

Technologies Used in Medical Rehabilitation: A Systematic Review Regarding the Applicability of Rehabilitation Technologies in Certain Medical Domains

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Abstract: *This article aims to investigate and explore present rehabilitation technology. Through the accumulated results of this review, we will summarise the support and benefits that the emergence of technologies in medicine provides. The primary objective of this study is to demonstrate how patient rehabilitation is evolving compared to traditional rehabilitation. The initial search identified 113 titles in the databases; 18 duplicate articles were removed automatically. The remaining 95 articles were examined by title and abstract, which resulted in the elimination of 59 studies. The full texts of the remaining 36 articles were read and evaluated; nine articles were excluded because they did not satisfy the inclusion criteria established for this study. At the evaluation stage, nine studies were thrown out because they did not fit into the medical fields that the research was looking into or because there was not enough data and information to analyse or rate the results. Other studies were excluded from the full-text evaluation because the study sample was not specified. Technology integration into rehabilitation presents obstacles such as high costs and limited accessibility. Researchers, medicinal professionals, and the technology industry must work together to develop more effective and cost-effective solutions. Nevertheless, these obstacles pale in comparison to the patient benefits of technology. In order to maximise the benefits and surmount the current challenges, it will be necessary to continue the research and development of these technologies in the future.*

Keywords: *Technologies, Medical Rehabilitation, Medical Domains, Smart Devices.*

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Introduction

Medical recovery combines and complements traditional medical treatments, it can be used in all branches of healthcare, but it is not as simple as it seems. It requires a multidisciplinary approach integrated into a team, more precisely, a collaboration between doctors of different specialties providing rehabilitation treatment. Treatments specific to each patient's pathology are developed. These multidisciplinary teams allow the patient access to the full range of treatment options, so therapeutic decisions are based on valid medical information (Kraemer et al., 2009).

Neuromuscular disorders are a broad group of disorders involving damage or dysfunction of peripheral muscles and nerves or the central nervous system and spinal cord. The sites where injury can occur are multiple. It can occur in axons, cells in the body, neuromuscular junction, or muscles. Other neuromuscular disorders are associated with the central nervous system. These can cause significant damage to the brain or spinal cord (Morrison, 2016).

Advances in technology have revolutionised the neurological domain. Its use in assessing the neurological patient has helped medical professionals determine the extent of pathological processes more accurately (Michael & David, 2012).

Digital therapy is a medical field in which the patient can benefit from evidence-based therapeutic interventions provided by qualified programmes to prevent or treat specific conditions. It is used nowadays in most medical fields, such as oncology, endocrinology and neurology. This therapy can treat neuropsychiatric disorders such as depression or anxiety (Hong et al., 2021).

Rehabilitation in geriatrics refers to rehabilitative and post-acute care intended for older hospitalised patients or patients with various pathologies, especially those with preexisting functional decline. The central objective of geriatric rehabilitation is to optimise patients' functional capacities and to support their social participation despite older patients' impairments and conditions. This branch helps frail and elderly patients receive care following fractures, surgery, amputations, strokes and other conditions. Geriatric rehabilitation has become an essential avenue of care for the elderly, allowing them to enjoy a degree of independence at some point (De Groot et al., 2022).

For optimal recovery of geriatric patients, the healthcare professional must be knowledgeable about the general principles of rehabilitation and the key areas affecting the elderly population. The geriatric rehabilitation

program should consist of a multidisciplinary team of healthcare professionals, including a physician, physical therapist, occupational therapist, psychologist, and healthcare specialist (The World Health Organization, 2001).

The effects of using robotics for independent walking patients have been examined, and exoskeletons have been proposed for those who have undergone various lower-train conditions such as total hip arthroplasty, knee surgery or other surgeries and pathologies. Moreover, these exoskeleton mechanisms are also intended for walking exercises for patients with paralysis (Koseki et al., 2021).

The definition of paediatric rehabilitation is the care and treatment of children with congenital and acquired disabilities. This field of paediatric rehabilitation has become a recognised speciality. The rehabilitation nurse must always look for innovative ways to help children and their families adapt to their children's disabilities. That is why they also need to keep up with new technological developments. The influence of parents or other family members must be omnipresent (Blanchard & Øberg, 2015).

The use of robotics in paediatric rehabilitation has borne fruit. Research on robotic technology has shown that it is effective for patients with cerebral palsy (Alhasan et al., 2017).

The technology that has been used to combat spastic cerebral palsy is robotics. Spasticity refers to muscle hypertonia, where the muscles are very tight. When this condition manifests itself in the lower limbs, we can call it spastic diplegia. When a child suffers from spastic diplegia, he or she tends to walk on tiptoes and gait is affected. The therapist's solution is to stretch the muscles to prevent contractures and atrophy (Blanchard & Øberg, 2015).

Rehabilitation of cardiac patients is a complex, multidisciplinary group of actions that focus on patient education, an individual exercise programme, risk factor modification, and patients' general wellbeing. Cardiac rehabilitation programs are indispensable in modern cardiology (Tandon & de Ferranti, 2019).

They no longer rely solely on exercise therapies, but nowadays are looking for disease prevention strategies that manage psychological, stress, behavioural, social and risk factors that affect patient outcomes. The benefits of cardiac recovery include reduced mortality, reduced smoking, improved symptoms, increased exercise tolerance and overall patient wellbeing. In addition to primary prevention of heart disease aimed at delaying or delaying the onset of disease, cardiac rehabilitation also focuses on secondary prevention. This consists of early detection of the disease and the

application of interventions to prevent its progression (Bonafide et al., 2018).

Mobile health apps compatible with smartphones are used in managing cardiovascular disease, and there is a growing trend in their use. Most of these apps provide medical recommendations, medical appointments and notifications for cardiovascular disease monitoring. Using wearable devices to monitor conditions in this medical field has resulted in cost savings and improved patient outcomes (Mampuya, 2012).

Injuries to the musculoskeletal system cause pain and loss of physical function over time, leading to functional disability. Orthopaedic rehabilitation aims to restore physical function in these individuals (Jain et al., 2017).

The therapist must understand orthopaedic conditions and their medical treatment to develop a treatment plan for the patient that will help them return to standard functionality effectively and without complications. The therapist must constantly evaluate the orthopaedic patient and adjust the therapy plan to the patient's needs. The parameters that the therapist should be strictly aware of are the knowledge of tissue healing stages (García-Bravo et al., 2020).

Innovative implants are implantable devices that can be diagnostic in addition to therapeutic effects. With these implants, the healthcare system can save massive costs. They are most commonly applied in total hip arthroplasty, knee arthroplasty, fracture fixation and many other conditions (Ledet et al., 2018).

This review *aims to explore and investigate modern-day rehabilitation automation*. With the help of this review, through the collected results, we will summarise the support and benefits that the emergence of technologies in medicine offers. *The main objective of this research is to highlight how patient rehabilitation is changing compared to conventionally performed rehabilitation*. It will compare the devices used, the pathology in which they are used and the results extracted. The impact of medical systems and devices over time will be determined over less than eleven years.

The novel element of this systematic review is the assessment and synthesis of recent research on technologies used in medical rehabilitation in the areas covered. The world constantly evolves; therefore, new technologies and innovations in these target areas have significantly impacted rehabilitation approaches and methods. *This systematic review combines these developments in a comprehensive and up-to-date framework, providing healthcare professionals with essential information for clinical decision-making*.

Material and Methods

The presented study is a systematic review initiated in April 2023, completed in July 2023, and was done respecting the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) standards. It aimed to analyse modern technology's clinical and evolutionary aspects in medical recovery and its benefits.

Four central databases were used in this research: PubMed, GoogleScholar, ScienceDirect and SpringerLink. In these databases, the specific phrases as search formulas are:

- PubMed: (neurology rehabilitation) OR (neurological recovery technology) AND (geriatric rehabilitation) OR (geriatric device) AND (pediatric rehabilitation) OR (pediatric medical device) AND (cardiovascular domain) OR (wearable cardiovascular device) AND (orthopaedic rehabilitation) OR (orthopaedic rehab device)
- GoogleScholar: (neurology rehabilitation) OR (neurological recovery technology) AND (geriatric rehabilitation) OR (geriatric device) AND (pediatric rehabilitation) OR (pediatric medical device) AND (cardiovascular domain) OR (wearable cardiovascular device) AND (orthopaedic rehabilitation) OR (orthopaedic rehab device)
- ScienceDirect: (neurotechnologies) OR (neurological devices) OR (neuromodulation) AND (mobility of geriatric patients) OR (walking geriatric patients) AND (wearable device) OR (wearable orthopaedic device)
- SpringerLink: (robotic rehabilitation) OR (digital rehabilitation) AND (intelligent implants) OR (orthopaedic implants) AND (wearable device) OR (bio-feedback technology) AND (neurological rehabilitation) OR (neurological recovery technology)

Inclusion and Exclusion Criteria

Table 1. Inclusion/Exclusion criteria

PARAMETERS	INCLUSION CRITERIA	EXCLUSION CRITERIA
MEDICAL FIELD	Studies based on medical technologies have been used in neurology, paediatrics, geriatrics, cardiology, and orthopaedics.	Studies based on medical technologies that have been used in fields other than those of interest, publications being irrelevant.
YEAR OF APPEARANCE	Medical studies and articles that are no more than 11 years old.	Medical studies and articles are more than 11 years old.
TYPE OF TECHNOLOGY	Studies conducted on rehabilitative technologies for patients in a medical rehabilitation programme.	Studies and articles based on medical devices related to imaging, artificial intelligence or other technologies are not used in medical rehabilitation.
PATHOLOGY	Medical studies or articles containing diseases or pathologies related to the area of rehabilitation	Medical studies or articles about diseases or pathologies that do not involve rehabilitation.
POPULATION	Individuals who have benefited from medical rehabilitation using technology.	Studies where the sample is not specified.
METHODOLOGY	Studies that have a complex methodology with qualitative and relevant information.	Studies with poor design or inappropriate methodology.

Source: Author's own conception

Results

The initial search identified 113 titles in the databases described above, of which 18 duplicate articles were automatically removed. The remaining 95 articles were analysed by title and abstract, resulting in 59 studies removed. The full text of the remaining 36 articles was read and analysed; thus, nine articles were excluded for not meeting the inclusion criteria defined for the current study (Table 1). Studies were excluded at the screening stage because they did not belong to the medical domains targeted in the research and because of insufficient data and information to analyse or evaluate the results (n=9). Other studies were excluded from the full-text

screening because they did not specify the study sample. Thus, the articles were inconclusive ($n=2$). (Figure 1. —Flow chart of the study selection process according to PRISMA guidelines).

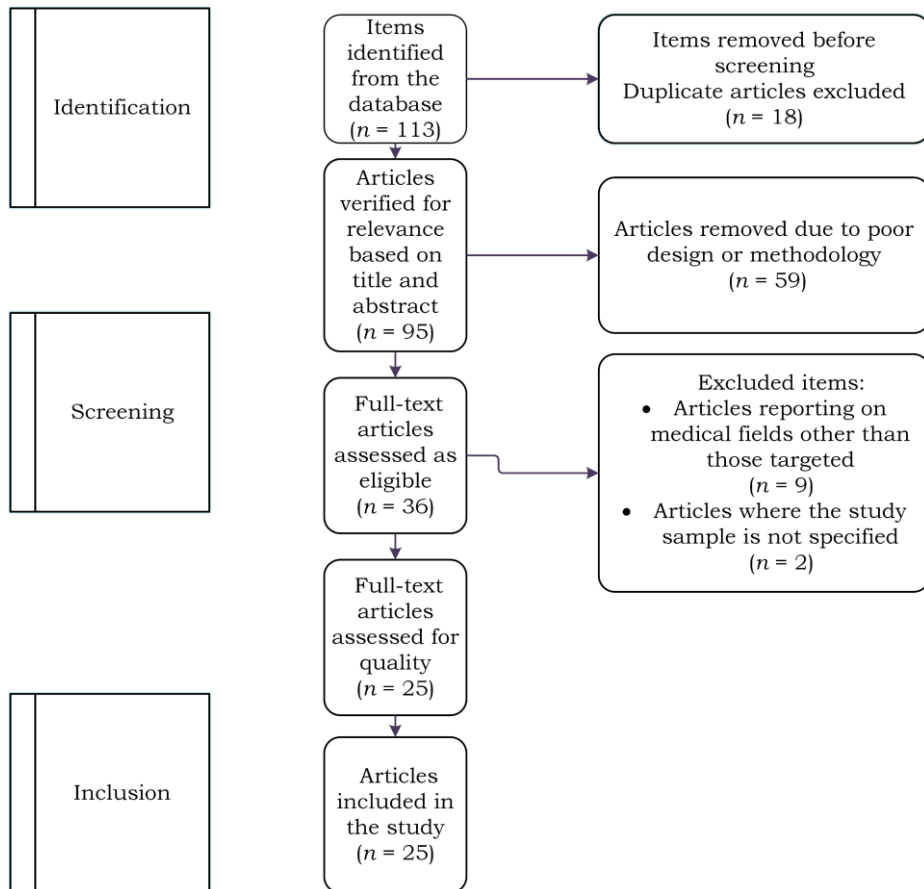


Fig. 1. Flow chart of the study selection process according to PRISMA guidelines –
Source: Author's own conception

Table 2. Study details

Ref.	Purpose	Equipment used	Pathology	Results
Sujat et al., 2019	Developing a brain-computer interface.	Neuralink is a bridge that makes the connection between the brain and technology. Equipment used in the field of neurology.	Alzheimer's, Stroke, Dementia.	According to data from this study, Neuralink can help us understand our brains better interacting with our neurons. The collected data can be used to discover new opportunities for various diseases such as Parkinson's, Alzheimer's and dementia.
Krish et al., 2019	Determining the effectiveness of a brain-computer interface.	Neuralink is a bridge that makes the connection between the brain and technology. Equipment used in the field of neurology.	Alzheimer's, Stroke, Dementia.	Following the study, the results are positive, with the Neuralink device successfully communicating between the brain and an external device.
Fiani et al., 2021	Determining the effectiveness of a brain-computer interface.	Neuralink is a bridge that makes the connection between the brain and technology. Equipment used in the field of neurology.	Alzheimer's, Stroke, Dementia.	The requirement for neurosurgical robots to implant the magnitude of device electrodes raises safety concerns.
Koski et al., 2021	Determining the effectiveness of using exoskeleton technology after total hip arthroplasty.	Honda Walking Assist (HWA) is an exoskeleton device in the ambulatory branch.	Total hip arthroplasty.	The interventions were successfully performed in all patients without adverse events after the study.
Giggins et al., 2013	Determining the results of using wearable technologies.	• Electroencephalography type equipment. • Cardiac coherence biofeedback device. • Thermal biofeedback type equipment. These devices are used in vast fields.	Disorders of many kinds.	According to research, the results of using biofeedback technology are promising, but more systematic reviews and other controlled studies are still needed.
Alhasan et al.,	A systematic review of studies examines whether biofeedback	Nintendo Wii technology is used in geriatrics significantly to restore balance and	Balance disorders.	Following the research, it was concluded that the equipment used does not make much

Ref.	Purpose	Equipment used	Pathology	Results
2017	technology is effective.	other motor functions.		difference compared to the traditional exercises used to improve balance.
Tan don & de Ferranti, 2019	Determining the effectiveness of wearable sensor devices.	Smartwatches used in cardiology that measure physiological parameters.	- Heart failure - Ventricular failure.	Following research, this technology offers a beneficial opportunity for both the patient and the medical environment.
Sashi, 2013	Determining the effectiveness of robotics on paediatric patients.	• FRIEND-1 • FRIEND-2 These technologies, more precisely the two robots, are used in the pediatric field and are substitutes for certain mechanical functions.	Cerebral palsy.	According to the studies, FRIEND-1 and FRIEND-2 significantly improved patients' quality of life from cerebral palsy.
Mapuya, 2012	A systematic review on rehabilitation of cardiac patients.	• Electrocardiograph • Devices for blood pressure monitoring • Ergometric equipment These technologies are applied in cardiology to record specific parameters.	Cardiovascular disorders of any kind.	The research concluded that although the cardiology branch is a significant medical branch, there is not enough promotion of cardiac recovery and prophylaxis programs at the global level.
Medina Quere et al., 2017	They are determining the outcomes of using intelligent bracelets and smartwatches in cardiac patients.	Heart rate measuring smartwatches. Smart bracelets that measure different cardiovascular parameters. These technological equipment are used in the field of cardiology.	Cardiovascular diseases such as heart arrhythmias and heart failure.	The results have a positive impact on cardiac rehabilitation programs.
Prieto-Avalos et al.,	Review of commercial and non-commercial wearable devices that monitor biomedical	Fit Bit is a wearable wireless technology Oximeter that precisely measures oxygen saturation smart watch ECG	Cardiovascular diseases.	The research found that 13% of the affected devices were FDA approved, 3% were partially approved, the FDA cleared 42%, 23%

Ref.	Purpose	Equipment used	Pathology	Results
2022	variables.	meter.		were not approved, and 19% had an unknown FDA status.
Bayoum et al., 2021	Highlighting sensor basics and sensor errors. Examining the role of wearable devices.	Smartwatch. The smart bracelet. Heart rate monitor Smart ring.	Hyperkalemia.	The results of using portable devices in the recovery of cardiac patients are positive, but if the patient does not have a balanced lifestyle, they will not help to improve the physiological parameters.
Konstantinidis et al., 2022	A systematic review of different portable blood pressure measurement technologies.	Omron HEM-6410T is a digital blood pressure monitor. smartwatch Smart mobile apps. These technological types of equipment are used in the field of cardiology.	Heart failure.	All the available evidence suggests that digital blood pressure management and blood pressure monitoring via wearable devices have good outcomes in terms of patient recovery.
Chung et al., 2020	Description and presentation of the only artificial heart approved by The Food and Drug Administration.	The Total Artificial Heart (TAH) is a technology used in the field of cardiology and replaces damaged ventricles and valves.	Cardiac hypotension.	Despite the indications and contraindications of this device, the Total Artificial Heart is a success for mechanical circulatory support.
Beatty et al., 2013	A systematic review of a study showing the beneficial effects of using mobile technology in the cardiovascular field.	Mobile applications, such as eHealth, are used to promote cardiac rehabilitation.	Cardiac hypertension.	The research on mobile technology is suggestive and shows that it improves the quality of life of patients as well as the amelioration of heart disease.
Antoniou et al., 2022	Evaluating the effectiveness of wearable sensor-assisted cardiac rehabilitation and health profiling.	Portable wireless devices that have sensors such as accelerometers and electrocardiograms. These devices are used in the field of modern cardiology.	Heart failure. Angina pectoris. Coronary revascularisation.	Sistemele de asistență cu inteligență artificială (AI) au fost utilizate pentru extragerea și încărcarea datelor monitorizate. Aceste date relevă că studiul a fost un succes, tehnologiile folosite îmbunătățind domeniul cardiologiei.

Ref.	Purpose	Equipment used	Pathology	Results
Ros e et al., 201 8	Understanding the relationship between enjoyment and potential patient adherence to virtual reality rehabilitation routines.	Haptic devices like gloves with sensors and intelligent controllers. They are used in the correction of musculoskeletal deficiencies.	Ischaemic heart disease Parkinson's disease Guillain-Barré syndrome . Cerebral palsy Arthritis.	Limited data did not allow a firm conclusion between enjoyment and adherence, but patient enjoyment and willingness to participate were reported in care plans.
Gar cía- Bra vo et al., 202 0	Determining the effects of a V.R. program and video games as complementary tools for a conventional rehabilitation program for patients with phase II ischemic heart disease.	Microsoft XBOX® console Kinect 2®, a motion-sensing input device. These devices have been used in the field of cardiology.	Ischaemic heart disease.	There were no statistically significant differences compared to the traditional intervention so that they could become alternatives to usual programs in patients with ischemic heart disease at low risk.
Tor regr ossa et al., 201 4	Exploring the potential benefits of implants in rehabilitation.	SynCardia.	Heart disease.	Significant improvements were seen in the control group.
Kim et al., 202 0	Highlight the materials used for bone graft substitutes to treat fractures and defects.	Innovative implants are composed of different materials such as metal, polymer, ceramic or intelligent materials. This technology is used in conditions that belong to the field of orthopaedics.	Fractures of any kind.	According to this research, there is still no ideal biomaterial for fracture fixation or bone defect repair.
Led et et al., 201 8	Evaluation of new sensor technology that minimises changes to existing implants	Microelectromechanical systems. These represent the technology of microscopic devices.	Spinal fusion surgery.	The use of intelligent implants in daily clinical practice has been prohibitive, but new sensor technology that

Ref.	Purpose	Equipment used	Pathology	Results
		In the current study, this technology was used in the field of orthopaedics.		minimises changes to existing implants is critical to rehabilitation through this technology.
Gu maa et al., 201 9	A systematic review and critical appraisal of controlled clinical trials have investigated V.R.'s effectiveness in orthopaedic rehabilitation.	Custom Hardware and Software Devices (VirtualEx-FM) used in orthopaedic medicine.	Fibromyalgia Back pain Knee arthroplasty Other orthopaedic conditions of the upper and lower limbs and spine.	The study found that V.R. and exercise had similar effects on rheumatoid arthritis, knee arthritis, ankle instability and post-anterior cruciate reconstruction. For fibromyalgia and back pain, as well as after knee arthroplasty, the evidence for the effectiveness of V.R. compared to exercise is absent or inconclusive.
Gia nola et al., 202 0	Evaluating the effectiveness of early VR-based rehabilitation versus traditional rehabilitation after total knee arthropathy.	Virtual Reality Rehabilitation System (VRRS) - Amelia® is a device used exclusively for rehabilitation.	Osteoarthritis.	VR-based rehabilitation is not superior to traditional rehabilitation in pain relief, medication assumptions, and other functional outcomes but appears to improve overall properties for total hip arthroplasty patients.
Alc ocer et al., 201 2	Impact of industrial robotics on ankle recovery and ankle injury highlighting.	The JACE Ankle A330 is a device used for orthopaedic rehabilitation, focusing on restoring range of motion and improving ankle muscle flexibility. The Biodex multi-joint system has similar functions to the device shown above, and in addition, it can store patient data and progress.	Ankle fractures. Turning Pseudarthrosis. Osteoporosis.	Currently, several devices on the market help rehabilitate the ankle. The devices reviewed in the current study are listed among these, but it is of great interest for some research centres worldwide to propose and develop automated ankle rehabilitation systems.
Kho se et	This paper covers the fundamental	Sistem exoschelet	Orthopaedic	After a thorough analysis, the results say

Ref.	Purpose	Equipment used	Pathology	Results
al., 202 2	concepts of the various prototypes designed and developed over the years.	funcționabil pe bază pneumatică.	diseases of the upper limbs.	that exoskeletons based on the pneumatic system can reduce costs, weight and the ease with which patients use them.

Source: Author's own conception

Discussions

This paper aimed to systematically analyse the impact of the emergence of modern technologies in medical rehabilitation in the five areas of focus: neurology, geriatrics, paediatrics, cardiology and orthopaedics. The aim was to analyse modern technology's clinical and evolutionary aspects in medical rehabilitation and its benefits. Following the stages of a systematic review according to the protocol, numerous data were collected on different technologies applied to various diseases and pathologies. These data include information on the purpose of the studies, their objectives and the results of each study. Evidence-based medical literature provides and enables reviewers and readers access to a wide range of new approaches and current information in modern medicine.

To this end, relevant clinical trials published in the last 11 years with a complex methodology investigating various devices and technologies used in medical rehabilitation have been included. In the screening stage of this systematic review, initial scanning and evaluation of numerous literature sources was carried out to ensure objectivity and consistency in evaluating various devices.

Initially, selection criteria were defined. In the process of selecting the studies of interest, the medical field in which the technologies are rooted, the year of appearance, the typology of the technology, excluding all devices that are not used in rehabilitation, the pathologies in which they are used, the appropriate sample and the study design were taken into account, including only research containing relevant and attested information. In other words, articles were targeted that are part of the field of neurology, geriatrics, paediatrics, cardiology, and orthopaedics, not older than eleven years, that include technologies belonging exclusively to medical rehabilitation. Duplicates were eliminated by manually comparing titles, authors and other details of similar articles without special reference management software. For the remaining studies after the initial screening stage, the texts were read in full to check that they met the above conditions through a more detailed

analysis of the results, methodology and conclusions of the research considered.

The first area targeted in this systematic review was the field of neurology. The aim was to ensure that the technologies used were as new and up-to-date as possible. That is why Neuralink was the target technology, a revolution in modern technology.

This device is a high-tech neural interface that allows the direct connection of the human brain with computers and digital devices. The study explored different aspects of Neuralink talk, giving an overview of its effects on how people communicate. Three different studies were analysed in this regard from different research sources. The selection criteria included the direct relevance of the information to the impact of Neuralink on the human body. According to research results, they can communicate and interact with digital devices directly from their brains. Because more clinical tests will be required in the not-too-distant future, one can only conjecture about the safety and usefulness of the gadget at this point. However, this might result in quicker, more efficient, and more intuitive communication.

The field that was researched next was the field of geriatrics.

Here we searched for studies in the broader variety of devices and pathologies. The Honda Walking Assist (HWA) exoskeleton was first reviewed. The study aimed to determine its effectiveness in patients undergoing hip replacement surgery. The findings were encouraging and encouragingly hopeful, with no adverse effects occurring in any participants who participated in the study. Another technology reviewed was the Nintendo Wii. Patients who suffer from balance difficulties are given this to try to help them. The main objective of this clinical research was to compare rehabilitation with this technology and rehabilitation done traditionally, but the results and extracted data tell us that there is no significant difference between these two rehabilitation methods.

The third researched field was paediatrics. The first technology targeted was robotics technology. In the systematic review of Friend-1 and Friend-2 robotic technology, critical aspects of this robotic system and its impact on paediatric rehabilitation were analysed. This advanced system was developed to help children with medical conditions or physical impairments recover and develop motor and cognitive skills. After the study was completed, it was found that these devices have many functions, such as personalised therapy, progress monitoring, improvement of motor and cognitive functions, and even emotional support. The purpose of the study was to determine the usability and efficiency of the robots, which, according

to the results, proved a success because this robotics technology significantly improves the quality of life of children and facilitates the recovery process.

Nevertheless, maintaining human interaction in the therapy process with children must also be considered. Wearable sensor technology has also been researched in this area. The study aimed to determine its performance in paediatric heart or ventricular failure patients. According to the results, the technology benefits patients and medical professionals.

Cardiology is an essential medical branch, which is why numerous clinical studies have been thoroughly researched. The technologies reviewed were mainly: wearable sensor technology, echocardiography technology, ergometry technology, artificial implant technology, blood pressure equipment and others. Numerous studies have been reviewed to determine the outcomes of wearable therapy. The main objective of these systematic reviews was to improve the cardiology field with their help. After studying several types of research on this topic in detail, a summary of the obtained results was gathered, the conclusion being that monitoring certain vital functions through these devices improves the rehabilitation of cardiac patients, provided that they have a balanced lifestyle.

Another targeted technology was the Total Artificial Heart, which replaces certain heart functions. The Food and Drug Administration (FDA) has blessed this artificial heart as the only kind. Patients suffering from biventricular heart failure were targeted in the reviewed study.

The study was completed, and according to the results, it was a total success in modern cardiology, even if this device has specific indications and contraindications.

While examining the devices and technologies used in the recovery of cardiac patients, digital technology was also explored.

Its main objective is to promote and make accessing reliable medical information easier for the patient. That is why the eHealth mobile app has also been revised. According to the discussions, conclusions and results, digital applications of this type improve the medical conditions of patients suffering from various heart conditions and their quality of life. Moreover, virtual reality is also used as a therapy method. Several clinical studies have been verified and examined in which the degree of impact of virtual reality in patients suffering from ischemic heart diseases has been followed. The devices used were a Microsoft XBOX console and the Kinect 2 device. The research objective was to establish the differences between virtual reality therapy and medical therapy done classically. The goal was to make rehabilitation more enjoyable and valuable for patients. However, from a summary point of view, after studying the relationship between this type of

therapy and the classical one, we can conclude that there is no significant improvement in the results, but patients perform the therapy with greater pleasure in this way.

The last field reviewed was that of orthopaedics. Modern technologies have had and are currently having a significant impact on orthopaedic rehabilitation, helping to improve the efficiency, comfort and results of treatment. Six studies were researched because a diversity of technologies was desired. In orthopaedics, innovative implant technology, exoskeleton mechanism technology, and virtual reality technology have been reviewed. Following the review of exoskeleton mechanism technologies, we can conclude that they have an extraordinary impact, contributing to the restoration or replacement of various mechanical functions. Virtual reality technology, as in the other fields, does not make a difference according to all the results, but it improves the form of rehabilitation and motivates the patients. The main objective of intelligent implant studies was to determine whether or not innovative implants improve the field of orthopaedics. According to the results, they correct and improve the rehabilitation of orthopaedic patients, but clinical trials say that new sensor technology that minimizes changes to existing implants is the future. The results of each study were analysed in detail to be able to conclude the impact of modern technologies on medical recovery. In the field of neurology, the summary of the results is a positive one, and in the future, with the help of the evolution of the technological process, it is desired to improve brain implants and neuromodulatory therapies. The geriatrics side tells us that the results are promising, but more studies are needed in this regard to be able to establish a clear conclusion. Cardiology and everything related to it has been significantly improved by technology, and much more technology is desired because, unfortunately, cardiovascular diseases have been the leading cause of death globally in recent decades.

The results of all the studies were concrete and cheerful, the technology making its mark on cardiac rehabilitation. The systematic review of the field of orthopaedics was rich in studies and articles in which robotic technology was present. Robotics significantly impacts orthopaedic rehabilitation, benefiting health professionals and the rehabilitation profile. The part of robotics that was targeted in the articles was the exoskeleton system.

After collecting data and results, we found that these systems improved and amplified the users' strength and power, helped restore mechanical and muscle function, and provided increased accessibility for patients. The results and benefits of technology in this branch have been visible, and in the future, it is hoped for total automation of therapies. The field of paediatrics has not shown as much interest in the technology as the

others. After reviewing the technologies used and outcomes in paediatric patients, it was found that robotics improved and provided support in physical and occupational therapy, improving children's mobility, muscle strength and coordination. It has also been used in psychological therapy to help children develop social and emotional skills.

Scientific data and accumulated results have been extracted exclusively from eligible sources. Technologies have greatly influenced the medical fields that have been considered, but in the future, technological advances will continue to improve the rehabilitation process and provide new solutions for patients and healthcare professionals. The concept of technology and hardware used to simulate virtual reality has had questionable results. Several studies have shown that it is not as beneficial as expected, the results being almost unchanged.

Conclusions

1. Following the performance of this systematic review on medical fields, in the care of interest was the technology used, it was possible to conclude, it provides scientific information, that technologies have an enormous potential to work in the recovery process and to achieve the quality of life of patients. Digital and innovative technologies are having a significant impact in the field of rehabilitation, providing more effective and personalised treatment and recovery opportunities for patients. Robotic assistive devices can help patients regain mobility and strength after injury. Research shows that monitoring devices such as wearable sensors and motion analysis technology allow therapists to obtain accurate data on patients' progress and adjust treatment accordingly. Providing rehabilitation services through remote communication technology has gained popularity in recent years. Because of this, patients can receive assistance and treatment from specialists even when they are not physically present in the doctor's office.

2. Integrating technologies into rehabilitation involves challenges like high costs and limited accessibility. Collaboration between researchers, medical professionals and the technology industry is needed to develop more effective and affordable solutions. Nevertheless, these are all small hurdles compared to technology's patient benefits. That is why it is necessary to continue the research and further development of these technologies in the future to maximise the benefits and overcome the current challenges.

Conflict of interests

Nothing to declare.

References

- Alcocer, W., Vela, L., Blanco, A., Gonzalez, J., & Oliver, M. (2012). Major trends in the development of ankle rehabilitation devices. *Dyna*, 79(176), 45-55.
- Alhasan, H., Hood, V., & Mainwaring, F. (2017). The effect of visual biofeedback on balance in elderly population: a systematic review. *Clinical interventions in aging*, 12, 487–497. <https://doi.org/10.2147/CIA.S127023>
- Antoniou, V., Davos, C.H., Kapreli, E., Batalik, L., Panagiotakos, D.B., & Pepera, G. (2022). Effectiveness of home-based cardiac rehabilitation, using wearable sensors, as a multicomponent, cutting-edge intervention: A systematic review and meta-analysis. *Journal of clinical medicine*, 11(13), 3772. <https://doi.org/10.3390/jcm11133772>
- Bayoumy, K., Gaber, M., Elshafeey, A. et al. (2021). Smart wearable devices in cardiovascular care: where we are and how to move forward. *Nat Rev Cardiol*, 18, 581–599. <https://doi.org/10.1038/s41569-021-00522-7>
- Beatty, A.L., Fukuoka, Y., & Whooley, M.A. (2013). Using mobile technology for cardiac rehabilitation: a review and framework for development and evaluation. *Journal of the American Heart Association*, 2(6), e000568. <https://doi.org/10.1161/JAHA.113.000568>
- Blanchard, Y., & Øberg, G.K. (2015). Physical therapy with newborns and infants: applying concepts of phenomenology and synactive theory to guide interventions. *Physiotherapy theory and practice*, 31(6), 377–381. <https://doi.org/10.3109/09593985.2015.1010243>
- Bonafide, C.P., Localio, A.R., Ferro, D.F., Orenstein, E.W., Jamison, D.T., Lavanchy, C., & Foglia, E.E. (2018). Accuracy of pulse oximetry-based home baby monitors. *JAMA*, 320(7), 717–719. <https://doi.org/10.1001/jama.2018.9018>
- Chung, J.S., Emerson, D., Megna, D., & Arabia, F.A. (2020). Total artificial heart: surgical technique in the patient with normal cardiac anatomy. *Annals of cardiothoracic surgery*, 9(2), 81–88. <https://doi.org/10.21037/acs.2020.02.09>
- De Groot, A.J., Wattel, E.M., van Dam, C.S., van Balen, R., van der Wouden, J. C., & Hertogh, C.M.P.M. (2022). Referral to geriatric rehabilitation: a scoping review of triage factors in acutely hospitalised older patients. *Age and ageing*, 51(2), (2022). <https://doi.org/10.1093/ageing/afac015>
- Fiani, B., Reardon, T., Ayres, B., Cline, D., & Sitto, S.R. (2021). An examination of prospective uses and future directions of Neuralink: The brain-machine interface. *Cureus*, 13(3), e14192. <https://doi.org/10.7759/cureus.14192>
- García-Bravo, S., Cano-de-la-Cuerda, R., Domínguez-Paniagua, J., Campuzano-Ruiz, R., Barreñada-Copete, E., López-Navas, M.J., Araujo-Narváez, A., García-Bravo, C., Florez-García, M., Botas-Rodríguez, J., & Cuesta-Gómez, A. (2020). Effects of virtual reality on cardiac rehabilitation

- programs for ischemic heart disease: A randomised pilot clinical trial. *International journal of environmental research and public health*, 17(22), 8472. <https://doi.org/10.3390/ijerph17228472>
- Gianola, S., Stucovitz, E., Castellini, G., Mascali, M., Vanni, F., Tramacere, I., Banfi, G., & Tornese, D. (2020). Effects of early virtual reality-based rehabilitation in patients with total knee arthroplasty: *A randomised controlled trial. Medicine*, 99(7), e19136. <https://doi.org/10.1097/MD.00000000000019136>
- Giggins, O.M., Persson, U.M., & Caulfield, B. (2013). Biofeedback in rehabilitation. *Journal of neuroengineering and rehabilitation*, 10, 60. <https://doi.org/10.1186/1743-0003-10-60>
- Gumaa, M., & Rehan Youssef, A. (2019). Is virtual reality effective in orthopedic rehabilitation? A systematic review and meta-analysis. *Physical therapy*, 99(10), 1304–1325. <https://doi.org/10.1093/ptj/pzz093>
- Hong, J.S., Wasden, C., & Han, D.H. (2021). Introduction of digital therapeutics. *Computer methods and programs in biomedicine*, 209, 106319. <https://doi.org/10.1016/j.cmpb.2021.106319>
- Jain, N.B., Schneider, B.J., Kuhn, J.E., Murrell, W.D., Stark, S., & Archer, K.R. (2017). What's new in orthopaedic rehabilitation. *The Journal of bone and joint surgery. American volume*, 99(22), 1956–1963. <https://doi.org/10.2106/JBJS.17.00905>
- Khose, A.S. (2022). Pneumatic exoskeletons for orthopedic rehabilitation of the upper arm—An overview. *Journal of Orthopaedics, Trauma and Rehabilitation*, 29(1). doi:10.1177/22104917211056947
- Kim, T., See, C. W., Li, X., & Zhu, D. (2020). Orthopedic implants and devices for bone fractures and defects: Past, present and perspective. *Engineered Regeneration*, 1, 6-18.
- Konstantinidis, D., Iliakis, P., Tatakis, F., Thomopoulos, K., Dimitriadis, K., Tousoulis, D., & Tsioufis, K. (2022). Wearable blood pressure measurement devices and new approaches in hypertension management: the digital era. *Journal of human hypertension*, 36(11), 945–951. <https://doi.org/10.1038/s41371-022-00675-z>
- Koseki, K., Mutsuzaki, H., Yoshikawa, K., Iwai, K., Hashizume, Y., Nakazawa, R., & Kohno, Y. (2021). Early recovery of walking ability in patients after total knee arthroplasty using a hip-wearable exoskeleton robot: A case-controlled clinical trial. *Geriatric orthopaedic surgery & rehabilitation*, 12, 21514593211027675. <https://doi.org/10.1177/21514593211027675>
- Kraemer, W., Denegar, C., & Flanagan, S. (2009). Recovery from injury in sport: considerations in the transition from medical care to performance care. *Sports health*, 1(5), 392–395. <https://doi.org/10.1177/1941738109343156>

- Krish N., Krishnachalitha K.C. (2019). A literature survey on brain computer interface. *International Journal of Advance and Innovative Research*, 6, 42-50.
- Ledet, E.H., Liddle, B., Kradinova, K., & Harper, S. (2018). Smart implants in orthopedic surgery, improving patient outcomes: a review. *Innovation and entrepreneurship in health*, 5, 41–51. <https://doi.org/10.2147/IEH.S133518>
- Mampuya W.M. (2012). Cardiac rehabilitation past, present and future: an overview. *Cardiovascular diagnosis and therapy*, 2(1), 38–49. <https://doi.org/10.3978/j.issn.2223-3652.2012.01.02>
- Medina Quero, J., Fernández Olmo, M.R., Peláez Aguilera, M.D., & Espinilla Estévez, M. (2017). Real-time monitoring in home-based cardiac rehabilitation using wrist-worn heart rate devices. *Sensors (Basel, Switzerland)*, 17(12), 2892. <https://doi.org/10.3390/s17122892>
- Michael, P.B., David, C.G., (2012). Neurological Rehabilitation, 1st Edition. Imprint: *Elsevier*, 84-97. Hardback ISBN: 9780444529015, eBook ISBN: 9780444595843.
- Morrison, B.M. (2016). Neuromuscular Diseases. *Seminars in neurology*, 36(5), 409–418. <https://doi.org/10.1055/s-0036-1586263>
- Prieto-Avalos, G., Cruz-Ramos, N.A., Alor-Hernández, G., Sánchez-Cervantes, J.L., Rodríguez-Mazahua, L., & Guarneros-Nolasco, L.R. (2022). Wearable devices for physical monitoring of heart: A review. *Biosensors*, 12(5), 292. <https://doi.org/10.3390/bios12050292>
- Rose, T., Nam, C.S., & Chen, K.B. (2018). Immersion of virtual reality for rehabilitation - Review. *Applied ergonomics*, 69, 153–161. <https://doi.org/10.1016/j.apergo.2018.01.009>
- Sashi S.K. (2013). Rehabilitation robotics. *Intechopen*, 132-140.
- Suja A., Kuraman U., Santhana M.A. (2021). Novel applications of Neuralink in healthcare, *International Journal of speech*, 1-5.
- Tandon, A., & de Ferranti, S.D. (2019). Wearable biosensors in pediatric cardiovascular disease. *Circulation*, 140(5), 350–352. <https://doi.org/10.1161/CIRCULATIONAHA.119.038483>
- The world health organisation, 2001: https://apps.who.int/gb/ebwha/pdf_files/EB110/eeb11011.pdf. Accessed on 06.05.2023
- Torregrossa, G., Anyanwu, A., Zucchetta, F., & Gerosa, G. (2014). SynCardia: the total artificial heart. *Annals of cardiothoracic surgery*, 3(6), 612–620. <https://doi.org/10.3978/j.issn.2225-319X.2014.11.07>