Gamification elements in the rehabilitation of motor symptoms in people with Parkinson's Disease: A Scoping Review

Pere Bosch-Barceló, Oriol Martínez-Navarro, Maria Masbernat-Almenara, Carlos Tersa-Miralles, Anni Pakarinen, Helena Fernández-Lago

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Abstract

Background: Parkinson's disease (PD) is a rapidly growing neurological condition worldwide. While physiotherapy and exercise are effective interventions, the addition of motivational aspects that improve adherence could be beneficial for people with PD. Incorporating technological devices into motor rehabilitation, coupled with gamification elements, could enhance the relevance of rehabilitation and alleviate motor symptoms.

Objective: The aim of this scoping review was to identify and classify the technological devices integrating gamification elements used in motor rehabilitation in PD, and to describe the justification behind the use of these devices and elements in this context.

Methods: We conducted a Scoping Review following the framework proposed by Arksey and O'Malley, along with the PRISMA-ScR guidelines. Major health science databases (Medline, Cinahl, EMBASE, Scopus, Cochrane, PsycInfo, and Epistemonikos) were systematically searched. Relevant studies were included if they utilized technological interventions with gamification elements for motor symptom rehabilitation in PD. Gamification elements were extracted and categorized based on established frameworks, and content analysis was used to review the justifications for the use of technologies integrating gamification.

Results: A total of 3,681 studies were retrieved from the search. After abstract and full-text screening, 81 studies were eligible for data extraction. The analysis identified 453 gamification elements across studies, with Development and Accomplishment being the most prominent core drive. Progress/Feedback was the most frequently used element (97.53% of studies), followed by Points (86.42%) and Levels/Progression (81.48%). Other notable elements included Badges, Leaderboards, and Customization, while several core drives, like Ownership and Possession, lacked reported elements. Expected roles of technology were clear, but intentional use of gamification was scarce. Almost half of all studies used off-the-shelf commercial videogames to deliver their rehabilitation intervention.

Conclusions: This scoping review highlights the widespread adoption of technologies integrating gamification elements for motor symptom rehabilitation in individuals with PD. However, it also underscores a critical gap in understanding and justifying gamification mechanics. The current landscape relies heavily on commercial video games and emphasizes performance-based experiences, lacking theoretical grounding. Clinical Trial: This Scoping Review is registered at the Open Science Framework database (OSF.IO/TX3D9)

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Conclusions: This scoping review highlights the widespread adoption of technologies integrating gamification elements for motor symptom rehabilitation in individuals with PD. However, it also underscores a critical gap in understanding and justifying gamification mechanics. The current landscape relies heavily on commercial video games and emphasizes performance-based experiences, lacking theoretical grounding.

Keywords: Gamification; Motor rehabilitation; Parkinson's disease; Rehabilitation; Physiotherapy

Introduction

Parkinson's Disease (PD) is the second most prevalent neurodegenerative disease in the world, as well as the fastest growing one (1,2). Over the last twenty years, the global impact of Parkinson's disease in terms of deaths and disability has increased by more than twofold (3).

PD is mainly characterized by the presence of several cardinal motor symptoms, mainly stiffness, bradykinesia, tremor and postural instability (4). The progression of these symptoms heavily impacts the ability of people with PD to manage daily activities (5). Pharmacological treatment options for PD motor symptoms are mainly comprised of dopamine-based options: levodopa, dopamine agonists and monoamine oxidase-B inhibitors (6). However, these pharmacological choices come with their own array of issues: for example, Levodopa is known to eventually cause undesirable and involuntary movements known as dyskinesias in over half of patients after 6 years (7). Due to these secondary effects, other treatment options are needed for people with PD. Physical therapy and exercise training have proven capable of inducing long-term improvements in motor symptoms and physical function among individuals with PD (8). These interventions may also enhance the efficacy of pharmacological treatments, and help delay the progression of the disease and age-related decline, thus becoming a key part of the management of people with PD (8,9).

In the last decades, a wide array of technological devices has been incorporated to the rehabilitation of neurological conditions with the aim of assisting training. In this context, options such as Virtual Reality (VR) (10,11), robotics (12), smartphone applications (13), telerehabilitation options (14) and videogames and exergames (15,16) have been studied and shown positive effects for people with PD. With this massive implementation of technological solutions often follows the implication that, in trying to affect and improve the users' experience and behavior, mechanics reminiscent of games are used. This concept of "*the use of game design elements in non-game contexts*" is widely known as gamification (17). In the context of rehabilitation, the integration of gamification elements into technological devices is designed to create a more engaging and challenging experience for users. This approach is anticipated to enhance adherence and motivation among participants (18). The combination of gamification and VR could even add benefits for elderly people in physical and cognitive domains while allowing complex training scenarios such as Dual Task training to be performed (19,20).

To effectively incorporate gamification elements across various intervention designs, it is essential to thoroughly understand gamification principles and their interaction with human motivation. Frameworks play a pivotal role in organizing available gamification elements into coherent categories, thereby guiding developers in selecting the most appropriate elements to achieve the desired user experience. Common frameworks include the Octalysis Framework by Yu-kai Chou (21), which identifies eight core drives of human motivation, such as Epic Meaning and Social Influence; and Marczewski's 52 Gamification Mechanics and Elements (22), which classify elements based on the type of player they best cater to. However, the decision of which gamification elements to apply in interventions is often not thoroughly considered, in a context where treatment options should cater to the needs of end-users (23). Recent studies point at most VR rehabilitation options for PD being administered through commercial videogames, which are designed for entertainment in healthy individuals, far away from the context of rehabilitation for people with PD (24–26).

In PD, where apathy and depression are often present, long-term adherence to exercise and rehabilitation is concerning (27,28). Previous research has shown that the implementation of VR does not warrant a higher adherence to treatment (10). Strategies to promote motivation to stay involved in the rehabilitation process are key to long-term success in a population with a tendency to dropping-out (29–31). However, current literature lacks information on the implementation of gamification in technological devices aimed at rehabilitating motor conditions in PD. Understanding which elements are currently employed and the types of technological solutions they are integrated into is essential for developing further interventions that address the specific needs of individuals with PD. Therefore, the aim of this scoping review is to identify and classify the gamification elements and technologies used in motor rehabilitation in PD and to describe the justification behind the use of gamification and technology in this context.

Methods

Registration and Framework

This Scoping Review is registered at the Open Science Framework database (OSF.IO/TX3D9). To develop the overall structure for our Scoping Review, we followed the Arksey and O'Malley (32) framework, which involves a five-step process to identify the research question, then identify and select relevant studies, extract their data and report the results. This Scoping Review also adheres to the PRISMA guidelines for Scoping Reviews (PRISMA-ScR) to ensure quality, transparency and reproducibility (33).

Objective

The objective of this study is to explore the use of technological devices integrating gamification in the rehabilitation of motor symptoms for individuals with PD. Specifically, it aims to identify the gamification elements and technological devices employed in this context, classify the gamification elements based on the core motivational drives they target and the devices according to the motor symptoms they address, and describe the rationale behind their application in enhancing motor symptom rehabilitation for people with PD.

Elegibility criteria

All peer-reviewed articles and peer-reviewed conference papers published in English or Spanish were included. To guide the eligibility criteria, the PCC framework was used, in which Population, Concept and Context (PCC) are defined in order to guide study selection (34). Population referred to people with PD. The Concept considered all intervention studies that aimed to describe the rehabilitation of motor aspects through technological solutions that incorporated gamification elements and those could be identified. In situations where not enough details were given regarding the intervention to chart its gamification elements, the studies were excluded. Context restrictions were not applied. No limitations regarding year of publication were established. Articles that met the selection criteria were incorporated without assessing their quality, as the objective of scoping reviews is to chart the pertinent works in a particular area and pinpoint areas lacking research (32).

Information Sources and Search strategy

The search strategy was performed by a librarian on November 23rd, 2023, on seven electronic databases: Medline, Cinahl, EMBASE, Scopus, Cochrane, PsycInfo, and Epistemonikos. No systematic or scoping reviews reporting on the indicated topic were found. The search was conducted using the following keywords and their combinations: Parkinson's disease, gamification, rehabilitation, motor symptoms and different technological rehabilitation strategies (e.g., virtual reality, videogames, exergames).

Study Selection and Data Extraction

All articles extracted from databases were imported to Covidence (35) and checked for duplicates by using its duplicate detection system. Following, a title and abstract screening for all available studies was independently conducted by three reviewers (PBB, OMN, MMA), who confirmed the inclusion of all articles matching the PCC requirements. Full-text screening was then performed by the same three reviewers, and conflicts were solved by discussing all inconsistencies among the reviewing team.

A total of 3681 articles were retrieved from all databases. After duplicates were removed, both by Covidence and manually, 58.62% of all articles underwent title and abstract reviewing (2158/3681). After this first title and abstract screening, 87.62% were excluded (1891/2158). 267 were left for full-text screening, 69.66% of which were excluded (81/267). Finally, altogether 81 studies were included in the final review (Table 1). The PRISMA flow diagram (Figure 1) details the steps followed during the screening process and data on number of excluded studies as well as reasons for exclusion on the full-text step.

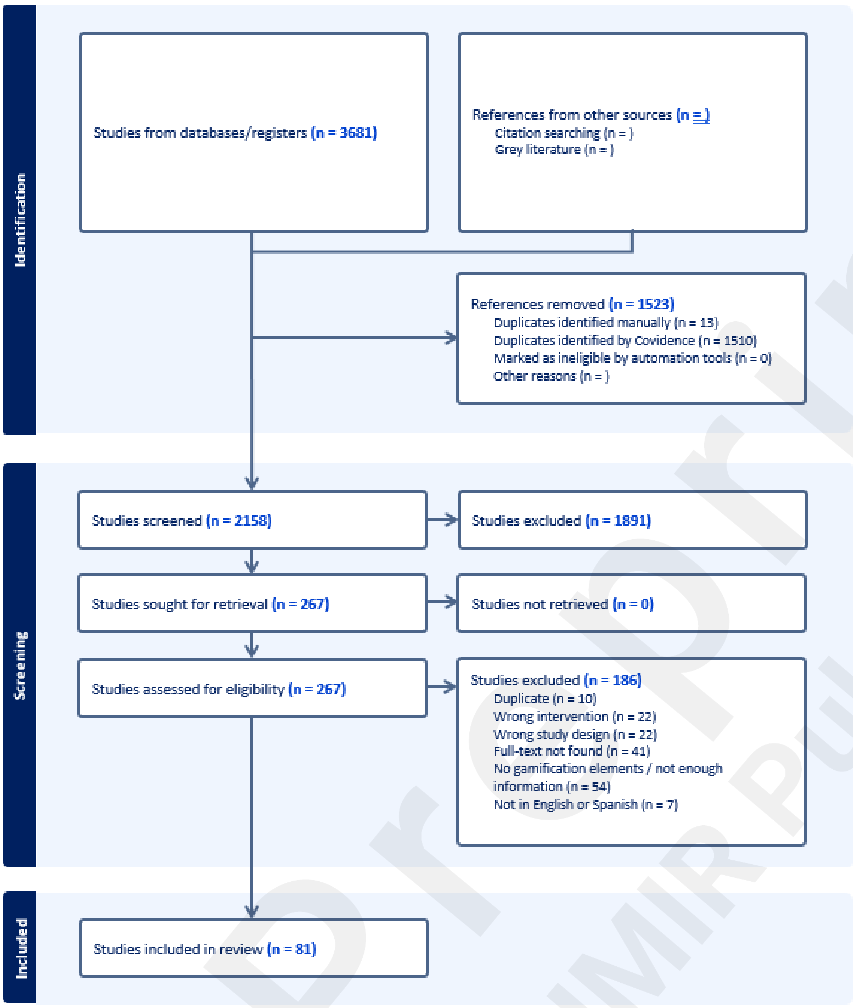

Figure 1: PRISMA flow diagram

Synthesis of results

General study information such as location, sample size, age, disease duration, gender, year and study design were collected. Specific data pertinent to the review's objectives was also collected:

In order to identify and name the gamification elements found in each study, Marczewski's 52 Gamification Mechanics (22) nomenclature was used due to its clear terminology and ease of use. All gamification elements identified were then classified using Yu-kai Chou's Octalysis Framework (21) due to its focus on motivation and end-user interaction with the system. The Octalysis Framework delineates human motivation into eight different core drives: Epic Meaning and Calling, Development and Accomplishment, Empowerment of Creativity and Feedback, Ownership and Possession, Social Influence and Relatedness, Scarcity and Impatience, Unpredictability and Curiosity and Loss and Avoidance. All gamification elements identified using Marczewski's framework were classified with the core drive they most effectively addressed.

Technological devices integrating gamification were classified based on the type of platform they

were used with, and also based on which symptoms they intended to address.
Finally, to describe the rationale behind using technological devices integrating gamification in PD motor symptom rehabilitation, content analysis methodology was used (36). Data was gathered by extracting relevant codes from the introduction and methodology section of all included articles. Each authors' explanations for incorporating technological devices or gamification elements were codified, then classified into categories.

Results

General Information

Altogether 81 studies were included in the final review (Table 1). Of the 81 articles included, over 50% were published in the year 2019 or later (41/81). Italy and Brazil were the two countries where most research was produced, with 18.5% and 17.3%, respectively. The most frequent study design consisted of Randomized Controlled Trials, which accounted for 49.4% of all studies, followed by Quasi-Experimental Studies, which accounted for 46.9% of all studies. Sample sizes from the included studies ranged from 2 to 302 participants, with an average sample size of 32.2 participants. Mean age for participants was 66,64 ± 5,05 years old, with a mean of 2,29 ± 0,57 on the Hoehn&Yahr (H&Y) scale for disease severity and a mean disease duration of 7,35 ± 2,70 years. 39.39% of all participants were female.

Table 1: Study characteristics and identified hardware, software and gamification elements.

Reference	Age	Number of participants with PD	Gender (% Female)	Disease severity		Hardware set-up	Software and games used	Gamification elements identified
				H&Y (0-5)	Disease duration (years)			
Albiol-Perez 2017 (37)	79,6	10	60,00%	-	4,52	Computer + Balance Board (Nintendo Wii's)	Active Balance Rehabilitation System (ABAR)	Levels/Progression, Points, Progress/Feedback,
Allen 2017 (38)	67,5	38	31,58%	-	8,3	Tablet + Pannel with buttons/keyboard	Marshmallow game & Chicken game	Progress/Feedback, Points, Time Pressure, Badges, Levels/Progression
Alves 2018 (39)	61,07	27	7,40%	1,74	-	Nintendo Wii + Nintendo Wii Balance Board; Microsoft Xbox + Xbox Kinect	Wii Fit Plus; Kinect Adventures! and Your Shape: Fitness Evolved	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition
Anwar 2021 (40)	55	24	-	-	-	Nintendo Wii + Nintendo Wii Balance Board	Nintendo Wii Sports & Nintendo Wii Balance Board Games	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition
Bacha 2021 (41)	63,4	10	40,00%	1,85	-	Microsoft Xbox + Xbox Kinect	Kinect Adventures!: 20000 Leaks, Space Pop, Reflex Ridge, River Rush	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition
Barth 2023 (42)	73,18	74	25,68%	3	8,26	Computer + Xbox Kinect	Coconuts, Balloons, Balls, Stars	Levels/Progression, Progress/Feedback, Points
Bekkers 2020 (43)	70,96	121	47,11%	2,455	9,57	Computer + Xbox Kinect + Treadmill	V-TIME	Progress/Feedback, Points
Bevilacqua 2022 (44)	75,4	9	44,44%	1,8		SI-ROBOTICS system	Let's dance game	Progress/Feedback, Levels/Progression
Brachman 2021 (45)	67,4	24	37,50%	2,5	9,3	Computer + Xbox Kinect + Custom Force Platform	Boat, Colors, Froglet, Football Player, Burro, Bicycles, Fruits	Progress/Feedback, Levels/Progression, Points,
Calabrò 2019 (46)	66	22	18,18%	2	7	CAREN System	CAREN System	Progress/Feedback, Levels/Progression, Points
Carpinella 2017(47)	74,3	42	33,33%	2,8	8,9	Computer + Balance Board (Gamepad system)	Customized software	Progress/Feedback, Points, Levels/Progression
Cerqueira 2020 (48)	68,9	8	50,00%	2.3	-	Microsoft Xbox + Xbox Kinect	Your Shape: Fitness Evolved 2012: Wall Break and Stack'Em Up Kinect Sports: Target Kick, Super Saver, Bump Bash, and Paddle Panic	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition
Chua 2021 (49)	67.55	9	77,78%	2.22	2,82	Computer + SMARTfit Trainer system:	Inventory of 16 items available in the SMARTfit Single system	Customisation, Progress/Feedback,

						SMARTfit Single and SMARTfit Strike Pods		Levels/Progression
Cikajlo 2016 (50)	68	18	-	-	-	Computer + Leap Motion Controller	10 cubes	Progress/Feedback, Time Pressure,
Cikajlo 2018 (51)	68	28	57,14%	-	-	Computer + Xbox Kinect	Fruit picking	Levels/Progression, Progress/Feedback, Points, Consequences,
Cikajlo 2019 (52)	69,45	20	55,00%	-	-	Computer + Leap Motion Controller + Oculus Rift CV1 for 3D display	10 cubes	Progress/Feedback, Time Pressure
Cikajlo 2021 (53)	65,9	28	57,14%	-		Computer + Leap Motion Controller	10 cubes	Progress/Feedback, Time Pressure
Dauvergne 2018 (54)	65	16	25,00%	-	10,19	Tablet	Rhythm Workers	Points, Levels/Progression, Unlockables, Progress/Feedback
Ellis 2013 (55)	65.6	20	55,00%	2.175	3	Computer + Pedometer	Virtual Coach	Progress/Feedback
Esculier 2012 (56)	62,7	10	50,00%	-	8,5	Nintendo Wii + Nintendo Wii Balance Board	Nintendo Wii Fit: Table Tilt, Ski Slalom, Balance Bubble, Ski Jump, Penguin Slide, Deep Breathing and Hula-Hoop Wii Sports: Golf and Bowling	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition
Fernandez-Gonzalez 2019 (57)	66,65	23	52,17%	-	-	Computer + Leap Motion Controller	Reach Game, Sequence Game, Grab Game, Pinch Game, Flip Game and Piano Game	Progress/Feedback, Points
Ferraz 2018 (58)	68,33	62	40,32%	2,5	-	Microsoft Xbox + Xbox Kinect	Kinect Adventures!: River Rush, Reflex Ridge, 20000 Leaks	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition
Fundarò 2019 (59)	68	20	35,00%	-	5	Lokomat System	Customized VR software	Points, Progress/Feedback,
Gandolfi 2017 (60)	68,6	76	32,89%	2,5	6,82	Nintendo Wii + Nintendo Wii Balance Board	Nintendo Wii Fit: Table Tilt, Penguin Slide, Balance Bubble, Ski Slalom, Skateboarding, Perfect 10, Tilt City, Snowball Fight, Rhythm Parade, Bird's-eye Bulls-eye	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition
Ganzeboom 2018 (61)	65	5	0,00%	-	3,35	Tablet	Treasure Hunters	Progress/Feedback, Guilds/Teams, Quests, Knowledge Share
Ganzeboom, 2021 (62)	64	8	37,50%	-	4,875	Tablet	Treasure Hunters	Progress/Feedback, Guilds/Teams, Quests, Knowledge Share
Goffredo 2023 (63)	67,8	105	43,81%	2	4,5	Tablet	VRRS Table System by Khymeia Srl	Progress/Feedback, Levels/Progression
Gonçalves 2014 (64)	68,7	15	53,33%	2,1	7,3	Nintendo Wii + Nintendo Wii Balance Board	Nintendo Wii Fit Plus: Free Step, Rhythmic Step, Rhythmic Boxing, Ski Slalom, Advanced Skiing, Ski Jumping, Header, Jump Rope, Segway Circuit and Cycling	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition
Gulcan 2023 (65)	60,5	30	13,33%	3	6	C-Mill VR + (Motek Medical)	Stepping stones, Random stepping stones, Obstacle avoidance, Speed adaptation, Slalom, Monster game, Balls track, Auditory cueing, Nature island, The Italian Alps	Progress/Feedback, Levels/Progression, Points
Hajebrahimi 2022 (66)	65,95	23	21,74%	-	-	Nintendo Wii + Nintendo Wii Balance Board	Nintendo Wii Fit Plus: Sun Salutation, Chair Pose, Half Moon, Single Leg Extension, Torso and Waist Twist, Lung and Side Lung, Marble Balance, Ski Slalom and Balance Bubble	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition
Hashemi 2022 (67)	58,64	45	35,56%	1,98	7,92	Microsoft Xbox + Xbox Kinect	Main Reach, Random Reach, Tracking, Rotating Wheel, Library	Levels/Progression, Progress/Feedback, Points, Time Pressure,
Herz 2013 (68)	66,7	20	35,00%	-	5,5	Nintendo Wii	Nintendo Wii Sports: Tennis, Boxing and Bowling	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition
Holmes 2013 (69)	66.63	15	26,67%	2.27	8,45	Nintendo Wii + Nintendo Wii Balance Board	Nintendo Wii Fit Plus: Balance Bubble, Table Tilt, Soccer Heading, Tightrope Tension, Penguin Slide, Ski Slalom, Snowboard Slalom	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition
Imbimbo 2021 (70)	73	30	13,33%	2	5	Nirvana system	Nirvana system: Sprites, Follow Me, Motion, Hunt	Progress/Feedback, Levels/Progression, Points
Jäggi 2023 (71)	72,38	40	32,50%	3	9,88	Dividat Senso	Dividat Senso game library	Progress/Feedback, Levels/Progression, Points,
Kashif 2022a (72)	63,08	44	43,18%	2,18	6,39	Nintendo Wii + Nintendo Wii Balance Board	Nintendo Wii-Fit: Table Tilt, Penguin Slide, Title City, Soccer, Torso Twists, Single Leg Stance Nintendo Wii Sports: Tennis, Bowling, Boxing, Kicking	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition
Kashif 2022b (73)	63,08	44	43,18%	2,18	6,41	Nintendo Wii + Nintendo Wii Balance Board	Nintendo Wii-Fit: Table Tilt, Penguin Slide, Title City, Soccer, Torso Twists, Single Leg Stance Nintendo Wii Sports: Tennis,	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition

							Bowling, Boxing, Kicking	
Lameira de Melo 2018 (74)	62,27	37	24,32%	1,67	-	Microsoft Xbox + Xbox Kinect	Your Shape – Fitness Evolved 2012 – Run the World	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Competition
Lau 2022 (75)	67,5	18	33,33%	1,95	-	Computer + Split-belt treadmill + Large button controllers	Customized software	Progress/Feedback, Levels/Progression, Time Pressure
Lee 2015 (76)	69,25	20	50,00%	-	-	Nintendo Wii	Nintendo K-Pop Dance Festival	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition
Liao 2014 (77)	65,66	36	52,78%	1,97	7,14	Nintendo Wii + Nintendo Wii Balance Board	Nintendo Wii Fit Plus: Yoga exercises + Strengthening exercises + Balance exercises	Progress/Feedback, Points, Levels/Progression, Leaderboards, Customisation
Liao 2015 (78)	65,66	36	52,78%	1,97	7,14	Nintendo Wii + Nintendo Wii Balance Board	Nintendo Wii Fit Plus: Yoga exercises + Strengthening exercises + Balance exercises	Progress/Feedback, Points, Levels/Progression, Leaderboards, Customisation
Maranesi 2022 (79)	74,1	32	46,88%	2,15	-	Tymo System	Tymo system: Apple picking, the hot-air balloon, the labyrinth	Progress/Feedback, Levels/Progression, Points
Mazur 2013 (80)	61,8	24	29,17%	-	9,21	Nintendo Wii + Nintendo Wii Balance Board	Nintendo Wii Fit: Ski Slalom, Balance Bubble Wii Sports: exercises on flexibility, upper and lower limb strength, motor coordination and balance	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition
Melo 2018 (81)	-	37	-	-	-	Microsoft Xbox + Xbox Kinect	Your Shape – Fitness Evolved 2012 – Run the World	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Competition
Mhatre 2013 (82)	67.1	10	60,00%	-	6.7	Nintendo Wii + Nintendo Wii Balance Board	Nintendo Wii Fit Plus: Marble Balance, Ski Slalom and Balance Bubble	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition
Mirelman 2011 (83)	67,1	20	30,00%	2,2	9,8	Computer + Treadmill + Light-emitting diodes	Customized software	Progress/Feedback, Levels/Progression, Points
Mirelman 2016 (10)	73,75	302	33,11%	-	-	Computer + Xbox Kinect + Treadmill	V-TIME	Progress/Feedback, Points
Negrini 2017 (84)	66,5	27	48,15%	-	-	Nintendo Wii + Nintendo Wii Balance Board	Nintendo Wii Fit Plus: Table Tilt, Ski Slalom, Balance Bubble, Ski Jump and Penguin Slide	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition
Nuic 2018 (85)	64	10	50,00%	3,3	18,1	Computer + Xbox Kinect	Toap Run game	Points, Progress/Feedback, Levels/Progression,
Nuic 2023 (86)	66,7	45	42,22%	-	11,9	Computer + Xbox Kinect	Toap Run game	Points, Progress/Feedback, Levels/Progression,
Oña 2018 (87)	56.6	5	40,00%	-	-	Computer + Leap Motion Controller	Reach Game, Sequence Game, Grab Game, Pinch Game, Flip Game and Piano Game	Progress/Feedback, Points
Özgönenel 2016 (88)	65	33	33,33%	-	3,83	Microsoft Xbox + Xbox Kinect	Kinect Adventures!: Reflex Ridge, 20000 Leaks, River Rush	Customisation, Points, Progress/Feedback, Badges, Competition, Time Pressure, Levels/Progression
Palacios-Navarro 2015 (89)	67	7	42,86%	-	-	Computer + Xbox Kinect	"Crush the Mole" game	Points, Levels/Progression
Pastore-Wapp 2023 (90)	63,6	9	55,56%	3	7,21	Tablet + Leap Motion Controller / GripAble	Leap Motion Gallery: Blocks, Flowers, Tilt Your Ball, Fragmental 3D GripAble: Plume, Windowsill, Balloon Buddies, Circus Escape, Pufferfish	Consequences, Points, Progress/Feedback, Levels/Progression,
Pazzaglia 2021 (91)	71	51	31,37%	-	6,08	Nirvana system	Nirvana system: Touch the Trumpet, Touch the Rose, Lead the Dog, Touch the Eggs, Reach a Mole, Maintaining Balance, Clear all the Leaves	Progress/Feedback, Levels/Progression, Points
Pelosin 2021 (92)	73,97	96	44,79%	2,46	7,95	Computer + Xbox Kinect + Treadmill	V-TIME	Progress/Feedback, Points
Pompeu 2012 (93)	-	32	-	-	-	Nintendo Wii + Nintendo Wii Balance Board	Nintendo Wii Fit Plus: Single Leg Extension, Torso Twists, Table Tilt, Tilt City, Soccer Heading, Penguin Slide, Rhythm Parade, Obstacle Course, Basic Step and Basic Run	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition
Pompeu 2013 (94)	72	7	14,29%	2,1	-	Microsoft Xbox + Xbox Kinect	Kinect Adventures!: Space Pop, 20000 Leaks, Reflex Ridge and River Rush	Customisation, Points, Progress/Feedback, Badges, Competition, Time Pressure, Levels/Progression
Pompeu, 2015 (95)	61	6	33,33%	1,9	-	Microsoft Xbox + Xbox Kinect	Kinect Adventures!: Space Pop, 20000 Leaks, Reflex Ridge and River Rush	Customisation, Points, Progress/Feedback, Badges, Competition, Time Pressure, Levels/Progression
Pullia 2023 (96)	65	20	35,00%	3	10,8	C-Mill VR + (Motek Medical)	Tandem path, Slalom, Path with obstacles, Arkanoid, Catch, Soccer, Italian Alps, Traffic Jam	Progress/Feedback, Levels/Progression, Points

Puyjarinet 2022 (97)	68,2	22	27,27%	-	9,9	Tablet	Rhythm Workers and Tetris	Progress/Feedback, Levels/Progression, Points, Consequences, Leaderboards
Qayyum 2022 (98)	52,5	16	25,00%	-	-	Nintendo Wii + Nintendo Wii Balance Board	Nintendo Wii Fit: Perfect 10, Wii Skiing, Wii Cycling	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition
Ribas 2017 (99)	60,95	20	60,00%	1,5	6,75	Nintendo Wii + Nintendo Wii Balance Board	Nintendo Wii Fit Plus: Table Tilt, Tilt City, Penguin Slide, Soccer Heading, Basic Run, Obstacle Course and Basic Step	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition
Sanchez-Herrera-Baeza 2020 (100)	74,5	6	16,67%	2,66	-	Computer + Leap Motion Controller	Reach Game, Sequence Game, Grab Game, Flip Game	Points, Progress/Feedback
Santos 2019 (101)	64,2	45	22,22%	1,4	7,1	Nintendo Wii + Nintendo Wii Balance Board	Nintendo Wii Fit: Soccer Heading and Running Wii Sports: Golf and Boxing	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition
Schaeffer 2019 (102)	58,4	18	45,71%	2,02	4	Microsoft Xbox + Xbox Kinect	Your Shape – Fitness Evolved 2012 – Run theWorld: Virtual Smash, Light Race, Kardio Boxing	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Competition
Severiano 2018 (103)	57,5	16	37,50%	-	-	Nintendo Wii + Nintendo Wii Balance Board	Nintendo Wii Fit: Soccer Heading, Table Tilt, Tightrope Walk and Ski Slalom	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition
Shih 2016 (104)	68,15	20	20,00%	1,5	4,625	Computer + Xbox Kinect	Reaching Task 1, Reaching Task 2, Obstacle Avoidance, Marching	Progress/Feedback, Levels/Progression, Points
Song 2017 (105)	66,5	60	60,00%	-	8	Computer + Balance board	Dance Dance Revolution Stepmania	Progress/Feedback, Levels/Progression, Points
Summa 2015 (106)	67	7	28,57%	3	5	Computer + Xbox Kinect	Customized software	Progress/Feedback, Points
Syed 2021 (107)	-	2	100,00%	-	-	Computer + Xbox Kinect	MIRA (Medical Interactive Rehabilitation Assistant)	Progress/Feedback, Points
van den Heuvel 2014 (108)	67,55	33	39,39%	2,5	8,9	Computer + Force plate + Inertial sensors	Visual Feedback Based Balance Training by Motek Medical	Progress/Feedback, Levels/Progression, Points
van Beek 2019 (109)	65,4	10	30,00%	2,4	8,5	Computer + Leap Motion Controller	Leap Motion Gallery: Cut the Rope, Dots, Blocks, Flower, and ASL Digits	Consequences, Points, Progress/Feedback, Levels/Progression,
van der Kolk 2019 (110)	59,35	130	38,46%	1,96	3,288	Tablet	Custom motivational app and coaching and non detailed virtual reality for stationary cycling	Progress/Feedback, Levels/Progression
Wang 2020 (111)	-	5	40,00%	-	-	Computer + HTC Vive Pro	Treasure Island Adventure	Consequences, Time Pressure, Points, Levels/Progression, Progress/Feedback
Yang 2016 (112)	73,95	23	39,13%	3	8,85	Computer + Balance board	Star Excursion, Ball Maze, Table tilt, Home Yoga, Cooking, Cloth Washing, Car Racing, Park Walking, Apple Catching	Consequences, Time Pressure, Points, Levels/Progression, Progress/Feedback
Yen 2011 (113)	70,7	42	21,43%	2,53	6,63	Computer + Balance board	Bang Bang Ball, Simulated Board Driving	Points, Levels/Progression
Yuan 2020 (114)	67,15	24	54,17%	2,035	-	Computer + Balance board	Modified XaviX entertainment system	Progress/Feedback, Levels/Progression, Points
Yun 2023 (115)	73,86	12	75,00%	2,7	10,73	Computer + HTC Vive Pro	Go/no-go punch game, go/no-go stepping game, and number punch game	Progress/Feedback, Levels/Progression, Points, Consequences
Zeigelboim 2019 (116)	57,5	16	37,50%	-	8,8	Nintendo Wii + Nintendo Wii Balance Board	Nintendo Wii Fit: Soccer Heading, Table Tilt, Tightrope Walk and Ski Slalom	Progress/Feedback, Badges, Points, Levels/Progression, Leaderboards, Challenges, Customisation, Time Pressure, Consequences, Competition

Identification and classification of gamification elements and technological devices

Gamification elements

Detailed data on the frequency and distribution of the identified gamification elements and their association with the Octalysis Framework's 8 Core Drives of motivation can be found on Table 2.
A total of 453 gamification elements were identified across all included studies, categorized into 14 distinct types based on Marczewski's classification of gamification mechanics (22). For the Epic Meaning and Calling core drive, only Quests were identified as a relevant gamification element,

appearing 2 times across studies. This element was used in 2.47% of the studies, accounting for 0,44% of the total gamification elements used. The Development and Accomplishment core drive was the most prominent category, containing a variety of gamification elements and showing extensive usage across the studies. Progress/Feedback mechanics were the most frequently used element, appearing in 79 studies (97.53% of studies) and representing 17.44% of the total gamification elements used. Other commonly used elements included Points, which appeared in 86.42% of studies and accounted for 15.45% of total elements; Levels/Progression, which appeared in 81.48% of studies and represented 14.57% of total elements; Badges, used in 37.04% of studies, accounting for 6.62% of total elements; Leaderboards, used in 35.80% of studies, making up 6.40% of total elements; and Challenges, which appeared in 32.09% of studies and represented 5.72% of total elements. The Empowerment of Creativity and Feedback core drive included only one gamification element, Customization, which was used in 32 studies (39.51% of studies) and accounted for 7.06% of total elements. Neither the Ownership and Possession core drive nor the Unpredictability and Curiosity drive showed any specific gamification elements reported across the studies. Under the Social Influence and Relatedness core drive, elements like Competition, Knowledge Share and Guilds/Teams were identified. Competition was used in 35.80% of studies, contributing 6.40% to the total elements, while both Knowledge share and Guilds/Teams appeared only in 2.47% of studies, accounting for a mere 0.44% of total elements each. The Scarcity and Impatience drive included only one element, Unlockables, which was used in just one study, appearing in 1.23% of studies and making up only 0.22% of the total gamification elements. Lastly, the Loss and Avoidance core drive included the elements Consequences and Time Pressure. Consequences was used in 37.04% of studies, contributing 6.62% to the total elements, while Time Pressure appeared in 45.68% of studies, making up 8.14% of the total elements used.

Octalysis' Core Drive	Gamification elements	Times used (out of 81 studies)	% Total studies where used	% Of total used elements
Epic Meaning & Calling	Quests (61,62)	2	2,47%	0,44%
Development & Accomplishment	Progress/Feedback (37–88,90–112,114–117)	79	97,53%	17,44%
	Points (37–43,45–48,51,54,56–60,64–74,76–109,111–117)	70	86,42%	15,45%
	Levels/Progression (37–42,44–49,51,54,56,58,60,63–86,88–91,93–99,101–105,108–116)	66	81,48%	14,57%
	Badges(38–41,48,56,58,60,64,66,68,69,72–74,76,80–82,84,88,93–95,98,99,101–103,116)	30	37,04%	6,62%
	Leaderboards (39–41,48,56,58,60,64,66,68,69,72–74,76–78,80–82,84,93,97–99,101–103,116)	29	35,80%	6,40%
	Challenges (39–41,48,56,58,60,64,66,68,69,72–74,76,80–82,84,93,98,99,101–103,116)	26	32,09%	5,72%
Empowerment of Creativity & Feedback	Customisation (39–41,48,49,56,58,60,64,66,68,69,72–74,76–78,80–82,84,88,93–95,98,99,101–103,116)	32	39,51%	7,06%
Ownership & Possession	-	-	-	-
Social Influence & Relatedness	Competition (39–41,48,56,58,60,64,66,68,69,72–74,76,80–82,84,88,93–95,98,99,101–103,116)	29	35,80%	6,40%
	Knowledge share (61,62)	2	2,47%	0,44%
	Guilds/Teams (61,62)	2	2,47%	0,44%
Scarcity & Impatience	Unlockables (54)	1	1,23%	0,22%
Unpredictability & Curiosity	-	-	-	-

Loss & Avoidance	Consequences (39–41,48,51,56,58,60,64,66,68,69,72,73,76,80,82,84,90,93,97–99,101,103,109,111,112,115,116)	30	37,04%	6,62%
	Time Pressure *(38–41,48,50,52,53,56,58,60,64,66–69,72–76,80–82,84,88,93–95,98,99,101–103,111,112,116)*	37	45,68%	8,14%

Table 2: Distribution of use of gamification elements and classification according to Octalysis Framework

Technological devices integrating gamification

The technological devices integrating gamification identified across 81 studies were categorized into four groups based on the platforms they were used with: video game consoles, computer-based systems, tablet-based systems, and integrated rehabilitation platforms. Detailed information on each category and the specific motor symptoms in PD they address can be found in Figure 2.

Video game consoles like the Nintendo Wii and Microsoft Xbox, originally designed for entertainment, were frequently repurposed for rehabilitation. The Nintendo Wii was the most commonly used device, appearing in 27% of studies, almost exclusively in combination with the Wii Balance Board (91% of all Nintendo Wii studies). Most studies with this video game console addressed balance (82% of studies), gait (55%), functional mobility (50%), and motor function impairment (41%). The Microsoft Xbox, used with the Kinect motion sensor in 14% of studies, similarly focused on balance (91% of studies), gait (73%), functional mobility (73%), and motor function impairment (28%). None of the video game consoles were created with rehabilitation as their primary goal.

Computer-Based Systems were utilized in 40% of studies, often in combination with motion-sensing devices like Kinect (37.5% of Computer-based systems), Leap Motion Controller (22%), and balance boards or force plates (22%). Kinect was applied mainly to improve balance (67%), gait (56%), and motor function impairment (44%), while balance boards and force plates focused on balance (100%), gait (57%) and functional mobility (57%), and the Leap Motion Controller targeted upper extremity dexterity (100%), motor function impairment (57%) and grip strength (43%). The HTC Vive Pro VR device was used (6%), enhancing immersion for balance (100%), gait (100%), and functional mobility (100%) training. Additionally, some studies combined treadmills with Kinect (9%), mainly to focus on falls (100%). 91% of all computer-based systems were created with rehabilitation as their primary goal.

Tablet-Based Systems appeared in 11% of all studies, either as standalone devices (67% of all tablet-based systems) or combined with motion-sensing devices such as the Leap Motion Controller (11%) or handheld tools like GripAble (11%). These tablet-based systems mainly targeted upper extremity dexterity (44%) and motor function impairment (33%). 100% of tablet-based systems were created for rehabilitation as their primary goal.

Integrated Rehabilitation Platforms appeared in 11% of all studies, testing systems explicitly designed for comprehensive rehabilitation. These platforms were used to rehabilitate balance (100%), gait (100%), functional mobility (56%) and motor function impairment (22%). All integrated rehabilitation platforms were created for rehabilitation as their primary goal.

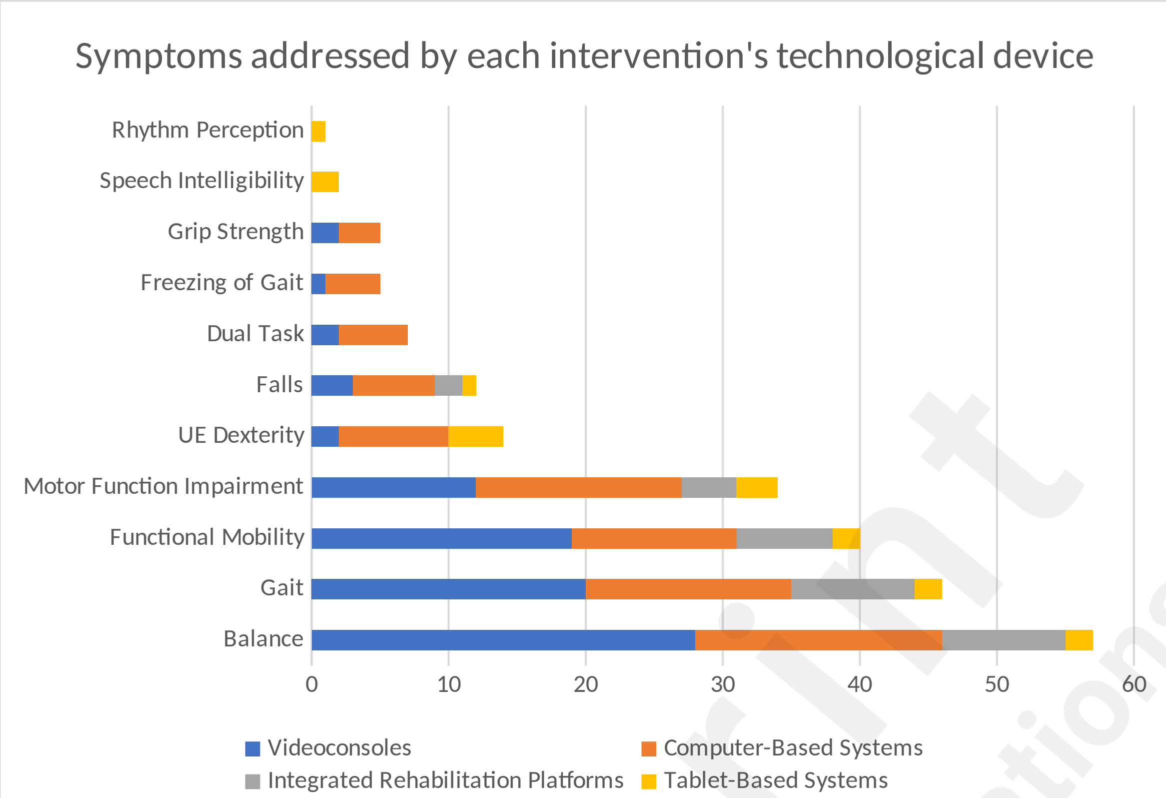

Figure 2: Distribution of motor symptoms based on technological devices. UE: Upper Extremity

Justification behind the use of technological devices integrating gamification

Four primary categories emerged for employing technology in the rehabilitation of motor symptoms in PD: 1) "Expected Role for Incorporating Gamification in Therapeutic Interventions"; 2) "Evidence of Effectiveness of technology in Rehabilitation in PD", centers on the availability of scientific evidence that supports either the effectiveness, the potential uses or the feasibility of technology in the rehabilitation of PD; 3) "Evidence of effectiveness of technology in rehabilitation across populations", centered on the available evidence for the use of technological devices across a wider range of populations; 4) "Specific Properties of Technological Solutions in Rehabilitation" highlighting unique qualities that enhance their applicability and utility in the rehabilitation of PD. Detailed information on data from all categories and subcategories can be found on Table 3.

Table 3: Detailed information on categories and subcategories identified on the expected role of technological devices integrating gamification

Categories and subcategories	Explanation	Highlights
Expected Role for Incorporating Gamification in Therapeutic Interventions (49,51)	Authors reported the use of gamified interventions, aimed at providing feedback on performance and progressive difficulty for participants	1 study presents their gamification platform as a tool to monitor performance and adjusting difficulty based on scoring 1 study presents their gamified system as a tool to provide feedback to participants, adjust difficulty and customize their experience
Evidence of Effectiveness of technology in Rehabilitation in PD	This category reflects empirical support for the impact of technology on improving motor and non-motor symptoms, broader clinical outcomes, and neuroplasticity in PD rehabilitation	
Improvement of Motor Symptoms in PD (37,41,46–49,51,52,56,59,63,64,66,69–75,77–	Technological devices have mentioned effectiveness, potential or feasibility as part of interventions	33 studies supported the effectiveness of VR, exergames and robotic systems in improving balance, gait and postural control

79,82,84,86–90,95,98,104,106–108,113–117)	aimed at improving a wide array of motor symptoms in people with PD	8 studies mentioned the potential of VR and exergames as tools for rehabilitation 4 studies pointed at the feasibility of technological interventions as affordable and accessible tools
Improvement of Non-Motor Symptoms in PD (46,49,52,63,66,71,73,78,89,95,98,99,102,107,108,111,117)	Technological devices have a role in supporting cognitive function and emotional wellbeing for people with PD	15 studies emphasize the effectiveness of technology to improve cognition, executive functions, self-esteem and mental health 4 studies highlight the potential of technology to create controlled environments that enhance cognitive therapies and emotional support 1 study points to the feasibility of technology to support cognitive therapies, pain management and motivation of participants
Positive Influence on Brain Activity Networks in PD (40,43,46,57,60,66,67,71–73,86,96,100,104)	Technology stimulates neuroplasticity, motor learning and motor-cognitive integration for PD rehabilitation	14 studies highlight that technology, especially VR and exergames, are useful for optimizing brain networks through repetitive, task-oriented training
Evidence of effectiveness of technology in rehabilitation across populations		
General Evidence for Physiotherapy (42,53,73,80,86,103)	Technology shows outcomes often comparable to or sometimes better than traditional physiotherapy	6 studies note VR and exergames enhance therapy effectiveness in older adults and PD patients
Evidence from Non-PD Populations (55,56,77,78,80,93,104,114,115)	Benefits have been observed in broader populations, such as stroke patients and elderly individuals, for rehabilitation through technological devices	9 studies demonstrate improvements in balance, mobility, and fall reduction through VR and video games
Improvement of Clinical Parameters (48,50,52,74,78,88,99)	Technology is a valuable tool to address overall quality of life, physical function, daily activities and pain management	7 studies link technology use to improvements in clinical measures like pain management and disease severity in children, adult populations, and PD patients
Specific Properties of Technological Solutions in Rehabilitation	This category highlights unique attributes of technological solutions that enhance their applicability and appeal	
Enhances Motivation through an Engaging Experience (39,42,45,46,49,52,54,58,61,62,66,67,69,71–73,85,87,89–91,93,96,98–102,104,105,107,109–111,113,115,116)	Technology plays a role in making rehabilitation engaging and entertaining, thus motivating sustained participation	37 studies highlight the role of technology emphasize engaging and rewarding experiences, thus encouraging patients to participate actively and complete their rehabilitation sessions
Provides Quality Biofeedback (40,41,44–47,49,56,57,65,67,68,74,76–78,80,83,85,86,93,94,96,100,102,104,105,108,109,111–114,116,117)	Real-time feedback provided by technological devices enhances performance, motor learning, and awareness	35 studies highlight the value of visual, auditory, and haptic feedback in improving task performance and motor learning
Customization of Training Parameters (42–44,49,52,55,59,65,67,72,74–76,79,86,93,96,99,102,103,107,109,113)	Technology allows for the design of tailored exercises that adapt to the specific individual needs of participants	23 studies highlight customizable settings where users can experience repeated movements in varied and rewarding contexts, promoting effective problem-solving and motor skill development
Enriched or Ecological Environment (52,56,57,62,65,75,77,79,81,86,94,99,100,103,111,114,115,117)	Technology offers the option to create simulated, real-life scenarios that support skill retention and application outside therapy	18 studies highlight that options such as immersive VR settings are effective for real-world skill transfer through ecologically valid scenarios
Supports Dual-Task Integration (49,64,68,79,85,91,94,95,97,99,102,108,113,117)	Technology allows for an easy combination of motor and cognitive components, allowing training for complex dual task situations	13 studies cite VR and exergames providing enriched environments that engage participants both physically and cognitively

Enables Telerehabilitation (39,60,63,85,99,102,105,108)	Technological devices make therapy accessible at home using affordable and user-friendly tools	8 studies demonstrate telerehabilitation as feasible and effective, especially using commercial gaming devices
Accessible and Cost-Effective (39,63,77,82,84,89,99,106)	Low-cost, portable technological solutions make rehabilitation convenient and affordable for home use	8 studies emphasize portable and low-cost options that integrate easily into daily routines, making them appealing for home use
Safe Intervention (54,91,100,114,115)	Technological interventions take place in controlled environments that ensure patient safety during higher-risk task	5 studies highlight safety as a major benefit of VR and exergames in rehabilitation

Discussion

The aim of this scoping review was to identify and classify the technological devices integrating gamification used in motor rehabilitation for PD, as well as to describe the rationale behind their application. This review is particularly relevant as it addresses a growing interest in leveraging innovative, technology-driven approaches to manage PD's motor symptoms, a field where gamification has been suggested to enhance patient engagement and therapeutic outcomes (19). Despite this potential, the integration of gamification into PD rehabilitation interventions remains underexplored, with limited understanding of how these elements are being applied in practice or their theoretical justifications.

Findings reveal that while technological devices integrating rehabilitation are widely used, the range of gamification mechanics is narrow, with a strong focus on the Development and Accomplishment core drive. This result aligns with statements by Yu-Kai Chou (21), according to which the core drive of Development and Accomplishment is the easiest to design and the one drawing the most focus from developers. Commonly employed elements like feedback mechanisms, points, and progression systems dominate interventions, reflecting an emphasis on monitoring and improving performance. This aligns closely with the most commonly targeted motor symptoms—balance, gait, and functional mobility—which significantly benefit from feedback-driven adjustments offered by motion-sensing technologies, aiding postural control in individuals with PD (118). Gamification mechanics such as time pressure and consequences from the Loss and Avoidance core drive are used less frequently with the goal to instill urgency and accountability, improving speed and efficiency. Elements from this core drive should be carefully considered in designing future interventions, since different motor phenotypes of PD appear to respond differently to reward or punishment-based systems (119). Similarly, competition mechanics foster motivation and social interaction, aiding long-term engagement. However, more intrinsic motivational pathways, such as those tied to Unpredictability and Curiosity or Ownership and Possession, remain underutilized. Notably absent are complex gamification features like narratives or exploratory elements, highlighting a gap in current approaches.

Out of all included studies in this review, only two (49,52) explicitly refer to the concept or use of gamification when describing their interventions, and none utilized a theoretical framework to justify their use. Additionally, 37 out of the 81 included studies employed technological devices originally designed for entertainment in healthy populations rather than as rehabilitation tools tailored to individuals with health conditions. These findings underline clear missed opportunities in applying gamification to its full potential in the rehabilitation of people with PD, as well as highlighting an overreliance on video game consoles and other devices designed for entertainment purposes (i.e., Nintendo Wii and Microsoft Kinect) rather than rehabilitation-specific technologies. The high presence of interventions based on commercial video consoles and video games for rehabilitation presents an intriguing landscape within this context. On one hand, leveraging refined, off-the-shelf commercial software offers distinct advantages—eliminating the need for costly development efforts and providing products inherently designed for entertainment, which may enhance participant engagement. However, it is essential to recognize that these interventions lack tailored considerations for populations affected by neurodegenerative conditions, such as PD. Furthermore, the feedback mechanisms embedded in these software options are geared toward game performance rather than exercise and motor learning, potentially rendering them less relevant for the rehabilitation of individuals with PD. As a result, gamification elements, virtual environments, and gameplay patterns may not align optimally with the requirements and objectives of this specific population (120). User-Centered Design would be an essential part of development in this context, incorporating the needs and preferences of individuals with PD into the interventions (121). Notably, people with PD exhibit distinct differences from the younger populations typically targeted by commercial video games, which could lead to unintended outcomes when using them to apply rehabilitation interventions (122).

This review identified four distinct categories through content analysis of the justifications provided by authors for using technological devices integrating gamification for rehabilitation. Collectively, these categories underscore expectations of such solutions as being safe, motivational, and engaging tools for addressing diverse conditions. They are bolstered by extensive evidence of potential and proven effectiveness and offer innovative training opportunities, including telerehabilitation, dual-task integration, and advanced biofeedback. Despite these well-defined expectations, authors give minimal or no attention to the gamification elements that significantly contribute to their interventions. Current evidence of gaming interventions is unclear, with no studies isolating the effects of gamification used in interventions on people with PD (123). These findings suggest that while technological solutions show great promise for advancing rehabilitation for individuals with PD, greater emphasis on thoughtfully integrating gamification elements could enhance outcomes by providing more tailored and effective interventions for this population (23).

To fulfill the potential of technologies incorporating gamification, future research and development should aim to align the expectations of gamification and technology with the implementation of elements rooted in User Centered Design and evidence-based frameworks. This review reveals that current literature is clearly lacking regarding the informed implementation of gamification in technological devices aimed at rehabilitating motor conditions for people with PD. This integration of user-friendly technological solutions tailored to the needs of end users, alongside frameworks rooted on human motivation or gamification experience will be a crucial part of guiding future interventions for rehabilitation of people with PD.

Limitations

This scoping review adhered to the PRISMA-ScR recommendations to ensure methodological rigor. However, several limitations warrant acknowledgment:

Due to the substantial volume of retrieved studies, an initial screening was conducted using only titles and abstracts. This step involved three different reviewers who reached consensus in cases of disagreement. Despite this method, there remains a risk of inadvertently excluding relevant papers.

Another limitation consists of the review's scope being bounded by the search date at which it was performed. Consequently, any studies published after this date were not considered. There is also a limitation in that grey literature, which may contain valuable insights, was not included in the search. As a result, some relevant research might have been overlooked. Articles published in languages other than English and Spanish were also not included, which may also omit relevant information from this review.

Finally, there is also a limitation in how the selection of gamification elements for this study was performed. While efforts were made to identify gamification elements in all included studies based on manuscript information and online sources, certain custom-made software options and commercial games were inaccessible or had limited available information. Consequently, some gamification elements may not have been fully accounted for.

Conclusions

This scoping review sheds light on the widespread adoption of technologies integrating gamification elements for motor symptom rehabilitation in individuals with PD. However, it also reveals a notable gap in understanding and acknowledging gamification mechanics among researchers and developers. The current landscape of gamification elements within the reviewed interventions predominantly emphasizes performance-based experiences, focusing on straightforward elements like scoring and feedback. Expectations of technological devices integrating gamification applied in rehabilitation contexts are clear, but there is a notable absence of justification for the specific inclusion of gamification through the application of relevant theories or frameworks, indicating a lack of standardization or rationale for the design of these interventions. Further studies in this field should focus on the importance of user-centered design for the inclusion of gamification mechanics that could modify the experience of users, as to optimize the development efforts to optimally reach the needs of people with PD. There is also a clear need for the development of studies that report on the effects of gamification itself, which would allow developers to precisely deploy elements according to the expected role of these mechanics within their interventions.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data availability

All data generated and analyzed during this study will be made available upon reasonable request.

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Abbreviations

PD: Parkinson’s Disease

VR: Virtual Reality

PRISMA-ScR: PRISMA guidelines for Scoping Reviews

PCC: Population, Concept and Context framework

H&Y: Hoehn and Yahr scale