positive outcomes in motor function and the performance of basic daily activities among chronic post-stroke patients. The study [15], argued that successful games in the industry, known for their immersive qualities, incorporate eight key features: game control technology, display technology, rewards, social elements, avatars, game difficulty, music/sound, and graphical realism. They proposed that future research could explore different game genres, aspects like game narrative and competition, improvements in user interface, and the integration of immersive technologies such as virtual and augmented reality. The exploration of therapeutic alternatives, combined with new technologies, enables professionals to employ a variety of tools for patient rehabilitation and treatment. However, it is crucial to comprehend the functionalities, potential applications, and limitations of these tools [23]. Future research should aim for higher methodological quality, larger sample sizes, and well-defined rehabilitation programs to mitigate inconsistencies in evidence within this field. [3, 24].

Video games designed for therapeutic use have distinct requirements compared to regular video games. There are differences in user characteristics, where the patient serves as the primary player and the therapist as a secondary user, in contrast to players of regular video games. These users also have different objectives, and the context varies [23]. Considering the patient as the sole end-user for any rehabilitation intervention is an aberration and diverges from standard practice as therapists are primarily responsible for motivating, guiding, and assessing the patient. The study [10] revealed that, although Individuals who have experienced a stroke were amenable to integrating exergames into their rehabilitation regimen, they noted that these games could not replace the essential role of therapist supervision. Integrating new technologies into clinical practice is complex, as it requires addressing the needs of both clients and clinicians. By considering these factors, technology developers can improve the chances that clinicians will embrace and adopt innovative technologies [25]. The study [26] highlighted two key factors for optimizing patient engagement: adequate support and a perceived benefit from the technology. It concluded that patients are more likely to engage with technology during rehabilitation when it is personalized by a therapist to fit their specific needs. Therapists and other healthcare practitioners play crucial roles in both patient recovery and the establishment of an effective rehabilitation system [27]. Since rehabilitation aims to restore patient independence and enhance the quality of life, achieving optimal outcomes requires a cohesive multidisciplinary team comprising doctors, psychologists, occupational therapists, nurses, social workers, and physiotherapists collaborating effectively [23]. The [23], highlights that, despite numerous studies on technology acceptance, there is still a lack of understanding regarding the factors that influence healthcare professionals' adoption of technological innovations. The study [28] argued although there has been speculation about the roles of therapists in game-based therapy and suggestions regarding varying levels of patient engagement, no comprehensive studies have been conducted to investigate these matters in depth. Understanding how games influence and support the different roles of therapists remains an area for future study [28]. The [29] argued that, although some serious games have been developed for physical therapy, little work has been conducted through a participatory design approach. The authors highlight the importance of involving diverse stakeholders in the design process to create more effective and user-centric serious games for rehabilitation. Therefore, effective implementation and use require collaboration from all parties involved in the process, including physicians, nurses, social workers, and other allied health professionals [23]. Thus, the objective of this study is to explore the intentions, needs, and desires of therapists and other practitioners, as well as to examine the factors and determinants influencing the effectiveness and efficacy of game-based physical rehabilitation.

2. Methodology

A design science research methodology was used in this research encompasses two iterations. The first iteration investigated the therapeutic game requirements and proposed guidelines to guide developers and practitioners in the design of therapeutic games which will be documented in this paper. The second iteration will use the findings from the first iteration to construct the main artifact in this study, which is a rehabilitation gaming system for physical rehabilitation. The earlier work outlines a more detailed description of the design science research methodology [30, 31]. Therefore, in the first iteration, with the fact that the lack of experienced therapists in the use of games-based physical rehabilitation for acquired brain injuries, the process took a long time to determine the research strategy that should be followed. Hence, before any actual game development, conducting a focus group with therapists and related practitioners is a great starting point as it helps generate interesting discussions between physical therapists, occupational therapists, service providers, special educators, psychologists, game designers, software engineers, other practitioners, and the researchers. The purpose of the focus group is two-fold: 1) To understand how rehabilitation exercises can be translated into a suitable game. This stage focuses on identifying rehabilitation exercises, in terms of required movements, constraints, difficulty levels, and required output, to design game interventions consistent with /matching these exercises. Therefore, low-fidelity game prototypes (paper mockups) that have been built (section 2.2) offer a good starting point, to learn how effective these game prototypes were in meeting the rehabilitation exercises required. The low-fidelity game prototypes (paper mockups) were developed through collaborative team brainstorming sessions and an in-depth review of the literature [32-51]. These prototypes are presented in the focus group to validate and/or correct them. 2) to test the game. The study [52], determines the feasibility of utilizing the Xbox Kinect gaming console (Kinect Adventure game series) in the rehabilitation of a single patient. This study opens a usability gap, mentioning that more research is needed to assess the usability of the Xbox Kinect gaming system in the clinical setting, and in different patient populations. Whole-body motion capture VR allows a unique opportunity for individuals to experience a heightened sense of realism during task-specific therapeutic activities. However, clinicians need to be able to match a game's components to an individual's functional deficits [53]. Even though none of these games were designed for clinical purposes, [54], stated that "Designers of rehabilitation tasks can benefit from examining the formulas that commercial game developers use". For example, [55], discussed that scoring mechanisms as well as mechanisms that maintain player engagement are commonly used in commercial games and can be used similarly in a rehabilitation setting. Therefore, the game test (Kinect Adventure game series and Motionsports Adrenaline) with therapists can capture information concerning (design, human-computer interaction, and a variety of mechanisms that are used to maintain patient engagement, etc.). Moreover it can to identify the missing components that make these games not suitable for physical rehabilitation. High-fidelity prototypes can be designed and developed based on the focus group result.

2.1 Materials and Methods

Motion-sensing devices like the Kinect fall under the category of gesture-tracking devices, utilizing a user interface known as a Natural User Interface (NUI). Consequently, participants moved around the play area, raised and lowered their arms, and adjusted their body positions to complete the tasks. Two commercially available games were selected: Kinect Adventures and Motionsports Adrenaline. Kinect Adventures was selected for its entertaining nature and its variety of mini-games, including Space Pop, 20,000 Leaks, Reflex Ridge, River Rush, and Rally Ball. These mini-games offer diverse scenarios and require different body movements. For instance, in 20,000 Leaks, players use their hands and feet to plug holes that appear when fish hit the tank glass. In Rally Ball, players hit a virtual ball toward targets, while in Reflex Ridge, they avoid obstacles while collecting coins. The second game chosen is Motionsports Adrenaline, which offers a range of sports experiences. It includes six distinct mini-games—Wingsuit, Kitesurfing, Kayaking, Mountain Biking, Rock Climbing, and Extreme Skiing—designed to simulate high-stakes stunts that most people would not attempt in real life. Unlike Microsoft's Kinect Sports series, Motionsports Adrenaline distinguishes itself with a focus on realistic visuals, setting it apart from the multitude of other Kinect games. A focus group consisting of 27 participants—4 occupational therapists, 10 physiotherapists, 2 game designers, 3 software engineers, 3 special educators, 3 psychologists, and 2 researchers—was convened to test and evaluate commercial games and our game prototype mockups (Figure 1.1). All participants have given their consent to participate in the study, and they receive important information from the researcher to help them make an informed decision. This includes their right to refuse participation without facing any penalties. The objective was to gather feedback, explore their needs and desires for a serious game, and understand the requirements for game-based physical rehabilitation. The assistant initially started the games for the participants. As the training advanced, some participants became proficient in navigating the game menus independently. When needed, participants were reminded of the game's objectives during the session (Figure 1.2 and 1.3). Table 1 shows the list of focus group participants that include all types of participants.


Figure 1.1: Focus group session briefing by the researcher

Figure 1.2 Focus Group session. Participants are playing the *Kinect Adventures Game*.

Figure 1.3 Focus Group session. Participants are playing the Kinect Motionsports Adrenaline Game.

Table 1 List of participants

Num	Role	Participant ID
1	Therapist	P1- P4
2	Physiotherapists	P5 – P14

3	Game designers	P15 - P16
4	Software engineers	P17 – P19
5	Special educators	P20 – P22
6	Psychologists	P23 – P25
7	researchers	P26 – P27

2.2 Low-fidelity prototypes/ Paper mockups

Rabbit Hunting: This game prototype shows a number of holes with a rabbit hiding inside one of them. Once the game starts, the rabbit peers out of one of 5 holes and stays at a hole for a short amount of time (depending on the patient's ability) as shown in Figure 2. The player has to hit the appearing rabbit with his hand and score a point. Using the Kinect motion recognition feature, the arm movement of the patient is mapped on the corresponding limb of the avatar (a model of a human represented on the screen). Feedback such as a buzzing sound, updating a score counter, and changing the rabbit color is displayed to the patient on the screen. The game prototype aims to score as many points as possible within the specified time limit that can be adjusted/controlled by the therapist according to the patient's ability. The game gets harder by increasing the game's speed and/ or adding a cat that the player has to avoid. The therapeutic goal is to improve shoulder elbow and wrest movement, ability to multifunction, eye-hand coordination and strengthen muscle power.

Figure 2: Rabbit Hunting game prototype.

Picking Balls: This game prototype is made of 3 levels, each with an increased difficulty than the previous one. The arm movement of the patient is mapped on the corresponding limb of the avatar (a model of a human represented on the screen) using the Kinect motion recognition feature. In the first level as shown in Figure 3 (a), the player has to put the balls in the basket without worrying about any ordering or colors, if he finishes the level, he goes to the next level, which consists of colored balls, as the system chooses which ball to be picked (the one of the color indicated on the screen) as shown in Figure 3 (b). The last level consists of balls with random numbers on them, and the player has to put them in order, ascending or descending, into the basket as shown in Figure 3 (c). In the advanced next levels, the patient will be asked with which hand he should pick the balls. The therapeutic goal is to improve cognitive skills, endurance, eye-hand coordination, awareness, and the ROM of the arm.

(a) (b) (c)

Figure 3: Picking Balls game prototype.

Organizing Eggs: This prototype shows an egg appearing in the middle of the screen. Using the Kinect motion recognition feature, the avatar (the virtual character portraying the player on the screen) mimics the movements that the player makes. The player has to pick and put each egg in the specified place in the basket as shown in Figure 4. The player gets a point for every egg put in the right place. The therapeutic goal is to improve motor functioning, balance, strengthen the muscle power in the whole upper limb, and movement of reach, grasp, and release.

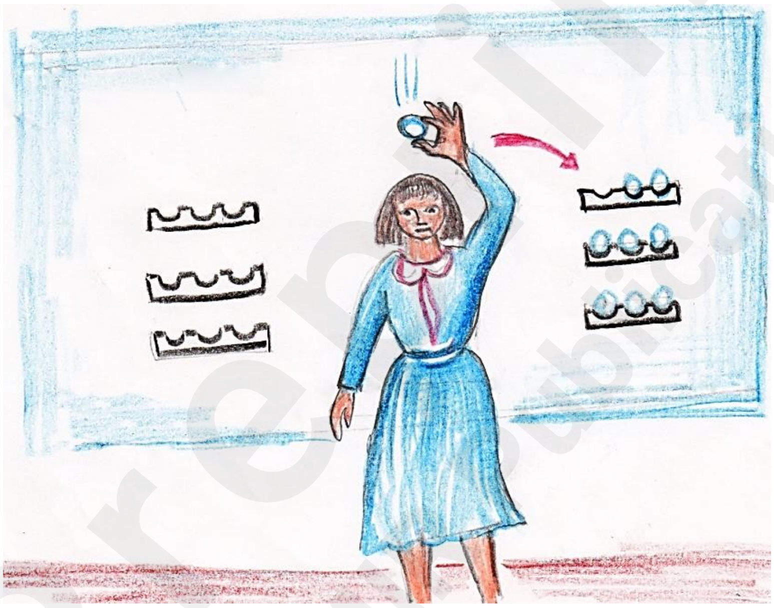

Figure 4: Organizing Eggs game prototype.

Shuffling Shelves: This game prototype intends to work on the patient’s cognitive and physical capabilities, as the patient has to grab/pick the book from the upper shelf and put it on the lower one (Figure 5), depending on both the book and the shelf’s colors. The arm movement of the patient is mapped on the corresponding limb of the avatar (a model of a human represented on the screen) using the Kinect motion recognition feature. The game starts with a number of colored books appearing on the upper shelf, above the divided and colored lower shelves. After the patient grabs the book and puts it on the suitable shelf, he gets a point. The therapeutic goal is to improve endurance and balance, trunk control, “Right-Left” discrimination, improving the patient's coordination skills, and arm movements (arm extension and shoulder abduction).

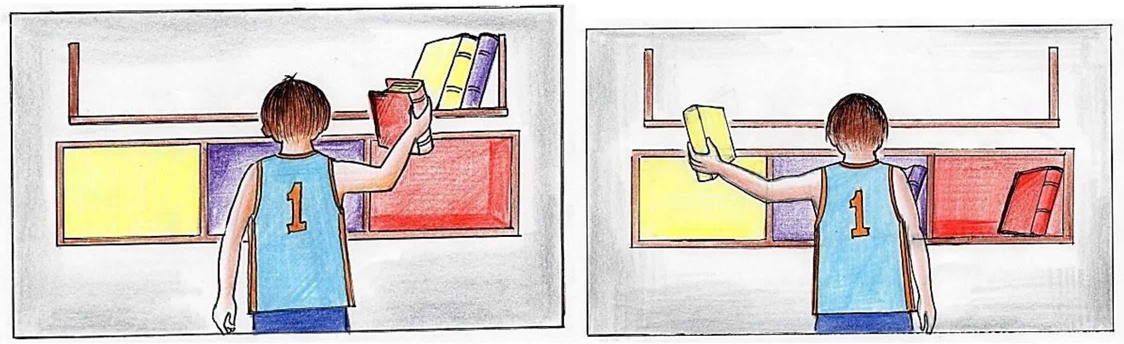

Figure 5: Shuffling shelves game prototype.

Hold the Boat: This prototype focuses on the arm’s strength and stability. Using the Kinect motion recognition feature, the avatar (the virtual character portraying the player on the screen) mimics the movements that the player makes. In this game prototype, the patient has to hold the boat and keep moving it to the goal (the end of the channel). Visual cues appear on the screen to guide the player as shown in Figure 6. The patient would have to, not only reach the game objects (the boat) but in addition, accompany their movements toward the final destination. This will promote the patient's stability and persistence. The therapeutic goal is to improve grabbing, hand awareness, stability, and shoulder ROM.

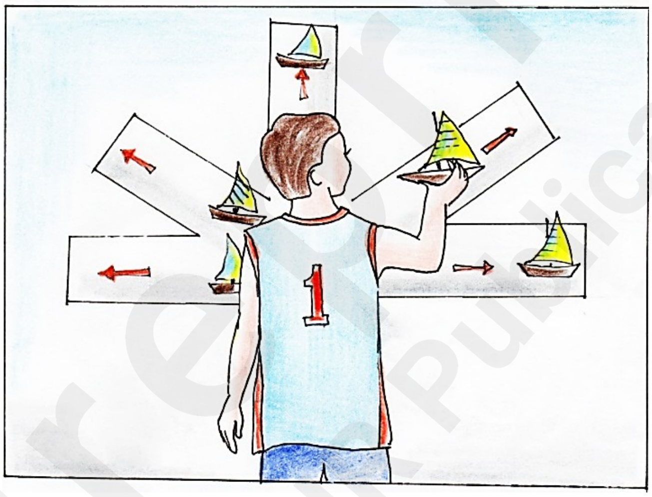

Figure 6: Hold the Boat game prototype.

Reaping the Oranges: In this game prototype, there are two modes: a single and a multiplayer mode. In the single mode, the patient plays alone, collecting as many oranges as possible from the tree during a certain period of time. Using the Kinect motion recognition feature, the avatar (the virtual character portraying the player on the screen) mimics the movements that the player makes. The player collects the oranges by simply moving his/her hands to touch the orange in the tree, then return it to the baskets displayed on the screen as shown in Figure 7. The game ends when the time limit is reached. The scores are shown to the patient which is, the number of oranges collected during the game. In the multiplayer mode, the goal of the game does not change, but there are two options: competition or collaboration. In the *competition*, both participants (two patients or a patient and a therapist) must collect as many oranges as they can. The winner will be the one who reaps more oranges. In the *collaboration*, both participants must collect as much as possible to achieve the target (number of oranges, which might be set and controlled by the therapist). In the next game levels, the patient can be asked to use either his right or left arm and to put the oranges in the right basket or the left one according to the patient’s case. The therapeutic goal is to strengthen the upper limb, improve eye-hand coordination, range of motion for the arm, “Right-Left” discrimination, weight shifting, abduction and adduction of the upper limbs of patients, and social interaction. In the next two game prototypes, the objective remained the same as above, with the difference that the game objects that the player would have to touch, would be moving instead of being static. This would add complexity, promoting stability and persistence.

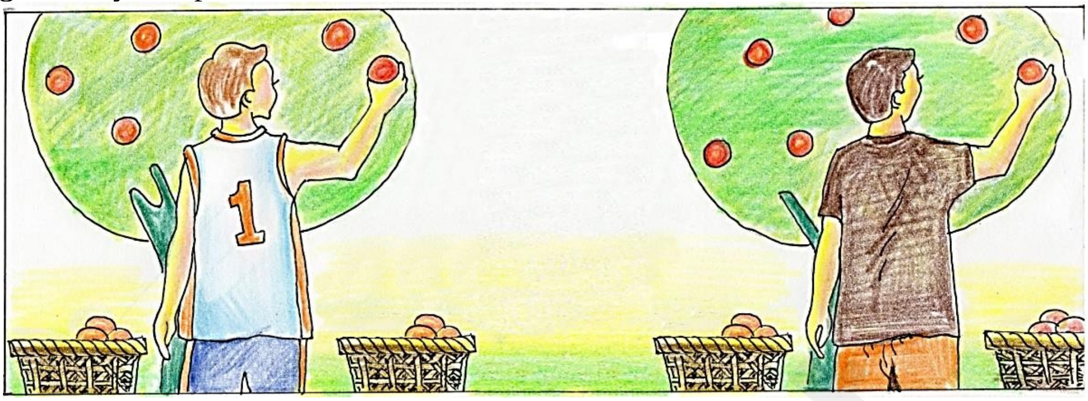

Figure 7: Grabbing the Oranges game prototype.

Ice Balls: In this game prototype, the patient has to move his hands (stretching his arms at different lengths) to catch ice ball drops from the top of the screen as shown in Figure 8. The game starts with a small number of balls with slow speed dropping from the top of the screen. The arm movement of the patient is mapped on the corresponding limb of the avatar (a model of a human represented on the screen) using the Kinect motion recognition feature. The more ice balls a player catches the higher the score is. In the next levels, the number and speed of dropping ice balls increased, and in more difficult places to reach. The therapeutic goal is to improve upper limb movement and coordination, motor planning, timing of reaching, and the supination and pronation movement of the forearm.

Figure 8: Ice Ball game prototype.

Blowing the Bubbles: In this game prototype, the player has to move his hand (or both hands). Using the Kinect motion recognition feature, the avatar (the virtual character portraying the player on the screen) mimics the movements that the player makes. The game starts with a girl on the side of the screen generating bubbles, and the player starts collecting points by blowing those bubbles with his/her hand as shown in Figure 9. The game gets harder by creating more bubbles and making them faster and harder to blow. The therapeutic goal is to improve supination and pronation movement of the forearm, shoulder and elbow muscle power, and elbow ROM.

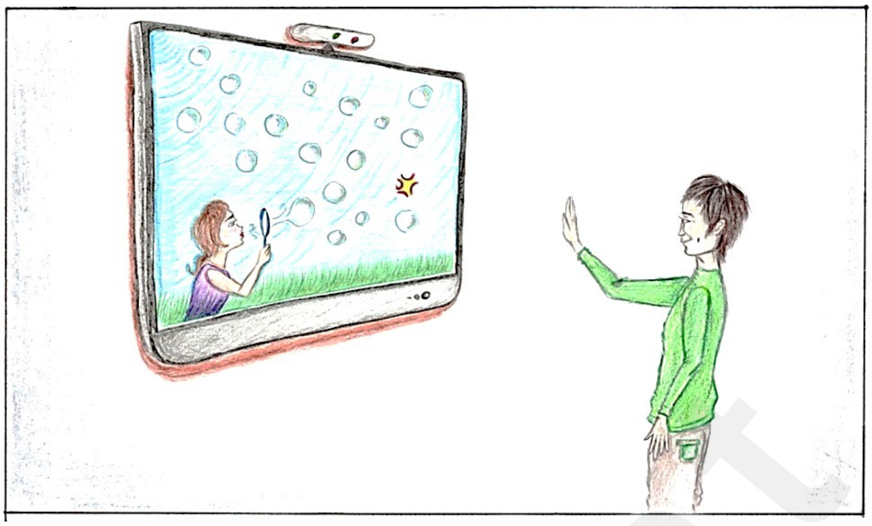

Figure 9: Blowing the Bubbles game prototype.

Matching Shapes: This game prototype focuses on cognitive and movement skills. The game starts as several shapes appear randomly on the screen (Figure 10). The arm movement of the patient is mapped on the corresponding limb of the avatar (a model of a human represented on the screen) using the Kinect motion recognition feature. The patient has to move both of his arms to select the same shapes/two identical symbols. The first levels have a smaller number of shapes and the advanced game levels have more complicated shapes. The player gets a point for correctly matching shapes. The therapeutic goal is to improve bilateral hand functioning, movement for the whole upper limb, coordination, and depth perception.

Figure 10: Matching shapes game prototype.

Colored Boxes: This game prototype focuses on cognitive and movement rehabilitation. The arm movement of the patient is mapped on the corresponding limb of the avatar (a model of a human represented on the screen) using the Kinect motion recognition feature. The patient uses both upper limbs to transport boxes from one side to the other. On the left of the screen, the colored boxes (red, yellow, and blue) gradually depart from one of three levels (the moving belts). The player stands in the middle of the screen using his upper extremities to make a bridge connecting both sides so that the appropriate colored box moves towards the same truck color as shown in Figure 11. As the game levels advance, the speed of the colored boxes increases. The therapeutic goal is to improve Bilateral-Hand functioning, endurance, coordination of movement in the upper limb, and hand control.

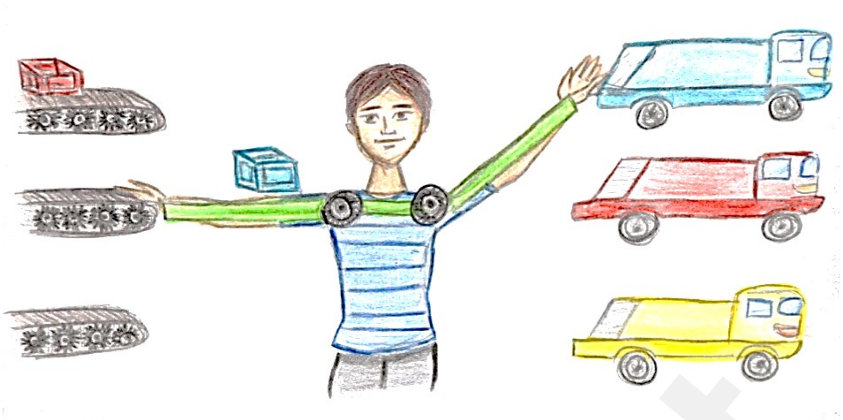

Figure 11: Colored boxes game prototype.

Fallen Apples: In this prototype, the patient raises his hands up and then moves them left and right making the apples drop down as shown in Figure 12. Using the Kinect motion recognition feature, the avatar (the virtual character portraying the player on the screen) mimics the movements that the player makes. As the game starts, the trees appear with the apples on, and then the player starts moving his hands left and right, the correct move makes the apples drop down and the patient will be given a point. As the levels get higher, the difficulty gets higher too by demanding the player to move his arms to a more difficult angle. The therapeutic goal is to strengthen the upper limb, maintain balance, motor-planning, and improves the movement of timing.

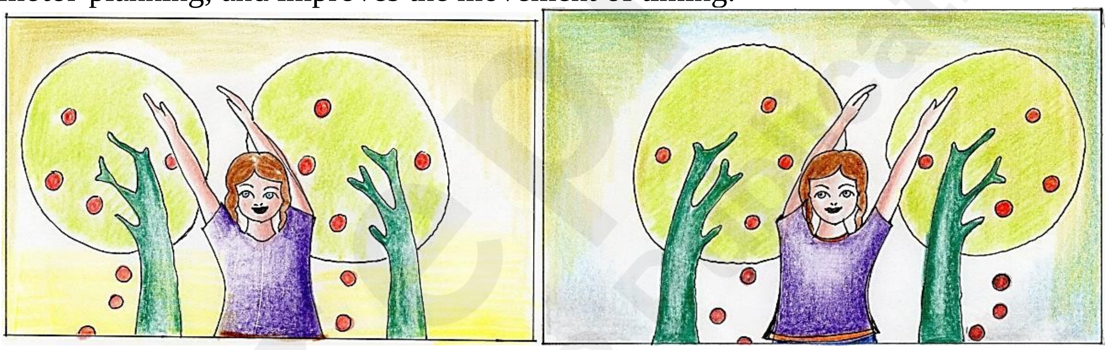

Figure 12: Fallen Apples game prototype.

Boat Driver: This game prototype relies on the player's ability to use both hands simultaneously. Using the Kinect motion recognition feature, the avatar (the virtual character portraying the player on the screen) mimics the movements that the player makes. The game starts with the boat in a river as shown in Figure 13, the player tries to lead the boat to the goal and starts moving his hands in order to move the boat's rudder to reach a specific point at a given time. Visual cues appear on the screen to direct the player's movement. The game gets harder by adding obstacles the player has to avoid before reaching the final destination. The game prototype mechanics focus on improving patients' speed, endurance, eye-hand coordination, rigidity, ROM, and bilateral movement.

Figure 13: Boat Driver game prototype.

Flying for Gold: In this prototype, the player emulates the movement of a flying bird, by raising his arms and moving them up and down towards the places the golden coins appear. Using the Kinect motion recognition feature, the virtual flying bird on the screen mimics the movements that the player makes. The game starts with the bird appearing on the screen as shown in Figure 14, followed by the golden coins that appear in a random way, as the player has to collect the coins using the movement mentioned above, the more coins he collects the higher his score will be. The therapeutic goal is to improve coordination, shoulder movement, and endurance.

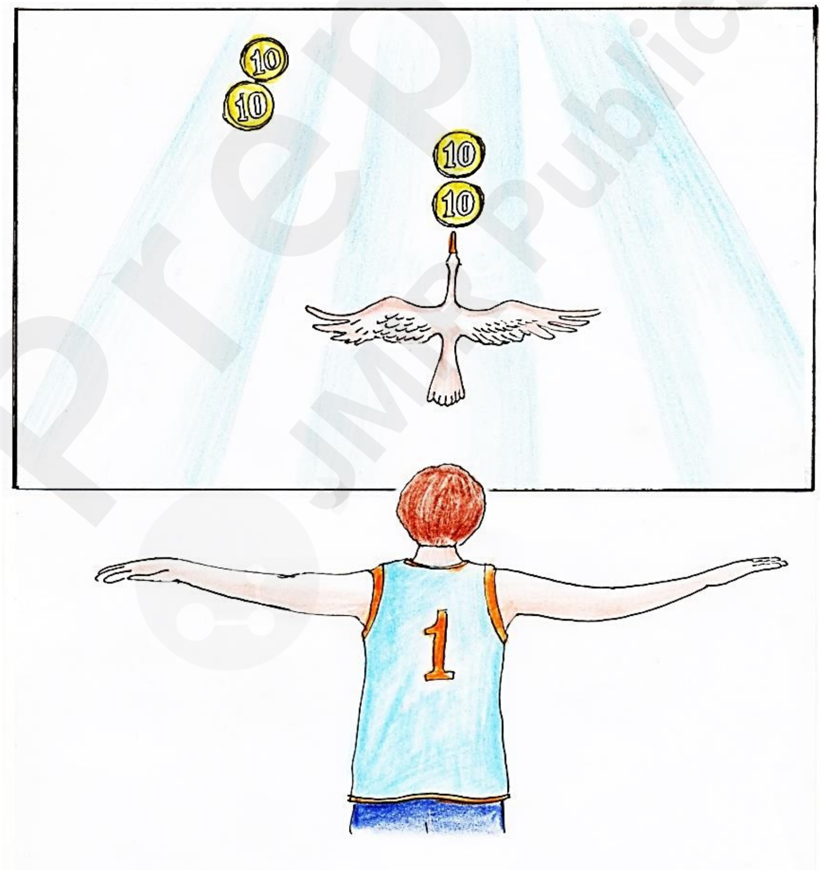

Figure 14: Flying for Gold game prototype.

The Rowing Boat: The prototype is designed to enable the patient to use both arms simultaneously. Using the Kinect motion recognition feature, the avatar (the virtual character portraying the player on the screen) mimics the movements that the player makes. The game starts with the two-paddled boat in a river (Figure 15), and the player starts moving his arms (bilateral movement) in order to reach a specific point at a given time. Visual cues will appear on the screen to guide the player. The faster he moves the paddles, the faster he can reach the finishing point. In the advanced next levels, there will be obstacles and the player has to avoid them in order to reach his destination. The prototype mechanics (the targeted exercise) focus on improving patients' speed, ROM, bilateral movement, body awareness, and reducing rigidity.

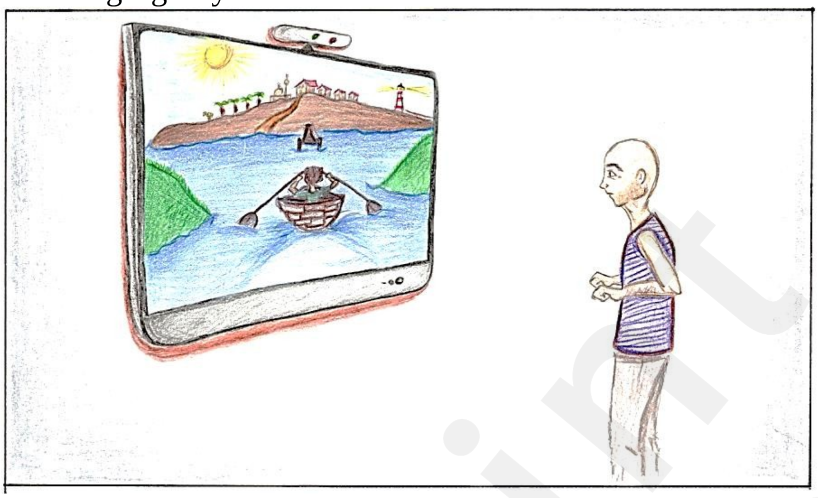

Figure 15 The Rowing Boat game prototype.

The Steam/Air Pump game: The game starts with the pump and steering wheel. The game's aim is for the player to rotate the steering wheel/ valve in several repetitions in order to release steam to create fire and cook the food within a given time. As the player moves the steering wheel in the right direction he gets the points. The targeted exercise is shown in Figure 16. Visual clues appear on the screen to direct the player's movement. Audio is used to set the rotation tempo. The game mechanics focus on improving uses speed, rigidity, ROM, and bilateral movement. The figures (Figure 16b) below depict different game scenarios of the Steam game.

(a) (b)

Figure 16 Air Pump game prototype.

3. Results and Discussion

The following section includes opinions and statements from expert participants regarding the presented commercial games and game prototypes (mockups). Additionally, it incorporates some observations made by the researchers. This section will discuss several design implications and recommendations. These aim to (1) enhance the effectiveness of game-based therapy for patients who struggle to engage with or benefit from it and (2) assist therapists in personalizing games more effectively for each patient. According to the discussions with therapists and other practitioners, the commercial games presented in the focus group are primarily designed for entertainment rather than ensuring exercises are performed correctly.

The participants were excited to test the Kinect device, discovering its features and expressing strong enthusiasm about its potential applications. One therapist pointed out that the Kinect Adventures and Motionsports Adrenaline games may not be entirely suitable for patients and would need significant modifications to settings such as speed and difficulty. (P4). He added that the extent of a patient's impairment increases the necessity for customizable difficulty settings. Some participants (P20, P22) who tested the adventure game observed a lack of clear initial in-game guidance, which required the facilitator to explain how to play. Most therapists (P1, P2, P4) agreed that the mockup prototypes were effective due to their simplicity and focus on specific movements, whereas the commercial games lacked this focus. It is important to note that these games are typically created for healthy individuals and often provide negative feedback upon losing, which may be unsuitable for patients. However, depending on the patient's rehabilitation stage and his motor and cognitive abilities, these games can be a fun alternative to conventional rigorous training, particularly for maintaining a training regimen at home after clinical sessions. P3 mentioned that in certain cases, the primary goal is to simply get patients moving and to create a positive experience with motion. While correct movement is important, it is not always the main focus. The greatest potential of this commercial game is its ability to motivate patients, providing a foundation for more advanced exercises. However, for these games to be effective, they need adjustable difficulty levels, minimal distracting elements to maintain focus, simplicity, easy-to-navigate menus, and clear feedback from the system.

P5 noted that the key factor in a successful game-based rehabilitation system is that therapists' roles in game-based therapy do not appear to differ significantly from their roles in conventional therapy. Once the therapist identifies the therapeutic goals, the game should allow them to assign therapeutic activities to their patients and adjust these game exercises to accommodate individual patients' impairment characteristics. Additionally, it should enable therapists to track patients' progress and monitor the quality of their exercise movements. (P15). The same participant also emphasized that rehabilitation game systems cannot operate independently (as stand-alone applications). They need to be part of a comprehensive framework involving patients, therapists, clinicians, hospitals, and other relevant parties, due to the multidisciplinary nature of the rehabilitation process. Participants (P5, P11) believed that the use of rehabilitation games helped reduce therapists' workload by automating exercise movements and providing monitoring and evaluation of patients' performance. (P5, P11). Another participant proposed expanding the game system to multiple stations, allowing therapists to work with several patients simultaneously, and after each session, data on patient usage would be stored in a database, providing therapists with easy access to review and analyze the information as needed. (P17).

Participants noted that in conventional rehabilitation, therapists used various methods to deliver instructions, including verbal, gestural, and physical approaches. For example, therapists might say, "Move your hand up," and often combine verbal cues with demonstrations of the movements. When patients had difficulty understanding the instructions through verbal or gestural means, therapists provided physical assistance, guiding the patients through the movements until they understood the instructions. Therefore, the game-based system should utilize multiple methods to communicate instructions and explain game-related rules to patients, particularly those with cognitive impairments. This includes offering audio and visual instructions through text, images, and animations on the screen. Additionally, it is important to provide feedback and multiple visual stimuli during gameplay to help direct and maintain patients' focus on the required exercises throughout the therapy sessions. In addition, another participant mentioned that for the game system to be a viable complement to in-hospital rehabilitation, it should provide clear and sufficient instructions for home-based exercises, allowing patients to participate independently. (P17). He suggested that one idea is to include video recording functionality, enabling therapists to record themselves while playing the game demonstrating the correct movements for their patients to follow at home. To communicate instructions to patients effectively, one participant suggested that, as shown in the mockup prototypes, patients' movements are reflected by an avatar, allowing patients to see each move they make, an additional avatar could be added to demonstrate the movements the patient should perform during the exercises. (P13). When asked about the importance of patients seeing themselves and their actions while exercising, as depicted in most of the presented game prototypes, most therapists appreciated the visual representation on the screen. One therapist (P3) noted that for youths and children, using a fun character to show movements on the screen would be beneficial, as many prefer not to see themselves in a real picture due to potential negative self-perception. Another participant, a psychologist (P23), added that role-playing in games is impactful because players develop emotional connections with their avatars. As avatars evolve through different stages, they play a key role in sustaining motivation. Important motivational factors include providing diverse avatar options to boost feelings of autonomy, which in turn fosters positive emotions and connections through the avatar's development and advancement. (P12). In the Reaping the Oranges mockup game (Figure 7), one participant (P25) recommended updating the avatar to a farmer. This change would let players take on the role of a farmer, harvesting oranges from a tree to fill a basket. He also suggested adding different game scenarios to involve a variety of physical movements. For example, instead of placing the basket beside the player, the avatar could carry a small basket on their head. In this setup, the player would need to reach up to pick oranges from the tree and place them into the basket on their head. (P25). Another participant proposed incorporating different game scenarios for subsequent or advanced levels. For example, oranges could appear on a tall tree that the player's avatar cannot reach by hand. In this case, the avatar could use a small basket, either on its head or held in its hands, to catch the falling oranges before they hit the ground. The avatar would move left or right depending on where the orange will fall, considering the patient's conditions and limitations. (P26). He also suggested that with each new game level, the system could change the shape and size of the tree and add animated objects to the environment to increase visual variety. Another participant suggested that the game system should allow them to choose from a list of available exercises. This way, each patient can be assigned different exercises based on what the therapist wants to evaluate (P23).

Another participant (P15) pointed out that consideration should be taken carefully when choosing game themes, as some themes could trigger negative reactions in patients. For example, a car racing game might be uncomfortable for someone who has been involved in a car accident. To address these concerns, it’s essential to provide a variety of themes to suit different needs and sensitivities. One participant (P7) proposed that farm life could be an excellent theme for game-based physical rehabilitation, and many others agreed with this suggestion. This theme could appeal to a broad range of patients, including elderly individuals who may have connections to rural environments from their youth, as well as younger adults and children. The peaceful and relaxing nature of farm life can instill a sense of purpose in patients, potentially improving their commitment to the rehabilitation process(P11). Furthermore, the theme of farm life aligns with the slow pace of seasonal changes and the growth cycles of crops and animals, reflecting the long-term nature of rehabilitation. This theme emphasizes the need for patients to commit to intensive exercise over an extended period, much like the ongoing care required in farming. For example, various farming activities can be adapted into game exercises targeting different movements, such as shearing sheep, herding flocks, milking cows, sowing seeds, planting trees, weeding, fishing, mending fences, cutting grass, picking fruit, harvesting wheat, chopping wood, feeding chickens, selling corn, irrigating, collecting honey, gathering eggs, watering plants, driving a tractor, trimming hedges, spraying pesticides, raking leaves, and scaring birds (P11, P15, P16, P20, P22). Another participant (P3) mentioned that adding a farmer's house to the game scene and incorporate more game exercises related to Activities of Daily Living (ADLs). These exercises could include real-life activities such as cleaning dishes, brushing teeth, cooking, and shaving. (P3). Another participant noted that many of the mockup game prototypes, including The Steam/Air Pump Game, The Rowing Boat, Boat Driver, Colored Boxes, Matching Shapes, Reaping the Oranges, Shuffling Shelves, Organizing Eggs, Rabbit

Hunting, and Fallen Apples, could be adapted to fit within a farm life theme under a unified game system. This would provide a variety of game exercises centered around the farm life concept (P23). Another participant (P10) suggested that, given recent technological advancements, it is possible to enable immersive experiences through HMD (Head-Mounted Display) devices, which are now lightweight and affordable. These devices provide immersive 3D game experiences that can help sustain patient motivation and adherence. (P10).On the other hand, therapists and other practitioners have been asked about how to transform a physical rehabilitation procedure into a game. It is found that various devices are employed to facilitate therapeutic processes. A potentially transformative approach to conventional motor rehabilitation therapies involves upgrading the existing devices used by physiotherapists to be more advanced and engaging. For instance, during physiotherapy sessions, patients employ various auxiliary devices to facilitate task execution, such as the Shoulder Pulley T Type and the Shoulder Wheel, as depicted in Figure 17. The shoulder wheel is employed to regain the range of motion in shoulder joints. Although these devices support the execution of therapeutic movements, they often lack motivational aspects to engage patients. Integrating gamification with these instrumented devices could fill this gap by turning rehabilitation procedures into interactive and motivating experiences. This approach represents a valuable opportunity for enhancing therapeutic outcomes and deserves further investigation.

Figure 17. Examples of equipment used in physiotherapy sessions: (a) Shoulder Pulley T Type; (b) Shoulder wheel.

Adapting existing devices used in physiotherapy sessions and transforming them into game controllers could shift patients' focus from the monotonous repetitions of their exercises to engaging with the game itself. Consequently, actions performed with physical objects in the real world are mapped and reflected in the virtual environment. Here are some examples of games that utilize these devices: i) placing a screen in front of patients, the Shoulder Wheel can be used to explore a virtual city or world, enabling them to play the game and experience tailored stimuli and positive reinforcement, where actions carried out by the player with physical objects in the real world are mapped and reflected in the virtual environment. ii) the Shoulder Wheel can be employed for various therapeutic exercises aimed at strengthening the shoulder muscles. When used with both hands, the gestures can be integrated into a racing car simulator. Conversely, when used with one hand for arm extension, it can be adapted for a firefighter pump game, where patients simulate supplying a water hose to help a firefighter extinguish a fire. iii) the Shoulder Pulley T Type can be employed to simulate the flapping of a bird or the soaring of an aircraft through the skies. Therefore, games can be designed to intentionally balance patients' enjoyment (entertainment value) with a focus on the quality of their exercise movements (therapeutic value). This configuration aims to enhance both engagement and the effectiveness of the rehabilitation process.

According to the investigation in terms of effective game-based system architecture, any potential game-based physical rehabilitation system architecture should support flexible configuration. Unlike traditional video game design, which seeks to maximize player engagement, rehabilitation games aim to balance engagement with therapeutic relevance (e.g., quality of movement).

The design of rehabilitation games should accommodate different levels of players' cognitive abilities and game style preferences. To meet these challenges, a flexible game architecture that includes key components such as rehabilitation-specific physical movements, adaptable game mechanics and difficulty levels, and customizable visual designs/ appearance are suggested.Within this architecture, the relationship between physical movements and their in-game representation can be easily modified or reconfigured to suit different rehabilitation needs. However, As detailed in Section 2.2 of this study, the game prototypes presented in this study are designed to permit only predefined exercise movements to interact with/play a specific game.

For example, in Vertically Scrolling Shoot 'Em Up games or Blowing the Bubbles game (see Figure 9), patients use reaching movements to guide the jet fighter or inflate bubbles. In the Boat Driver game (see Figure 13), patients perform circular movements to control the boat. A game system that enables therapists to customize and align different physical movements with game actions (such as using circular motions to maneuver a jet fighter) can enhance the gaming experience for patients and support their rehabilitation goals more effectively.

Additionally, the controllers of the rehabilitation game system should be designed to enable patients to practice various exercise movements while intentionally suppressing their compensatory behaviors. For instance, a controller could be configured by the therapist to recognize only the horizontal movements of the patient's hand, or to consider trunk movements as input, thereby reducing trunk-related compensatory actions. Likewise, for stroke patients who unintentionally involve their shoulder or elbow, the game system can allow the therapist to address this by using the compensating joint as an input. Moreover, the system should be adjustable and flexible, allowing the therapist to choose which hand or side of the patient (left or right) will be used for game interaction.

It is believe that a game system with reconfigurable visual elements, tailored to patients' preferences and needs, can enhance their engagement and participation in game-based therapy. Patients may respond differently to visual stimuli/ visual appearance. Those with severe cognitive impairments often have difficulty processing realistic graphics, leading to disengagement. Simplifying graphical representations to basic 2D or cartoon-like visuals can improve comprehension and engagement in therapy for these patients. Older patients or those with a negative attitude toward games may view rehabilitation games as childish and lacking in therapeutic value. To address this, the design of the games can be adjusted to resemble real-world therapeutic interventions, thereby conveying that these games are intended for serious therapeutic purposes rather than mere entertainment. Therefore, adjustable visual settings can be tailored to accommodate patients with varying preferences and cognitive levels. A game-based systemshould be able to reconfigure its visual appearance and tailor the game to a patient's preferences and needs is crucial and can greatly enhance their engagement and participation in game-based therapy. This highlights the need for future research to develop tools that allow therapists to adjust the entertainment features of serious games. These tools should help maintain therapeutic factors, such as movement quality, especially when patients begin to prioritize entertainment over therapeutic goals.

Another therapist highlighted the need for the game system to facilitate practice movements and tasks associated with Activities of Daily Living (ADLs). Effective game scenarios should incorporate real-life activities, such as cleaning dishes, brushing teeth, combing hair, grasping a spoon, holding a cup, shaving, and moving objects. These scenarios should involve virtual representations of ADLs performed by the in-game avatar, integrating various joint movements such as shoulder abduction and adduction, elbow flexion and extension, and forearm pronation and supination to interact with virtual objects.

One therapist (P2) suggested that the multiplayer aspect of the Reaping the Oranges game, whether through competition or collaboration or connecting with other patients face to face or online, could enhance engagement and enjoyment for many patients. However, it is important to recognize that game interactions might add stress for some individuals. Therefore, while this game has the potential to improve the overall gaming experience, it is crucial to consider the varying preferences and needs of different patients.

One therapist suggested providing a pool of games each targeting different exercise movements. Another therapist (P1) suggested that developers could take advantage of existing commercial games to create diverse game scenarios. He added that a game like Kinect Adventures: 20,000 Leaks could be modified by simplifying its design, allowing therapists to control aspects such as difficulty level, speed, and range of motion, and to tailor patients' interactions with virtual game objects.

One therapist (P2) with experience using games in rehabilitation mentioned dissatisfaction with the preprogrammed difficulty levels of games, such as adventure games discussed in the focus group session. They expressed a desire for more flexible control over game parameters, emphasizing the need for therapists to have a way to adjust the difficulty level of rehabilitation games.

Therapists revealed the data parameters to be collected from the game-based intervention reflect various insights. The scores at the end of a game session are commonly used to measure performance, additional metrics can be collected to provide insights into patients' motor and cognitive abilities, as follows: 1) Score: Higher scores may indicate better performance in response to challenging tasks. 2) Time: Longer session durations suggest a greater number of repetitions of the prescribed exercises. 3) Level: Advancing to higher game levels is associated with increased challenges. 4) Distance: Assessing the distance covered by the affected limbs helps determine the level of muscle engagement and effort exerted during the exercise. 5) Changes in Motion Direction: A higher frequency of changes in movement direction might indicate inaccuracies in execution or that the movements were performed without a clear purpose. 6) Initial Movement Range/Amplitude: This metric is crucial for evaluating patients' progress and understanding their development over time. 7) Number of Sessions: Tracking the number of sessions played and any interruptions can help therapists determine whether patients felt uncomfortable with specific games or if they were disengaged and did not complete the prescribed exercises.

In addition, one therapist mentioned that electromyography (EMG) sensors could be employed to monitor muscle activity during exercises. By recording EMG readings, therapists can assess movement patterns, measure muscle fatigue, identify disorders, and evaluate the effectiveness of exercise interventions. Movement correction measure: A key factor in the effectiveness of game-based rehabilitation systems is the accurate assessment of the patient's movements during gameplay sessions. However, according to a therapistthe steps that are taken to reduce the likelihood of incorrect execution of exercises in motion-sensing technology-based gamesis minimized because patients who are at risk of injury would not be permitted to use the device. It is the therapist's responsibility to evaluate and manage these situations. Another practitioner highlighted that some of the major benefits of using this technology include engaging patients, making exercise enjoyable, providing opportunities for social interaction, and offering feedback on exercises. The experts were less worried about the games enforcing or ensuring correct movement and addressing compensatory actions, as they would personally guide and decide when and how patients should use motion games. According to the discussed metrics, these metrics are expected to provide valuable insights for therapists to evaluate a patient's recovery progress. For instance, low scores and extended playtimes may indicate that patients are struggling to complete the required tasks, which can result in frustration and a negative perception of the game. Additionally, Covering longer distances with the affected limb and making fewer changes in motion direction suggests that patients are performing movements with greater amplitude, indicating they are in a more advanced stage of recovery. Conversely, if patients cover short distances with frequent changes in motion direction, it indicates that they either struggle to perform wide gestures or exhibit inaccuracies in their movements. Thus, while the patient enjoys the game, these parameters can be collected and stored for later analysis. This allows therapists to monitor and assess the patient's progress and development over time, providing insights into the quality and effectiveness of the game exercises performed. Another therapist suggested developing an online game-based system accessible to both patients and therapists. Therapists would log in to the system to view their patients, and once a specific patient is selected, the therapist could access their records, review collected data, and customize each game's settings as needed to better suit the patient's needs. One therapist proposed that, following a patient's discharge from the hospital or rehabilitation center, it would be beneficial if the game-based system could record the patient while they practice at home. This would allow therapists to review and evaluate these recordings to monitor the patient's adherence and ensure the exercises are being performed correctly. Table 2 shows the summary of comments and suggestions by participants and description of their comments. Based on the summary, it shows that three major suggestions on game settings are on game character, theme and difficulties, specifically focusing on customization. About 30% of the comments are align with the research objectives.

Table 2 Summary of comments/ suggestions

Comment/ Suggestion	Participant	Description
Kinect Adventures and Motionsports Adrenaline games may not be entirely suitable for patients and would need significant modifications to settings such as speed and difficulty. The extent of a patient's impairment increases the necessity for customizable difficulty settings.	P4	Customize setting (speed and difficulties)
A lack of clear initial in-game guidance, which required the facilitator to explain how to play	P20, P22	Include game manual
Prototypes were effective due to their simplicity and focus on specific movements, whereas the commercial games lacked this focus.	P1, P2, P4	Align with objective
For these games to be effective, they need adjustable difficulty levels, minimal distracting elements to maintain focus, simplicity, easy-to-navigate menus, and clear feedback from the system	P3	customize setting (speed and difficulties)
It should enable therapists to track patients' progress and monitor the quality of their exercise movements. They need to be part of a comprehensive framework involving patients, therapists, clinicians, hospitals, and other relevant parties, due to the multidisciplinary nature of the rehabilitation process	P5	Align with objective
rehabilitation games helped reduce therapists' workload by automating exercise movements and providing monitoring and evaluation of patients' performance.	P5, P11	Align with objective
Data on patient usage would be stored in a database, providing therapists with easy access to review and analyze the information as needed.	P17	Align with objective
Include video recording functionality, enabling therapists to record themselves while playing the game.	P17, P21	content
Patients' movements are reflected by an avatar, allowing patients to see each move they make	P13	Align with objective
Using a fun character to show movements on the screen would be beneficial, as many prefer not to see themselves in a real picture due to potential negative self-perception	P3	Align with objective

As avatars evolve through different stages, they play a key role in sustaining motivation. Important motivational factors include providing diverse avatar options to boost feelings of autonomy.	P23	game setting – player characters
Updating the avatar to a farmer. This change would let players take on the role of a farmer, harvesting oranges from a tree to fill a basket.	P25	game setting – player characters
Incorporating different game scenarios for subsequent or advanced levels. For example, oranges could appear on a tall tree that the player's avatar cannot reach by hand.	P26	game setting – player characters
Each patient can be assigned different exercises based on what the therapist wants to evaluate.	P23	Align with objective
pointed out that consideration should be taken carefully when choosing game themes, as some themes could trigger negative reactions in patients. For example, a car racing game might be uncomfortable for someone who has been involved in a car accident. To address these concerns, it’s essential to provide a variety of themes to suit different needs and sensitivities	P15	game setting – game theme
farm life could be an excellent theme for game-based physical rehabilitation, and many others agreed with this suggestion.	P7	game setting – game theme
The peaceful and relaxing nature of farm life can instill a sense of purpose in patients, potentially improving their commitment to the rehabilitation process	P11	game setting – game theme
Various farming activities can be adapted into game exercises targeting different movements.	P11, P15, P16, P20, P22	game setting – game theme
Add a farmer's house to the game scene and incorporate more game exercises related to Activities of Daily Living (ADLs).	P3	game setting – game theme
many of the mockup game prototypes could be adapted to fit within a farm life theme under a unified game system. This would provide a variety of game exercises centered around the farm life concept.	P23	game setting – game theme
Recent technological advancements, it is possible to enable immersive experiences through HMD (Head-Mounted Display) devices.	P10	game setting
One therapist suggested that the multiplayer aspect of the Reaping the Oranges game, whether through competition or collaboration.	P2	game setting – customization
Provide a pool of games each targeting different exercise movements.	P1	game setting – customization
preprogrammed difficulty levels of games, such as adventure games as inflexible control over game parameters.	P2	customize setting (speed and difficulties)

It is recommended a dedicated user interface for therapists to enable efficient control. This interface would allow therapists to subtly configure game settings, encouraging patients to perform therapeutically appropriate movements. For instance, if a patient begins to show compensatory behaviors during gameplay, the therapist can adjust the game settings to reduce the range of motion or slow down the game pace. This allows the patient to perform movements without severe compensatory behaviors. When patients experience fatigue or pain, therapists can make the games less challenging or pause them. Additionally, therapists can have full control over the games to maintain a balance between therapeutic and engagement values.

In conventional rehabilitation sessions, therapists must physically interact with patients to correct inappropriate movements. This often requires therapists to stand or sit next to or behind their patients, meaning they need to continuously reposition themselves throughout the therapy sessions. Thus, a dedicated and portable user interface is essential, allowing therapists to control game-based therapy more efficiently using handheld devices like tablets or mobile phones. This interface would facilitate better interaction with the games and improve the moderation of therapy sessions.

Consequently, based on the earlier discussion, it is evident that there is a need for game systems with high configurable ability. Such systems would allow therapists to customize therapy programs to better meet individual patient needs. These systems should offer the flexibility required for therapists to tailor therapy programs to each patient's specific needs. However, the increased complexity of game system operations places additional demands on therapists and requires comprehensive training to effectively manage and moderate game-assisted therapy sessions.

In our discussions with therapists, they emphasized the importance of proper training to effectively utilize rehabilitation games as a therapeutic tool. For instance, one therapist remarked, "I am motivated to use games with my patients, but I don't know what to do”. Therapists explained that improper use of rehabilitation games can result in patient pain or injury, making it challenging for therapists who are new to or lack experience with game-based therapy. Another therapist noted that using rehabilitation games without prior training can make it difficult to determine how to tailor the therapy to meet patients' needs effectively. With proper training, therapists would gain a clearer understanding of their roles, leading to more efficient use of the games and an improvement in the quality of game-based therapy sessions. Therefore, thorough training on the game system is crucial for therapists to let them grasp the system’s details and learn the most effective ways to utilize it. Consequently, it is essential to thoroughly assess and prioritize the usability of the game system for therapists to ensure it is both effective and user-friendly. This underscores the necessity for future research to examine the usability and effectiveness of interactive mechanisms that allow therapists to configure and customize game-based interventions.

4. Conclusions

Incorporating serious games and advances in ICT into physical rehabilitation can enhance the rehabilitation process, offer benefits beyond those of conventional methods, and improve both the effectiveness and efficiency of rehabilitation. Therapists and other healthcare professionals are crucial for effective game-based therapy, which is why they were involved in this phase of the research. While the participation of brain injury survivors (including those with traumatic injuries and stroke) is also important, this aspect will be addressed in future publications. To investigate the factors, determinants, requirements, and actual needs for the potential game-based rehabilitation, a focus group with therapists and other relevant healthcare professionals is organized. This decision is to evaluate the ideas with real rehabilitation therapists and practitioners. To effectively discuss the ideas with therapists and other related professionals before starting development, available commercial adventure games are tested and various paper game mockups created is evaluated. This approach facilitated productive discussions, validated rthe direction, and is expected to optimize our development timeline. The observations, feedback, and suggestions from the focus group and developed several guidelines to guide the design and development of an effective game-based physical rehabilitation system are analyzed. To increase compliance and ensure patients perform their exercises correctly, the game must maintain patient engagement and provide support during exercises. This can be achieved through appropriate feedback. Instant and clear feedback is crucial for providing a meaningful gameplay experience. It helps patients understand the outcomes of their actions, reflects their performance in exercises, and offers various in-game achievements. Feedback should include visual, audible, and haptic elements to enhance the user's interpretation of the gameplay and maintain their engagement. In addition, a game-based system needs to facilitate the practice of movements and tasks related to activities of daily living (ADL).

The social aspect of the game system is crucial, enabling patients to play with family members, friends, or other patients. Highlighting this feature enhances the overall experience. Additionally, incorporating a tracking mechanism for the quality of the patient's movements in the game system is advantageous. This will effectively support and facilitate the rehabilitation process, encouraging patients to perform the exercises accurately. In addition, a potential game-based system should be capable of tracking patients' progress. This feature could benefit both patients, by providing positive reinforcement and encouraging compliance, and physiotherapists, by allowing them to monitor and assess the patients' development. In addition, Simple art styles and graphics, as seen in the mockup prototypes, can motivate players and make the games more approachable, a feature that participants seemed to appreciate. This cartoon-like, simplistic art style has benefits such as lower processing power requirements and encouraging a more playful state of mind compared to realistic graphics. However, different demographics might respond differently to this style, given that many people are now used to almost photo-realistic graphics in games like Call of Duty. People generally tend to prefer familiar styles. Simple art styles and graphics, as seen in the mockup prototypes, can motivate players and make the games more approachable, a feature that participants seemed to appreciate. This cartoon-like, simplistic art style has benefits such as lower processing power requirements and encouraging a more playful state of mind compared to realistic graphics. However, different demographics might respond differently to this style, as many people today are accustomed to games with nearly photo-realistic graphics, such as Call of Duty. People generally tend to prefer familiar styles.

Furthermore, the game system should offer significant flexibility and adaptability to suit each patient's specific degree of injury. It is essential for a potential game-based rehabilitation system to allow therapists to customize the game exercises. Since individuals have different needs based on their injury and stage of rehabilitation, customization ensures that the game can better accommodate these unique patient requirements and preferences. Given that the rehabilitation process often extends over a long period, the focus of the training changes throughout this time. Therefore, the game system should include mechanisms for adapting game interventions to accommodate the different stages and focuses of rehabilitation. On the other hand, since rehabilitation programs typically involve multiple exercises, the game system should be designed to incorporate them. Therefore, the game system should be expandable to include a variety of exercises, supporting the entire rehabilitation process. On the other hand, ensure that patients can concentrate on their exercises rather than dealing with technical details. The findings highlight the need for a rehabilitation game to be simple to install and start. It should be easy to begin without lengthy or complex setup processes. For home use, the game system should prioritize easy installation, fast start-up, and intuitive usability. These findings serve as the foundation for the next phase of our research, which involves designing and developing a game-based physical rehabilitation system that fulfills these requirements.

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