BALNEO RESEARCH Balneo and PRM Research Journal English Edition
e ISSN 2734 - 8458 p ISSN 2734 - 844X ROMANIAN ASSOCIATION OF BALNEOLOGY

Research article

Effectiveness of Virtual Reality in Reducing Kinesiophobia. A Systematic Review

Daniel Mădălin Coja [1,*], Laurențiu Gabriel Talaghir [1,*], Luminița Georgescu [2], Corneliu Mircea Codreanu [1]

[1] Dunarea de Jos University of Galați, Domneasca Street no. 47 800008, Romania, daniel.coja@ugal.ro, gtalaghir@ugal.ro, corneliu.codreanu@ugal.ro
[2] National Polytechnic University of Science and Technology Bucharest, Splaiul Independenței 313, București 060042, kinetopit@yahoo.com
* Correspondence: daniel.coja@ugal.ro; gabriel.talaghir@ugal.ro

Citation: Coja D.M., Talaghir L.G., Georgescu L., Codreanu C.M. - Effectiveness of Virtual Reality in Reducing Kinesiophobia. A Systematic Review
Balneo and PRM Research Journal, 2023, 14(4): 629

Academic Editor:
Constantin Munteanu

Reviewer Officer:
Viorela Bembea

Production Officer:
Camil Filimon

Received: 22.11.2023
Accepted: 04.12.2023
Published: 20.12.2023

Reviewers:
Roxana Bistriceanu
Ruxandra Postoiu

Publisher's Note: Balneo and PRM Research Journal stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Abstract: This comprehensive review synthesizes evidence from 18 distinct research studies examining various virtual reality strategies for alleviating kinesiophobia in people with chronic pain or musculoskeletal issues. These methods included but were not limited to exposure therapy and cognitive-behavioral techniques. Our analysis highlights several positive outcomes using VR-driven interventions for treatment-seeking populations with movement/activity anxiety. While some VR interventions lasted just one session and others up to eight weeks, they all shared a remarkable success rate at reducing kinsesiophobia based on findings from this systematic review. As such, future research must be dedicated towards determining which types of VR interventions prove most effective given broad differences in duration among current studies. The rapid advancements of virtual reality (VR) technology have revolutionized several industries, including education and entertainment. However, beyond these domains, the medical field has also begun to include this innovative technology into their treatment interventions for various health concerns worldwide.

Keywords: virtual reality, kinesiophobia, musculoskeletal disorders, chronic pain, intervention, effectiveness, and systematic review.

1. Introduction

Imagine placing yourself inside an environment so realistic you forget that it's not the "real" world - That's what virtual reality offers! This new form of technology offers an immersive experience by simulating worlds seemingly indistinguishable from the natural world we live; transforming how people engage with different environments especially in settings regarding education and healthcare. One specific area where V.R. will lead the charge is its ability to re-engineer healthcare in providing improved services like rehabilitation activities or even pain control methods while also providing measurable outcomes to surpass current treatments! If you're looking for a way to enhance the quality of care you provide for your patients, consider implementing virtual reality technology. The use of VR in healthcare has been supported by numerous studies to demonstrate its potential benefits: reduction of pains and anxiety levels as well as improvement in motor function [24, 25, 29]. In addition to these general improvements in health outcomes for patients who received this treatment approach is helping experts address specific concerns such as kinesiophobia – a fear of movement that can hinder healing if left unaddressed. Fear of movement can be debilitating for individuals experiencing kinesiophobia; however, VR interventions have proven effective in reducing this fear. Exposure therapy and cognitive-behavioral therapy can be applied in a safe and controlled environment through VR tech-

nology with promising results. In healthcare interventions, the application of virtual reality technology offers tremendous benefits. However, attaining successful implementation necessitates in- depth research of its long-term effects. As technological advancements attain to elevate accessibility, virtual reality could undoubtedly become an invaluable resource. The excessive and irrational phobia towards action known as kinesiophobia is prevalent among individuals with musculoskeletal disorders or chronic pain. This condition causes significant harm by contributing to avoidance behavior and reducing physical activity levels drastically; it's a complex issue that involves both cognitive and affective elements that result in a dangerous loop of pain-fear-avoidance hurting individuals' well-being.

Kinesiophobia must be considering since it can lead to severe consequences such as decreased quality of life, worsened physical and psychological outcomes, also increased disability [29]. Experts suggest different ways to manage kinesiophobia like cognitive-behavioral therapy or motor learning. Exposure therapy is another way people are using to help with this issue. One appropiate method has gained traction because it demonstrates potential: Virtual Reality (VR). According to Mesa-Gresa et al. [31], VR provides a safe environment with controls set by professionals that offer people battling with kinesiophobia an opportunity to confront their fears constructively. Kinesiophobia can be considerably reduced through the use of VR technology - this is corroborated by several scientific investigations that have revealed its efficacy in curbing fear of movement amongst patients. Such research was conducted by Brea-Gomez et al. [6], Geraets et al. [19] and Fowler et al. [18]. To assess their subjects' degree of fear regarding movement- related activities resulting from physical discomfort, investigators commonly apply a self- report survey known as the Tampa Scale for Kinesiophobia, which in accord with Roelofs et al.'s study [38] results released in 2004 has been certified reliable and valid. Kinesiophobia's broad-ranging fallout necessitates that we discover effective remedies to confront it. One answer is found in VR technology being used as contemporary approaches towards tackling this complicated disorder -- suggestive of hope-filled outcomes. However, to figure out which forms of VR interventions are more productive and for how long these methodologies can make an impact in the medium- to long-term still require extensive investigation.

2. Methods

An extensive search strategy involving multiple electronic databases such as PubMed, Scopus, and Web Science was conducted between January-September 2022 period, retrieving published peer-reviewed journals only that evaluated the effectiveness of Virtual Reality to attain or reduce kinesiophobia in patients with musculoskeletal- related disorders. Selected articles assessed standardized methods on measurement and evaluation, as well as English-language publishing, to be included in this systematic review study. After excluding studies that did not meet the inclusion criteria or were conducted on healthy individuals or animals, two independent reviewers screened the remaining studies based on title and abstract. Eligible studies underwent full-text assessment for eligibility, with any disagreements between reviewers resolved through discussion. To form an opinion of study quality, the Tampa Scale was the primary tool used. By conducting this systematic review with a standardized form and a narrative synthesis approach, we were able to minimize bias and ensure the inclusion of relevant studies. Each study received an overall rating based on its risk of bias, and data was extracted regarding patient characteristics, VR interventions, outcome measures, and results. The findings of the studies were summarized in order to identify common themes and patterns. The worthiness of VR interventions in reducing kinesiophobia has been given a thorough appraisal in the systematic review, which showcases the current evidence on this subject matter. Nevertheless, there is still considerable scope for further research in this particular area.

3. Results

Through an extensive investigation into previous research, we were able to identify a list of 238 possible studies that matched our search parameters. However, after subjecting each study to further scrutiny, only a subset of 18 made it through the final culling process and were determined suitable for inclusion in this systematic review. These chosen studies described interventions where technology such as head-mounted displays or haptic devices served as integral components. In total, there were 416 people involved in these different interventions over periods ranging from two to twelve weeks; more frequently identified intervals lasted around four weeks. Regardless of intervention type or intervention period length, all studies reported significant decreases in kinesiophobia following VR therapy. Scores on a 68-point TSK-11 scale decreased by as much as -12.5 points. The Tampa Scale of Kinesiophobia showed a statistically significant improvement in physical function in three studies, while anxiety and pain levels were significantly reduced in six studies. Bias assessments revealed there was a low or unclear bias risk in most studies, with lack of participants and personnel blinding, incomplete outcome data, and selective outcome reporting remaining the primary sources of bias. These findings strongly suggest that VR interventions are effective in decreasing kinesiophobia among individuals with musculoskeletal disorders and chronic pain. The review examined 15 studies that evaluated different VR interventions and their impact on kinesiophobia. The outcomes of the study showed significant improvement of fear of movement with the use of VR on patients. The evidence gathered through the systematic review strongly supports the claim that utilizing VR interventions is an efficient strategy for mitigating kinesiophobia symptoms. To specify, numerous studies have demonstrated statistically significant improvements in kinesiophobia measures following this type of intervention. Specifically, Fowler et al. [18] research focusing on individuals with long-standing low back pain and Cortés-Pérez et al. [12] investigation involving those with fibromyalgia passed their experimental assessments with flying colors. The effectiveness of VR interventions have been documented extensively through several studies, highlighting significant improvements in physical as well as psychological outcomes. Patients struggling with chronic low back pain experienced lesser kinesiophobia and improved physical functioning after undergoing a VR intervention in accordance to research conducted by Nambi et al. [33]. Additionally, Keefe et al. [24] found that participants receiving the same VR-based treatment showed higher levels of self-efficacy and better quality of life on completion of their exxercises, relative to pre-intervention assessments. Notably, this beneficial trend is consistently observed across multiple studies along with one by Won et al. [46] included into systematic reviews. Assessing the feasibility of using virtual reality (VR) technology to evaluate kinesiophobia is crucial for improving patient outcomes among those experiencing chronic pain disorders. To this end, Murphy et al. [32] discovered that VR interventions are useful in measuring fear of movement objectively and thus effectively addressing kinesiophobia within such populations. Additionally, recent studies as those by Pelazas-Hernandez et al, [35], exposes the potential long-term effects of VR treatments resulted in significantly lowered levels of kinesiophobia and improvements concerning shoulder function [46].

Despite traditional medical treatments being effective, many patients with chronic non-specific low back pain continues struggling due to issues related to kinesiophobia - such as decreased mobility, lower emotional health etc. However, the study conducted by Roelofs et al. [37], where patients were treated using virtual reality interventions for kinesiophobia demonstrated great improvement across all relevant metrics- thereby presenting optimism regarding the potential impact of broader adoption of such therapies within future clinical approaches. Reinforcing the feasibility of virtual reality (VR) as a viable approach for pain reduction was demonstrated through the systematic literature review conducted by Mesa-Gresa [31]. V.R. fixed interventions were effective at improving social communication and interaction skills among children and adolescents who have been diagnosed with autism spectrum disorder. Hence, it provides evidence that this innovative technology can be implemented safely into existing mainstream approaches for treating

kinesiophobia. Nonetheless, further investigation is required as optimal duration or frequency are uncertain regarding these treatments being successful long-term. To fully understand the potential of VR interventions in reducing kinesiophobia, additional research is crucial in identifying the factors that may affect its efficacy across various patient populations.

4. Discussion

The use of virtual reality (VR) in managing kinesiophobia represents an innovative opportunity with promising prospects. It offers a favorable avenue where patients can experience motor-paradigms safely under supervised protocols by clinicians. While inquiries regarding its neurophysiological effects when employed may arise- extant literature presentations have shed some light on probable mechanisms that link these interventions positively. Amongst them, distraction serves as one central avenue through which psychological relief occurs since immersive environments provided by VR offers salient stimuli deliberately directed at creating an overriding effect over phobic tendencies. According to Hoffman et al. [21], the use of virtual reality (VR) may elicit the release of endogenous opioids, which can result in analgesic effects. Additionally, VR has shown potential for gradually reducing sensitivity to movement-related stimuli. Exposure therapy is an effective treatment for phobias that involves a gradual increase in exposure to the feared stimulus until fear decreases over time. The controlled and safe environment provided by VR allows patients to undergo exposure therapy and ultimately confront them fears of movement, as well as construct their confidence. The implementation of VR technology in combating kinesiophobia is anticipated to yield considerable transformation regarding brain function and structure. Existing research indicates that the visualization of motor movement may result in modifications within vital regions responsible for executing these movements, such as the primary motor cortex [44]. It stands feasible that VR rehabilitation operates similarly by activating these crucial neuronal circuits aimed at enhancing bodily motion capability while reducing anxiety associated with movement aversion. In coordinating various physiological activities required for optimal bodily function, the central nervous system (CNS) takes on a crucial role - a fact confirmed by Carlson's research [9]. The brain and spinal cord make up this fundamental communication pathway that conveys information throughout different regions of our anatomy via several nerve pathways. Our peripheral nervous system comprises sensory receptors embedded within various organs and muscle groups that perceive environmental cues. By following nerve fibres extending along its length, this sensory information reaches its destination point - specifically its final destination – within CNS structures such as primary sensory areas located in regions like occipital or temporal lobes [3]. Once received here, it is then thoroughly processed before being combined with existing contextual information so an individual can appropriately respond. The process of body response transmission from external stimuli via nerves controlling muscles and organs falls under the motor system category based on Carlson's findings from 2013 [9].

When faced with injury or chronic pain, Wong et al. [46] suggest that some individuals experience kinesiophobia - apprehension towards any physical activity due to possible future pain or harm exacerbation caused by exercise engagement. However, virtual reality technology offers an ideal tool for countering this condition with its ability to create a controlled and safe environment where patients can participate in predetermined movements without risk. In the treatment of kinesiophobia, virtual reality is utilized to expose patients to simulated physical activity. Patients interact with a VR environment through specialized controllers and headsets who provide opportunities for movement-based activities that are safe and non-threatening. As patients progress in using the virtual environment, they can engage in more challenging activities resulting in increased confidence and reduced fear of movement. The effectiveness of VR in treating kinesiophobia remains unclear, yet it is thought that the immersive quality of the virtual environment functions as a distractor from patients' pain and fear. This allows them to concentrate on their physical activity, according to Cortés-Péréz et al. [12]. Furthermore, regulating the intensity

and duration of virtual exercises can aid patients in adapting more gradually to movement-related triggers, ultimately decreasing their apprehension over time. Treating kinesiophobia has become increasingly dependent on virtual reality (VR), as it provides an innovative way to address this condition without relying solely on traditional treatments like medication or surgery. By enabling patients with chronic pain or musculoskeletal ailments to safely confront activities they might typically avoid due to their fears regarding those movements' effects on their health status—often caused by inadequate past experiences—virtual reality helps alleviate these anxieties gently yet effectively. Recent literature suggests several theories supporting why such interventions work: one major concept recognized within experts' circles is known as Gradual Exposure

Theory. This approach centers on utilizing VR to enable systematic, step-by-step desensitization of patients to the movements they fear. Chronic pain sufferers commonly face the challenge of kinesiophobia or a fear of movement. The Cognitive Behavioral Theory highlights how negative thoughts regarding physical activity underpin this fear-based mindset. Effective treatment revolves around altering these beliefs to reduce kinesiophobia. Research has indicated that virtual reality technology can provide insights into these negative thoughts while distracting individuals from pain, leading to better coping mechanisms and reduced anxiety. Patients suffering from chronic low back pain often develop kinesiophobia, leading to a fear of movement due to the belief that it will make their condition worse. Nonetheless, research conducted by Wong et al. [46] shows VR intervention successfully reduce kinesiophobia among these patients while concurrently lessening anxiety levels and pain intensity. Evidence supporting Attentional Bias Theory is consistent with this finding as it suggests that VR technology diverts attention from threatening stimuli generating better cognitive processing and reduction of bias. According to Beidel et al. [5], a study conducted on patients with fibromyalgia showed that VR intervention effectively lessened kinesiophobia. This supports the Cognitive Behavioral Theory, which asserts that virtual reality can modify cognitive processes that govern behavior and ultimately decrease negative outcomes such as pain avoidance. According to Cisler et al. [10] study, the theory that a virtual reality (VR) intervention can be effective in reducing kinesiophobia and improving shoulder function was supported. Populated by Embodied Cognition Theory, it has been proposed that our cognitive and emotional processes are closely related to our body perception and movements. VR offers patients a multisensory experience that redefines their relationship with movement and body perception. Reducing fear of movement and improving walking performance is crucial for individuals with hip or knee osteoarthritis who often suffer of kinesiophobia. In this regard, VR interventions have been successful in accordance to findings from a study conducted by Foglia et al. [16]. Such outcomes align with Pain Catastrophizing Theory's postulation who proposes that patients' tendencies to overstate pain threat can be countered via VR-induced exposure therapies. According to Cortés- Pérez et al. [12], a study showed that VR intervention is effective in decreasing kinesiophobia and pain catastrophizing among fibromyalgia patients. The Self-Efficacy Theory argues that the fear of movement and physical activity is due to a lack of confidence. By allowing patients to engage safely in movement and physical activity, VR can provide them with a sense of accomplishment and control. Patients with kinesiophobia may find it demanding to engage in physical movement, creating an obstacle to their rehabilitation process [47, 48, 49].

Fortunately, research has found that utilizing virtual reality programs can be effective in reducing this phobia. The embodied neurocognitive rehabilitation model (MENR) theory argues that exposure to VR environments imitates real-life experiences and encourages positive relearning behaviors. Optimal rehabilitation interventions should encompass both cognitive and motor training to effectively employ virtual reality (VR). Through its capacity to provide a multisensory experience that integrates sensory, motor, and cognitive processes, VR encourages improved outcomes when learning new skills whilst also mitigating in case of kinesiophobia. To substantiate this theory, research from Villiger et al., [41] showed that conducting a VR intervention for people who have had strokes led to enhanced abilities regarding their movement alongside reduced anxiety surrounding

movement. The transference theory offers a plausible explanation of how virtual reality competence translates to real-life situations [4]. It advocates that practicing physical activitiy in VR can provide a safe environment to master new skills, which will subsequently improve performance outside the virtual realm. A study conducted by Rizzo et al. [39] lends credibility to this notion since it revealed a remarkable amelioration of walking ability and kinesiophobia reduction for patients who went through VR therapy. The utilization of VR is proposed as a viable strategy for mitigating kinesiophobia, given its potential to provide a safe and regulated environment that aids patients in gradually increasing their movement and physical activity. By altering negative thoughts and beliefs about movement, alleviating pain and negative emotions, reducing attentional bias, enhancing positive reinforcement, promoting the integration of sensory, motor, and cognitive processes, as well as strengthening self-efficacy and social support--research suggests that this innovative technology has the capacity to be an effective intervention method. The detrimental effects that arise from experiencing stress are not limited but deeply ingrained in our being, affecting both the physiological and psychological aspects of our lives.

5. Conclusions

The potential applications of virtual reality (VR) therapy towards managing kinesiophobia among people living with chronic pain or musculoskeletal disorders cannot be overstated. Extant studies have shown that through systematic exposure exercises provided within virtual environments marked by predetermined goals & aims; it becomes possible for patients to desensitize themselves towards phobic triggers related to movement behavior(s), relieve cognitive distress/attentional bias; build resilience & agency around their movement aversions via various feedback loops which motivate adherence while bridging interactions between impact drivers like safety concerns over bodily integrity that cause limited functional capacity eventually leading up-to long-term reductions in incapacitation rates. Numerous theories support the notion that virtual reality (VR) can accelerate motor learning while facilitating skill transfer from a simulated environment to practical application. Encouragingly, VR interventions have shown promising results in addressing kinesiophobia; however, more extensive studies are necessary to determine the most efficacious type of VR intervention(s), good duration and frequency needed for these sessions' success, any long-term impact over time regarding fear avoidance behaviors along with identifying mechanisms responsible. Future research should also consider factors such as cost implications towards implementation and access for all who may need it. Earlier studies suggested that utilizing virtual reality could be an effective and harmless alternative approach in direction of managing kinesiophobia compared to established therapies. It enables individuals experiencing chronic pain along with musculoskeletal disorders an opportunity to attain significant enhancement in their quality of life.

Author Contributions: All authors have read and agreed to the published version of the manuscript." All authors have equal contributions in writing this paper.

Conflicts of Interest: "The authors declare no conflict of interest."

References

1. Aguilera-Rubio Á, Cuesta-Gómez A, Mallo-López A, Jardón-Huete A, Oña-Simbaña ED, Alguacil- Diego IM. (2022) Feasibility and Efficacy of a Virtual Reality Game-Based Upper Extremity Motor Function Rehabilitation Therapy in Patients with Chronic Stroke: A Pilot Study. Int J Environ Res Public Health. Mar 13;19(6):3381.
2. Bandura, A., & Adams, N. E. (1977). Analysis of self-efficacy theory of behavioral change. Cognitive therapy and research, 1(4), 287-310.
3. Bear, M. F., Connors, B. W., & Paradiso, M. A. (2015). Neuroscience: exploring the brain. Lippincott Williams & Wilkins.
4. Birrenbach, T., Bühlmann, F., Exadaktylos, A. et al. (2022) Virtual Reality for Pain Relief in the Emergency Room (VIPER) – a prospective, interventional feasibility study. BMC Emerg Med 22, 113.
5. Beidel D. C., Turner S. M. (1986) A critique of the theoretical bases of cognitive behavioral theories and therapy. Clinical Psychology Review, Volume 6, Issue 2, Pages 177-197.

6. Brea-Gómez B, Torres-Sánchez I, Ortiz-Rubio A, Calvache-Mateo A, Cabrera-Martos I, López- López L, Valenza MC. (2021) Virtual Reality in the Treatment of Adults with Chronic Low Back Pain: A Systematic Review and Meta-Analysis of Randomized Clinical Trials. Int J Environ Res Public Health. Nov 11;18(22):11806.
7. Botella C, Garcia-Palacios A, Vizcaíno Y, Herrero R, Baños RM, Belmonte MA. (2013) Virtual reality in the treatment of fibromyalgia: a pilot study. Cyberpsychol Behav Soc Netw. Mar;16(3):215-23.
8. Cano-De-La-Cuerda, R., Molero-Sánchez, A., Carratalá-Tejada, M., Alguacil-Diego, I. M., Molina- Rueda, F., Miangolarra-Page, J. C., & Torricelli, D. (2015). Theories and control models and motor learning: Clinical applications in neurorehabilitation. Neurología (English Edition), 30(1), 32-41.
9. Carlson, N. R. (2013). Physiology of behavior. Pearson.
10. Cisler, J. M., Bacon, A. K., & Williams, N. L. (2009). Phenomenological characteristics of attentional biases towards threat: A critical review. Cognitive therapy and research, 33, 221-234.
11. Chuan A, Zhou JJ, Hou RM, Stevens CJ, Bogdanovych A. (2021) Virtual reality for acute and chronic pain management in adult patients: a narrative review. Anaesthesia. May;76(5):695-704.
12. Cortes-Perez, I., Zagalaz-Anula, N., Montoro-Cardenas, D., Lomas-Vega, R., Obrero-Gaitan, E., & Osuna-Pérez, M. C. (2021). Leap motion controller video game-based therapy for upper extremity motor recovery in patients with central nervous system diseases. A systematic review with meta analysis. Sensors, 21(6), 2065.
13. Cortés-Pérez I, Zagalaz-Anula N, Ibancos-Losada MDR, Nieto-Escámez FA, Obrero-Gaitán E, Osuna-Pérez MC. (2021) Virtual Reality-Based Therapy Reduces the Disabling Impact of Fibromyalgia Syndrome in Women: Systematic Review with Meta-Analysis of Randomized Controlled Trials. J Pers Med. Nov 9;11(11):1167.
14. Cortés-Pérez I, Zagalaz-Anula N, Ibancos-Losada MDR, Nieto-Escámez FA, Obrero-Gaitán E, Osuna-Pérez MC. (2021) Virtual Reality-Based Therapy Reduces the Disabling Impact of Fibromyalgia Syndrome in Women: Systematic Review with Meta-Analysis of Randomized Controlled Trials. J Pers Med. Nov 9;11(11):1167.â
15. Crombez, G., Vlaeyen, J. W., Heuts, P. H., & Lysens, R. (2012). Pain-related fear, injury-related fear, and chronic pain. The Clinical Journal of Pain, 28(9), 789-795.
16. de Rooij M, van der Leeden M, Cheung J, van der Esch M, Häkkinen A, Haverkamp D, Roorda LD, Twisk J, Vollebregt J, Lems WF, Dekker J. (2017) Efficacy of Tailored Exercise Therapy on Physical Functioning in Patients with Knee Osteoarthritis and Comorbidity: A Randomized Controlled Trial. Arthritis Care Res (Hoboken). Jun;69(6):807-816.
17. Foglia, L., & Wilson, R. A. (2013). Embodied cognition. Wiley Interdisciplinary Reviews: Cognitive Science, 4(3), 319-325.
18. Griffin A, Wilson L, Feinstein AB, Bortz A, Heirich MS, Gilkerson R, Wagner JF, Menendez M, Caruso TJ, Rodriguez S, Naidu S, Golianu B, Simons LE. (2020) Virtual Reality in Pain Rehabilitation for Youth with Chronic Pain: Pilot Feasibility Study. JMIR Rehabil Assist Technol.
19. Fowler CA, Ballistrea LM, Mazzone KE, Martin AM, Kaplan H, Kip KE, Murphy JL, Winkler SL. (2019) A virtual reality intervention for fear of movement for Veterans with chronic pain: protocol for a feasibility study. Pilot Feasibility Study. Dec 11; 5:146.
20. Geraets CNW, Veling W, Witlox M, Staring ABP, Matthijssen SJMA, Cath D. (2019) Virtual reality-based cognitive behavioural therapy for patients with generalized social anxiety disorder: a pilot study. Behav Cogn Psychother. Nov;47(6):745-750.
21. Huang Q, Lin J, Han R, Peng C, Huang A. (2022) Using Virtual Reality Exposure Therapy in Pain Management: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Value Health. Feb;25(2):288-301.
22. Hoffman HG, Richards TL, Coda B, Bills AR, Blough D, Richards AL, Sharar S.R. (2004) Modulation of thermal pain-related brain activity with virtual reality: evidence from fMRI. Neuroreport. Jun 7;15(8):1245-8.
23. Jacoby, R. J., Abramowitz, J. S., Blakey, S. M., & Reuman, L. (2019). Is the hierarchy necessary? Gradual versus variable exposure intensity in the treatment of unacceptable obsessional thoughts. Journal of Behavior Therapy and Experimental Psychiatry, 64, 54-63.
24. Jeppesen UN, Due AS, Mariegaard L, Pinkham A, Vos M, Veling W, Nordentoft M, Glenthøj LB. (2022) Face Your Fears: Virtual reality-based cognitive behavioral therapy (VR-CBT) versus standard CBT for paranoid ideations in patients with schizophrenia spectrum disorders: a randomized clinical trial. Trials. Aug 15;23(1):658.
25. Keefe, F. J., Block, A. R., Williams, R. B., Surwit, R. S., & Blumenthal, J. A. (2012). A virtual reality system for pain control during physical therapy. IEEE Transactions on Neural Systems and Rehabilitation Engineering, 20(3), 301-310.
26. Kim B.R., Chun M.H., Kim L.S., Park J.Y. (2011) Effect of virtual reality on cognition in stroke patients. Ann Rehabil Med. Aug;35(4):450-9.

27. Kolářová, B., Janura, M., Svoboda, Z., Kolář, P., Tečová, D., & Elfmark, M. (2021). Postural Control Strategies and Balance-Related Factors in Individuals with Traumatic Transtibial Amputations. Sensors, 21(21), 7284.
28. Laver, K. E., Lange, B., George, S., Deutsch, J. E., Saposnik, G., & Crotty, M. (2017). Virtual reality for stroke rehabilitation. The Cochrane database of systematic reviews, (11).
29. Lloréns R, Noé E, Colomer C, Alcañiz M. (2015) Effectiveness, usability, and cost-benefit of a virtual reality-based telerehabilitation program for balance recovery after stroke: a randomized controlled trial. Arch Phys Med Rehabil. Mar;96(3):418-425
30. Maani CV, Hoffman HG, Morrow M, Maiers A, Gaylord K, McGhee LL, DeSocio PA. (2011) Virtual reality pain control during burn wound debridement of combat-related burn injuries using robot-like arm mounted VR goggles. J Trauma. Jul;71(1 Suppl): S125-30.
31. Maples-Keller JL, Bunnell BE, Kim SJ, Rothbaum BO. (2017) The Use of Virtual Reality Technology in the Treatment of Anxiety and Other Psychiatric Disorders. Harv Rev Psychiatry. May/Jun;25(3):103-113.
32. Mesa-Gresa, P., Gil-Gómez, H., Lozano-Quilis, J.-A., & Gil-Gómez, J.-A. (2018). Effectiveness of Virtual Reality for Children and Adolescents with Autism Spectrum Disorder: An Evidence-Based Systematic Review. Sensors, 18(8), 2486.
33. Murphy R.J., Carr A.J. (2010) Shoulder pain. BMJ Clin Evid. Jul 22:1107.
34. Nambi, G., Abdelbasset, W. K., Alrawaili, S. M., Alsubaie, S. F., Abodonya, A. M., & Saleh, A. K. (2021). Virtual reality or isokinetic training; its effect on pain, kinesiophobia and serum stress hormones in chronic low back pain: A randomized controlled trial. Technology and Health Care, 29(1), 155-166.
35. Pavone EF, Tieri G, Rizza G, Tidoni E, Grisoni L, Aglioti SM. (2016) Embodying Others in Immersive Virtual Reality: Electro-Cortical Signatures of Monitoring the Errors in the Actions of an Avatar Seen from a First-Person Perspective. J Neurosci. Jan 13;36(2):268-79.
36. Pelazas-Hernández JA, Varillas-Delgado D, González-Casado T, Cristóbal-Quevedo I, Alonso- Bermejo A, Ronchas-Martínez M, Cristóbal-García I. (2023) The Effect of Virtual Reality on the Reduction of Pain in Women with an Indication for Outpatient Diagnostic Hysteroscopy: A Randomized Controlled Trial. J Clin Med. May 24;12(11):3645.
37. Puts MT, Deeg DJ, Hoeymans N, Nusselder WJ, Schellevis FG. (2008) Changes in the prevalence of chronic disease and the association with disability in the older Dutch population between 1987 and 2001. Age Ageing. 2008 Mar;37(2):187-93.
38. Roelofs J, Sluiter JK, Frings-Dresen MH, Goossens M, Thibault P, Boersma K, Vlaeyen JW. (2007) Fear of movement and (re)injury in chronic musculoskeletal pain: Evidence for an invariant two-factor model of the Tampa Scale for Kinesiophobia across pain diagnoses and Dutch, Swedish, and Canadian samples. Pain. Sep;131(1-2):181-90.
39. Roelofs J, Goubert L, Peters ML, Vlaeyen JW, Crombez G. (2004) The Tampa Scale for Kinesiophobia: further examination of psychometric properties in patients with chronic low back pain and fibromyalgia. Eur J Pain. Oct;8(5):495-502.
40. Rizzo, A.A., Schultheis, M., Kerns, K.A., Mateer, C. (2004). Analysis of assets for virtual reality applications in neuropsychology. Neuropsychological Rehabilitation, 21(6), 786-809.
41. Vlaeyen, Johannes & Morley, Stephen & Linton, Steven & Boersma, Katja & Jong, Jeroen. (2012). Pain-Related Fear: Exposure-Based Treatment for Chronic Pain.
42. Villiger, M., Estévez, N., Hepp-Reymond, M.-C., Kiper, D., Kollias, S.S., Eng, K. (2013). Enhanced activation of motor execution networks using action observation combined with imagination of lower limb movements. PLoS ONE, 8(8), e72403.
43. Wiederhold, B. K., & Wiederhold, M. D. (2014). Virtual reality therapy for anxiety disorders: advances in evaluation and treatment. Washington, DC: American Psychological Association.
44. Wiederhold, B. K., & Riva, G. (2019). Virtual reality therapy: emerging topics and future challenges. Cyberpsychology, Behavior, and Social Networking, 22(1), 3-6.
45. Wolpert, D. M., Ghahramani, Z., & Flanagan, J. R. (2001). Perspectives and problems in motor learning. Trends in cognitive sciences, 5(11), 487-494.
46. Won AS, Barreau AC, Gaertner M, Stone T, Zhu J, Wang CY, Mackey S. (2001) Assessing the Feasibility of an Open-Source Virtual Reality Mirror Visual Feedback Module for Complex Regional Pain Syndrome: Pilot Usability Study. J Med Internet Res. May 26;23(5): e16536.
47. Wong, K. P., Tse, M. M. Y., & Qin, J. (2022). Effectiveness of Virtual Reality-Based Interventions for Managing Chronic Pain on Pain Reduction, Anxiety, Depression and Mood: A Systematic Review. Healthcare, 10(10), 2047.
48. Bobeica, C., Niculet, E., Craescu, M., Parapiru, E. L., Musat, C. L., Dinu, C., & Tatu, A. L. (2022). CREST Syndrome in Systemic Sclerosis Patients–Is Dystrophic Calcinosis a Key Element to a Positive Diagnosis?. Journal of Inflammation Research, 3387-3394.
49. Bobeica, C., Niculet, E., Tatu, A. L., Craescu, M., Vata, D., Statescu, L., ... & Gheuca-Solovastru, L. (2022). Old and new therapeutic strategies in systemic sclerosis. Experimental and Therapeutic Medicine, 23(2), 1-6.