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INTEGRATING PHYSIOTHERAPY IN EXERGAMING MODELS EFFICACY, BENEFITS, AND POSSIBLE OUTCOME

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Abstract

Exergaming, the fusion of exercise and gaming, has emerged as an innovative approach in physiotherapy, leveraging technology to enhance the enjoyment and effectiveness of physical rehabilitation. This interactive exercise form caters not only to the younger, tech-savvy generation but also holds promise for individuals of all ages seeking rehabilitation or improved physical health. Physiotherapy holds a crucial role in the comprehensive field of physical rehabilitation, playing a significant part in restoring functional abilities, independence, and overall well-being. This allied health profession employs a holistic approach, utilizing specialized exercises, manual techniques, and patient education to address a wide range of physical impairments, injuries, and disabilities. The study aims to synthesize evidence, assess research rigor, and draw conclusions about integrating physiotherapy with exergaming. The rationale for this review extends to potential benefits, including enhanced motor skills, increased patient motivation, and exergaming's adaptability for diverse rehabilitation needs. The innovative fusion of technology and rehabilitation showcased in the integration of physiotherapy into exergaming presents a groundbreaking approach with remarkable efficacy and a multitude of benefits. This transformative model not only enhances patient engagement, motor skills, and coordination but also offers customizable and adaptive programs, real-time feedback, and social interaction opportunities, leading to positive outcomes in cardiovascular and musculoskeletal health, psychological well-being, data-driven decision-making, adherence, and potential lasting lifestyle changes. This technological integration not only revolutionizes therapy sessions into engaging experiences but also contributes to personalized, precise, and effective interventions, advancing rehabilitation practices holistically.

Keywords: physiotherapy, exergaming, efficacy, benefits, possible outcomes, exercise, gaming

Introduction

Physiotherapy plays a pivotal role in the comprehensive field of physical rehabilitation, contributing significantly to the restoration of individuals' functional abilities, independence, and overall well-being. This allied health profession employs a holistic approach, utilizing specialized exercises, manual techniques, and patient education to address a wide range of physical impairments, injuries, and disabilities (1). At its core, physiotherapy aims to optimize physical function and quality of life through a variety of therapeutic interventions. One of its primary roles lies in the rehabilitation of individuals recovering from injuries, surgeries, or debilitating health conditions. Physiotherapists, or physical therapists, are skilled professionals who assess patients' physical limitations, develop personalized treatment plans, and implement evidence-based interventions to promote recovery (2). The significance of physiotherapy in physical rehabilitation is underscored by its multifaceted approach to addressing diverse challenges. For individuals recovering from orthopedic injuries, such as fractures or joint replacements, physiotherapy is instrumental in restoring joint mobility, strengthening muscles, and improving overall musculoskeletal function. Through a combination of targeted exercises and manual techniques, physiotherapists work to alleviate pain, enhance flexibility, and facilitate the healing process (3). Neurological rehabilitation represents another critical domain where physiotherapy demonstrates its profound impact. Individuals affected by neurological conditions like stroke, traumatic brain injuries, or spinal cord injuries often experience a range of motor impairments and functional limitations. Physiotherapists employ specialized techniques to promote neuroplasticity, facilitating the reorganization of the nervous system and helping patients regain motor control, balance, and coordination (4). Cardiopulmonary rehabilitation is yet another area where physiotherapy plays a vital role. Patients recovering from cardiovascular surgeries or managing chronic respiratory conditions benefit from tailored exercise programs designed to improve cardiovascular fitness, respiratory function, and overall endurance. Physiotherapists monitor patients closely, adapting interventions to individual needs while promoting a gradual return to optimal physical health (5). Beyond addressing specific injuries or conditions, physiotherapy contributes significantly to pain management. Chronic pain, whether originating from musculoskeletal, neurological, or other sources, can significantly impact an individual's quality of life. Physiotherapists employ a combination of therapeutic exercises, manual therapies, and education to help patients manage pain, improve mobility, and regain control over their daily activities (6). Importantly, physiotherapy extends its influence beyond the clinical setting, promoting preventive care and encouraging individuals to adopt healthy lifestyle practices. Through education on proper body mechanics, posture, and ergonomics, physiotherapists empower patients to reduce the risk of injuries and maintain optimal physical function over the long term.

Exergaming, the fusion of exercise and gaming, has emerged as an innovative and engaging approach in the realm of physiotherapy, leveraging technology to make physical rehabilitation more enjoyable and effective. This interactive form of exercise not only caters to the younger, tech-savvy generation but also holds significant promise for individuals of all ages seeking rehabilitation or improved physical health (7). There are various types of exergaming, each designed to target specific aspects of physical fitness and rehabilitation. One prevalent form is motion-based gaming, where users utilize body movements to control the game. Systems like the Nintendo Wii, Xbox Kinect, and PlayStation Move have paved the way in this category, offering a range of games that encourage players to perform activities such as tennis, dancing, and bowling. These games require coordinated movements, promoting joint mobility, balance, and overall motor skills – making them particularly relevant in physiotherapy settings (8). Virtual reality (VR) exergaming represents another frontier in this domain. Immersive VR experiences not only engage the user visually but also stimulate a more comprehensive range of movements. VR systems like Oculus Rift or HTC Vive offer games and applications that simulate various environments, facilitating exercises that enhance flexibility, spatial awareness, and cognitive function. In physiotherapy, VR exergaming has proven beneficial in rehabilitation scenarios, especially for individuals recovering from stroke or neurological disorders (9). Dance-based exergaming has gained popularity as a fun and effective way to improve cardiovascular fitness, coordination, and endurance. Games like Dance Dance Revolution and Just Dance require players to

follow on-screen dance moves, turning a traditional workout into an entertaining activity. In physiotherapy, dance-based exergaming can be utilized to enhance motor skills, balance, and overall physical conditioning (10). The significance of exergaming in physiotherapy lies in its ability to address several key challenges faced by both therapists and patients. Firstly, it promotes increased patient engagement, a critical factor in the success of any rehabilitation program. By combining physical activity with the entertainment aspect of gaming, exergaming captures and sustains the attention of individuals, encouraging them to participate more actively in their therapy sessions. Secondly, exergaming allows for tailored and adaptive exercises, catering to the unique needs of each patient. Physiotherapists can customize gaming experiences based on a patient's rehabilitation goals, gradually increasing the intensity and complexity of exercises as the individual progresses. This adaptability ensures that therapy remains challenging yet achievable, optimizing the potential for positive outcomes (11). Furthermore, exergaming provides real-time feedback on performance, enabling both patients and physiotherapists to track progress and make necessary adjustments to the treatment plan. This data-driven approach enhances the precision and effectiveness of rehabilitation programs, contributing to improved patient outcomes (12).

This study is driven by the recognition of the growing importance of technology-enhanced interventions in physiotherapy and the increasing popularity of exergaming in healthcare settings. The rationale stems from the desire to explore the synergistic effects of combining traditional physiotherapeutic techniques with interactive and gamified exercises. By conducting a thorough literature review, this study aims to synthesize the available evidence, assess the methodological rigor of relevant research, and draw conclusions about the effectiveness of integrating physiotherapy with exergaming. The rationale for this review also extends to the potential benefits, such as enhanced motor skills, increased patient motivation, and the adaptability of exergaming platforms for various rehabilitation needs. By critically analyzing the current body of research, this study also seeks to contribute to the understanding of how the integration of physiotherapy in exergaming models can revolutionize rehabilitation practices. The anticipated outcomes include insights into the effectiveness of this innovative approach, identification of gaps in current knowledge, and recommendations for future research and implementation in clinical settings. Ultimately, this review aims to provide valuable information for healthcare professionals, researchers, and policymakers striving to optimize physiotherapeutic interventions through the integration of exergaming technologies.

Methods

Initiated on March 8th, 2023, this review article originated from an exhaustive examination of contemporary scholarly literature. A meticulous analysis of various databases, including PubMed, Web of Science, and Cochrane, was undertaken to comprehensively survey the literature. The search strategy involved employing diverse combinations of medical terminology, supplemented by manual searches on Google Scholar to identify pertinent research terms. The principal objective of this literature review was to gain insights into the positive integration of exergaming with physiotherapy and rehabilitation strategies. Furthermore, the review delved into the effectiveness, advantages, and potential outcomes associated with incorporating exergaming into the physiotherapeutic routines of patients. It is paramount to underscore that the articles selected for inclusion in this study adhered to stringent criteria, ensuring a thorough and meticulous review process.

Discussion

The significance of exergaming in physiotherapy lies in addressing key challenges. It enhances patient engagement by blending physical activity with gaming entertainment, encouraging active participation in therapy. Exergaming facilitates tailored exercises, allowing physiotherapists to customize experiences based on rehabilitation goals, progressively intensifying as patients advance. This adaptability ensures challenging yet achievable therapy, optimizing positive outcomes. Additionally, real-time feedback from exergaming enhances precision, allowing both patients and physiotherapists to track progress and adjust treatment plans, contributing to improved rehabilitation

outcomes. Integrating physiotherapy into exergaming models can offer numerous benefits for individuals undergoing rehabilitation or seeking to improve their physical health (8).

Increased patient engagement

Exergaming, blending physical activity with interactive gaming, has proven to be a powerful motivator for individuals undergoing rehabilitation. The dynamic and entertaining nature of these games captivates patients' attention, fostering a heightened level of engagement that is often challenging to achieve through traditional therapeutic approaches (13).

The efficacy of integrating physiotherapy into exergaming is evident in the positive impact on rehabilitation outcomes. Studies have shown that patients participating in exergaming interventions exhibit improved adherence to exercise regimens, contributing to more successful rehabilitation experiences. The gamified elements not only make the rehabilitation process enjoyable but also create a sense of accomplishment, encouraging individuals to actively participate in their therapy sessions (14). Increased patient engagement, a cornerstone of successful rehabilitation, brings about several positive outcomes. Patients are more likely to adhere to prescribed exercise routines, leading to improved physical function, enhanced motor skills, and expedited recovery. Moreover, the interactive and immersive nature of exergaming can positively influence psychological well-being, reducing anxiety and stress commonly associated with traditional rehabilitation methods (15).

Enhanced motor skills and coordination

Exergaming, which merges physical activity with interactive gaming, offers a dynamic platform to target and improve motor skills, making it particularly advantageous in physiotherapeutic contexts. Exergames often require users to perform a range of body movements, promoting the engagement of various muscle groups and stimulating coordination. This dynamic and purposeful movement can contribute significantly to the development and refinement of motor skills, addressing specific challenges faced by individuals undergoing rehabilitation (16). Research indicates that exergaming also provides a stimulating and enjoyable environment for patients to work on their motor skills, fostering a sense of motivation and commitment to the rehabilitation process. The interactive nature of the games encourages individuals to participate actively, leading to more meaningful and sustained improvements in motor coordination (17). Studies have also indicated that individuals engaged in exergaming interventions demonstrate improved balance, precision in movements, and overall motor control. These advancements can be particularly beneficial for patients recovering from injuries, surgeries, or neurological conditions where impaired motor skills and coordination are prevalent challenges. The combination of purposeful movements and interactive gaming not only facilitates targeted improvements but also provides a motivating and engaging rehabilitation experience (18).

Customizable and adaptive programs

Integrating physiotherapy into exergaming models introduces a paradigm shift in rehabilitation by offering highly effective and adaptable programs. This innovative approach not only demonstrates remarkable efficacy but also brings forth a multitude of benefits, primarily through the provision of customizable and adaptive exercise regimens tailored to individual patient needs.

The efficacy of integrating physiotherapy with exergaming lies in the ability to create personalized programs that cater to the unique requirements of each patient. Physiotherapists can leverage exergaming platforms to design exercises that specifically address a patient's rehabilitation goals, taking into account their current physical condition and progress. This customization ensures that therapy is not only relevant but also optimally challenging, maximizing the potential for positive outcomes. The benefits of this integration extend beyond the inherent adaptability of exergaming programs. The customizable nature allows physiotherapists to modify exercise intensity, duration, and complexity based on real-time assessments of the patient's abilities and progress. This adaptability ensures that individuals experience tailored interventions, fostering a sense of ownership and engagement in their rehabilitation journey. An important outcome of integrating physiotherapy into exergaming, with a focus on customizable and adaptive programs, is the enhanced potential for

sustained patient adherence. The gamified and personalized nature of these programs makes rehabilitation enjoyable, increasing patient motivation and commitment. This positive experience contributes to improved adherence rates, a critical factor in achieving long-term rehabilitation success.

Real-time feedback and monitoring

Exergaming models also bring forth a transformative approach that not only enhances efficacy but also provides a myriad of benefits, particularly concerning real-time feedback and monitoring. This innovative combination introduces a dynamic element to rehabilitation, allowing for immediate assessment and adjustment of therapeutic interventions based on the patient's performance (19). Exergaming platforms offer the capability to capture and analyze data on a patient's movements and progress during exercises instantaneously. This real-time information allows physiotherapists to make on-the-spot assessments, ensuring that interventions are precisely aligned with the patient's capabilities and rehabilitation goals (20). Furthermore, research suggests that patients receive instantaneous insights into their performance, fostering a sense of self-awareness and motivation. This immediate feedback mechanism not only engages individuals actively in their rehabilitation but also enables them to make real-time adjustments to improve their technique and achieve optimal therapeutic outcomes (21). A critical outcome of integrating physiotherapy into exergaming, with a focus on real-time feedback and monitoring, is the enhancement of treatment precision. Physiotherapists can track patients' progress continuously, identifying areas of improvement or potential challenges. This data-driven approach enables healthcare professionals to adapt and customize therapy plans dynamically, ensuring that interventions remain effective and align with the evolving needs of the patient (22).

Cardiovascular and musculoskeletal benefits

Using exergaming models for physiotherapy offers a compelling avenue to attain notable efficacy and a plethora of benefits, particularly concerning cardiovascular and musculoskeletal health. This approach harnesses the engaging nature of exergaming to deliver targeted exercises, providing a dynamic platform for achieving optimal outcomes in these critical areas of physical well-being (23). Exergaming platforms, designed to simulate activities such as running, cycling, or strength training, facilitate a cardiovascular workout within an interactive and engaging gaming environment. This translates to improved cardiovascular health, as patients actively participate in exercises that elevate heart rate and enhance overall cardiovascular fitness (24).

Moreover, exergaming incorporates a variety of movements that engage different muscle groups, promoting strength, flexibility, and endurance. The interactive nature of these exercises enhances overall musculoskeletal function, contributing to improved joint stability, reduced risk of injuries, and enhanced mobility – particularly beneficial for individuals undergoing rehabilitation or those seeking to maintain optimal physical health (24, 25). According to the research evidence, by combining therapeutic exercises with the engaging elements of exergaming, individuals can achieve a comprehensive workout that addresses both cardiovascular fitness and musculoskeletal health. This holistic approach is particularly advantageous in rehabilitation settings where a multifaceted approach is often required to address the diverse needs of patients (26).

Psychological well being

Exergaming, by combining physical activity with interactive gaming, transcends traditional therapeutic approaches to address not only the physical but also the psychological aspects of rehabilitation. Engaging in interactive and enjoyable exercises has been also shown to reduce stress and anxiety levels. Exergaming provides a unique platform where individuals can immerse themselves in entertaining activities while simultaneously participating in therapeutic exercises. This dual benefit contributes to a positive psychological experience, promoting a sense of accomplishment, empowerment, and overall well-being (27). Research evidence suggests that regular participation in these activities can serve as a positive coping mechanism for individuals dealing with the challenges

of rehabilitation. The gamified nature of exercises fosters a positive mindset, motivating patients to persevere through the rehabilitation process with enthusiasm and resilience (28). Additionally, studies have indicated that individuals engaging in exergaming interventions report enhanced mood, reduced feelings of depression, and an overall improvement in their mental well-being. This holistic approach acknowledges the interconnectedness of physical and mental health, offering a comprehensive therapeutic experience that addresses the multifaceted needs of patients (29).

Social interaction and motivation

The integration of physiotherapy into exergaming models not only underscores high efficacy but also introduces a wealth of benefits, particularly in the realms of social interaction and motivation. Exergaming, by merging physical activity with interactive gaming, creates a dynamic environment that enhances social engagement and motivation, fostering a sense of community and support among individuals undergoing rehabilitation (30). The efficacy of integrating physiotherapy with exergaming is notably evident in its positive impact on social interaction. Multiplayer exergaming models, in particular, provide a platform for individuals to connect, share experiences, and engage in friendly competition. This social component contributes significantly to the overall rehabilitation process, as it helps alleviate feelings of isolation that can often accompany physical health challenges (31). According to the research evidence, the benefits of exergaming extend beyond the physical exercises to include enhanced motivation. Exergaming introduces an entertaining and competitive element that inherently motivates individuals to actively participate in their therapy sessions. The gamified nature of these activities transforms rehabilitation into an engaging and enjoyable experience, motivating patients to persevere through their exercises and contribute positively to their overall well-being. An essential outcome of integrating physiotherapy into exergaming, with a focus on social interaction and motivation, is the potential for improved adherence to rehabilitation programs. The sense of camaraderie and support fostered by social interactions contributes to a positive and motivating environment, encouraging individuals to stay committed to their exercise routines. This increased adherence is a crucial factor in achieving successful rehabilitation outcomes (32).

Adherence and lifestyle changes

Exergaming, by combining physical activity with interactive gaming, creates a platform that not only engages individuals in their immediate rehabilitation but also motivates sustained adherence and promotes a shift towards healthier lifestyles (33). Research suggests that the interactive and entertaining nature of exergaming makes rehabilitation sessions enjoyable, increasing the likelihood of individuals actively participating in their prescribed exercises. The gamified elements provide a sense of accomplishment, fostering a positive association with rehabilitation activities and contributing to improved adherence over the course of treatment (34). The benefits of integrating exergaming in physiotherapy extend beyond adherence to rehabilitation programs to encompass potential long-term lifestyle changes. Exergaming introduces an engaging and entertaining form of physical activity that individuals can incorporate into their daily routines. This shift from traditional rehabilitation to a more enjoyable and interactive approach can contribute to the establishment of lasting habits, encouraging individuals to maintain regular physical activity even beyond the prescribed therapy period (35). Evidence also indicates that the enjoyable nature of exergaming promotes a positive attitude towards physical activity, increasing the likelihood that individuals will continue to prioritize movement and exercise in their daily lives. This, in turn, has the potential to contribute to broader lifestyle changes, fostering improved overall health and well-being (36).

Conclusion

In conclusion, the integration of physiotherapy into exergaming models emerges as a groundbreaking approach, demonstrating remarkable efficacy and offering a multitude of benefits across various dimensions. The integration of physiotherapy into exergaming not only advances rehabilitation practices but also paves the way for a holistic approach that addresses the diverse needs of individuals, ultimately fostering improved health outcomes and a more positive rehabilitation experience.

References

1. Moseley AM, Herbert RD, Sherrington C, Maher CG. Evidence for physiotherapy practice: a survey of the Physiotherapy Evidence Database (PEDro). Australian Journal of Physiotherapy. 2002;48(1):43-9.
2. Ainslie T. The Concise Guide to Physiotherapy-Volume 1-E-Book: The Concise Guide to Physiotherapy-Volume 1-E-Book: Elsevier Health Sciences; 2012.
3. Şimşek ME, Kapıcıoğlu MS. Physiotherapy in Orthopedic Knee Injuries: Rehabilitation After Articular Cartilage Repair of the Knee. Clinical Anatomy of the Knee: An Atlas: Springer; 2021. p. 283-98.
4. Kannan P, Bello UM, Winser SJ. Physiotherapy interventions may relieve pain in individuals with central neuropathic pain: a systematic review and meta-analysis of randomised controlled trials. Therapeutic Advances in Chronic Disease. 2022;13:20406223221078672.
5. Kang N-y, Park B-s, Kim M-h. Effect of cardiopulmonary physiotherapy on patients with percutaneous coronary intervention-systematic review and meta-analysis. Korean Society of Physical Medicine. 2019;14(1):63-73.
6. Semmons J. The role of physiotherapy in the management of chronic pain. Anaesthesia & Intensive Care Medicine. 2016;17(9):445-7.
7. Sween J, Wallington SF, Sheppard V, Taylor T, Llanos AA, Adams-Campbell LL. The role of exergaming in improving physical activity: a review. Journal of Physical Activity and Health. 2014;11(4):864-70.
8. Oh Y, Yang S. Defining exergames & exergaming. Proceedings of meaningful play. 2010;2010:21-3.
9. Pirovano M, Surer E, Mainetti R, Lanzi PL, Borghese NA. Exergaming and rehabilitation: A methodology for the design of effective and safe therapeutic exergames. Entertainment Computing. 2016;14:55-65.
10. Wagener TL, Fedele DA, Mignogna MR, Hester CN, Gillaspy SR. Psychological effects of dance-based group exergaming in obese adolescents. Pediatric obesity. 2012;7(5):e68-e74.
11. Yoo S, Parker C, Kay J, editors. Designing a personalized VR exergame. Adjunct Publication of the 25th Conference on User Modeling, Adaptation and Personalization; 2017.
12. Guimarães V, Oliveira E, Carvalho A, Cardoso N, Emerich J, Dumoulin C, et al. An exergame solution for personalized multicomponent training in older adults. Applied Sciences. 2021;11(17):7986.
13. Souza CHR, de Oliveira DM, de Oliveira Berreta L, de Carvalho ST, editors. A distributed exergame for telerehabilitation: An engaging alternative to improve patients' quality of life. Proceedings of the 1st Life Improvement in Quality by Ubiquitous Experiences Workshop; 2021: SBC.
14. Ambrosino P, Iannuzzi GL, Formisano R, Spedicato GA, D'Abrosca V, Di Gioia L, et al. Exergaming as an additional tool in rehabilitation of young patients with rheumatoid arthritis: a pilot randomized controlled trial. Games for health journal. 2020;9(5):368-75.
15. Cugusi L, Prosperini L, Mura G. Exergaming for Quality of Life in Persons Living with Chronic Diseases: A Systematic Review and Meta-analysis. PM&R. 2021;13(7):756-80.
16. Hilton CL, Cumpata K, Klohr C, Gaetke S, Artner A, Johnson H, et al. Effects of exergaming on executive function and motor skills in children with autism spectrum disorder: A pilot study. The American Journal of Occupational Therapy. 2014;68(1):57-65.
17. Vernadakis N, Papastergiou M, Zetou E, Antoniou P. The impact of an exergame-based intervention on children's fundamental motor skills. Computers & Education. 2015;83:90-102.
18. Di Tore PA, Raiola G. Exergames in motor skill learning. Journal of physical education and sport. 2012;12(3):358.
19. Hossain MS, Hassan MM, Alamri A, editors. An exergame framework for obesity monitoring and management. 2013 IEEE International Symposium on Haptic Audio Visual Environments and Games (HAVE); 2013: IEEE.
20. Sinclair J. Feedback control for exergames. 2011.

21. Bakker J, Donath L, Rein R. Balance training monitoring and individual response during unstable vs. stable balance Exergaming in elderly adults: Findings from a randomized controlled trial. Experimental gerontology. 2020;139:111037.
22. Doyle J, Kelly D, Patterson M, Caulfield B, editors. The effects of visual feedback in therapeutic exergaming on motor task accuracy. 2011 International Conference on Virtual Rehabilitation; 2011: IEEE.
23. Alfieri FM, da Silva Dias C, de Oliveira NC, Battistella LR. Gamification in musculoskeletal rehabilitation. Current Reviews in Musculoskeletal Medicine. 2022;15(6):629-36.
24. Blasco-Peris C, Fuertes-Kenneally L, Vetrovsky T, Sarabia JM, Climent-Paya V, Manresa-Rocamora A. Effects of exergaming in patients with cardiovascular disease compared to conventional cardiac rehabilitation: a systematic review and meta-analysis. International Journal of Environmental Research and Public Health. 2022;19(6):3492.
25. Mo N, yu Feng J, xia Liu H, yu Chen X, Zhang H, Zeng H. Effects of Exergaming on Musculoskeletal Pain in Older Adults: Systematic Review and Meta-analysis. JMIR Serious Games. 2023;11(1):e42944.
26. Feodoroff B, Konstantinidis I, Froböse I. Effects of full body exergaming in virtual reality on cardiovascular and muscular parameters: Cross-sectional experiment. JMIR Serious Games. 2019;7(3):e12324.
27. Perron RM, Graham CA, Hall EE. Comparison of physiological and psychological responses to exergaming and treadmill walking in healthy adults. GAMES FOR HEALTH: Research, Development, and Clinical Applications. 2012;1(6):411-5.
28. Hastürk G, Akyıldız Munusturlar M. The effects of exergames on physical and psychological health in young adults. Games for Health Journal. 2022;11(6):425-34.
29. Glen K, Eston R, Loetscher T, Parfitt G. Exergaming: Feels good despite working harder. Plos one. 2017;12(10):e0186526.
30. Li J, Erdt M, Chen L, Cao Y, Lee S-Q, Theng Y-L. The social effects of exergames on older adults: systematic review and metric analysis. Journal of medical Internet research. 2018;20(6):e10486.
31. Meekes W, Stanmore EK. Motivational determinants of exergame participation for older people in assisted living facilities: mixed-methods study. Journal of medical Internet research. 2017;19(7):e238.
32. Marker AM, Staiano AE. Better together: outcomes of cooperation versus competition in social exergaming. Games for health journal. 2015;4(1):25-30.
33. Kaos MD, Rhodes RE, Hämäläinen P, Graham TN, editors. Social play in an exergame: how the need to belong predicts adherence. Proceedings of the 2019 CHI conference on human factors in computing systems; 2019.
34. Anderson-Hanley C, Arciero PJ, Barcelos N, Nimon J, Rocha T, Thurin M, et al. Executive function and self-regulated exergaming adherence among older adults. Frontiers in human neuroscience. 2014;8:989.
35. Magalhães Novais MC, Carvalho VO, Duarte Sampaio LF, da Silva Lima YK, de Lima TV, Rocha Conceição LS, et al. ADHERENCE TO CARDIOVASCULAR REHABILITATION WITH THE USE OF EXERGAMING: A SYSTEMATIC REVIEW. Revista Movimenta. 2022;15(2).
36. Höchsmann C, Walz SP, Schäfer J, Holopainen J, Hanssen H, Schmidt-Trucksäss A. Mobile Exergaming for Health—Effects of a serious game application for smartphones on physical activity and exercise adherence in type 2 diabetes mellitus—study protocol for a randomized controlled trial. Trials. 2017;18:1-17.