MedCrave
Step into the World of Research
International Physical Medicine & Rehabilitation Journal

Research Article
Open Access
CrossMark

Artificial intelligence and rehabilitation: what's new and promising

Abstract

The development of artificially intelligent technological machine systems that can integrate large volumes of data, and also 'learn' to recognize notable patterns, are currently being widely discussed and employed in various health and other realms. In this regard, what promise do these systems hold for ameliorating the late life chronic disease burden of increasing numbers of adults globally that may stem from one or multiple chronic longstanding health conditions. To explore this issue, a broad exploration of rehabilitation associated artificial intelligence implications was conducted using leading data bases. Results show that there are some active advances in both artificial intelligence and machine learning realms, but not in the context of desirable robust observations in all cases. Much future work is indicated though and is strongly recommended.

Keywords: artificial intelligence, diagnosis, disease prediction, machine learning, rehabilitation

Volume 8 Issue 2 - 2023

Ray Marks
Department of Health and Behavior Studies, Teachers College, Columbia University, New York, NY 10027, USA

Correspondence: Ray Marks, Department of Health and Behavior Studies, Teachers College, Columbia University, New York, NY 10027, USA, Tel +1-212-678-3445, Fax +1-212-678-8259, Email rm22@columbia.edu

Received: June 15, 2023 | **Published:** June 29, 2023

Introduction

Artificial intelligence [AI], a rapidly developing field and branch of computer science with a variety of applications designed to improve health and wellbeing including diabetes, neurological, and cardiovascular diseases has the potential to modify, reform or supplement current approaches to diagnosing and managing these plus multiple other chronic health conditions such as stroke[1–4] and cancer.[5] Current data reveal multiple chronic health conditions and their prognoses and diagnoses may indeed be especially enhanced by a variety of AI approaches as well as associated machine learning [MI] applications.[6]

In addition, many novel assessment techniques that may still be in the experimental phase, such as the prospective application of AI with optical correlation tomography in stroke rehabilitation[3] are being developed for AI-based applications that are expected to significantly enhance stroke diagnostics and their predictive outcomes. Another AI-based application method known as Virtual Reality is being used and explored for purposes of improving rehabilitation treatments in both the cognitive and motor domains. In this review, we set out to explore what if anything is being proposed for the use of AI in a wide variety of rehabilitation contexts that may affect older adults, regardless of health status, and if it appears there is more reason than not to advance AI research rather than explore this 'theory' from a purely entertainment perspective.[7] In particular, we describe some of the diverse realms wherein research is being pursued and applied to clinical practices in the realm of rehabilitation.

The topic appears especially relevant today due to the great need to advance wellbeing in all parts of the globe, and in light of shrinking economies and health personnel to deal with aging populations and their susceptibility to one or more chronic health challenges. Indeed, the ability of AI to advance through the application of ML is believed to have the potential to not only help to support generalizable predictive models for determining the risk of developing multiple chronic health conditions, but can possibly speed up early disease detection or treatable impairments, while assisting in personalizing the health assessment. In addition, digital therapeutics may be helpful for supplementing lifestyle therapies that can be applied in a variety of different chronic illness states and that can be drawn on efficiently to mitigate various key health problems and do this efficiently. For example, one report implies diabetes patients who are increasingly being empowered to be self-managers, rather than passive managers or bystanders, can benefit from the ability of AI to advocate and direct patients towards needed and useful resources as well as from its ability to render appropriate clinical decision support. Moreover, AI allows for a continuous and burden-free remote monitoring of a diabetic patient's symptoms and can track selected biomarkers that can be helpful and would be challenging to detect otherwise in a timely manner. Further, social media and online communities can be harnessed to foster patient self-care engagement.

Together, these intelligent technical systems do appear to promote better blood glucose control with reductions in fasting glucose levels, and hemoglobin concentration. Thus, building targeted data-driven precision care action plans to mitigate or manage some forms of diabetes and its multiple adverse health impacts appears to have a strong basis and is thus worthy of future development.[1,7]Additionally, AI approaches and the inferences that they can generate and articulate based on a large amount of data, can be extended to include many health care realms, and duly supplemented and expanded upon by ML and deep learning approaches that have made significant progress to date as a result of dramatically improved computer performances. In time, they may be more efficient and efficacious for advancing rehabilitation in complex realms, such as those where no concordance about rehabilitation has emerged to date.[8] Used as a means of laser directed treatments for arthritis, significant benefits have been realized by elderly rheumatoid arthritis cases.[9] In this review, a wide ranging search was undertaken to examine AI/ML-based usage or its potential in rehabilitation spheres, rather than diagnostic, measurement, disease classification, or predictive spheres based upon patient and generic data. Its use in surgical or drug based interventions was not examined. The aim was to identify areas where AI and ML may help to advance one or more rehabilitation strategies that are commonly sought for advancing the wellbeing of older adults, either independently or in conjunction with therapists. Diseases and conditions reviewed were those that predominate in the older age groups and are disabling and immensely costly, such as diabetes.

Methodology

Using the electronic data sources **PUBMED, PubMed Central**, and **Google Scholar** articles published in the past five years [January 1, 2019-June 15 2023] using the key words, *Artificial Intelligence [AI], Machine learning [MIL], and Rehabilitation* was undertaken. All forms of reports were deemed acceptable. However, because this is an emerging topic, with few actual applications and well designed prospective analyses, only a narrative summary was deemed possible. Excluded were articles that did not focus specifically on conditions that an allied health professional in physical medicine might encounter, such as AI and COVID-19. The use of AI for stroke was not detailed as it is too voluminous, but this and other AI facts can be gleaned from Zelenak et al.,[10] and Sesinaro et al.,[11] Information pertaining to AI and the rehabilitation of youth or young adults or pediatric populations, which was not currently examined, may be gleaned via the paper written by Kaelin et al.,[12]

Results

Although only selected data bases were used, the current search engines chosen were those most likely to house peer reviewed topical papers, and while not all inclusive, clearly showed the emergence of many citations [e.g., **PUBMED** lists 202, 193 citations as of June 14, 2023], These are currently highly varied not only in the realm of discussing some form of health associated AI application or implication, but very few detail evidence based concrete facts or generalizable conclusions. Variations in topical themes are also highly evident, especially as regards chronic health issues affecting older adults, and even in the case of publications on similar topics, for example cardiovascular disease, most do not detail its management or any related AI rehabilitation application, to any degree with the exception of stroke care. Among the 13, 964 healthcare related **PUBMED** listings, only 2086 focus on older adults, but possibly excluding those in the higher age ranges due to age cutoffs in most clinical studies, and no uniform body of criterion based and clearly delineated literature currently prevails, especially as this pertains to rehabilitation of any condition other than stroke.

Many publications too, for example those listed as being relevant to arthritis care tend to focus on various diagnostic benefits, describe how AI assessments and therapeutic inferences can be more readily and accurately derived than current mainstream methods, or how AI can inform therapeutic decisions, but little on actual rehabilitation options for any affected joint. Although multiple methodological issues, as well as ethical issues are frequently discussed, most publications focus on the future and concur that this will be advantaged significantly by AI in various spheres,[13–16] but this remains to be shown in varying contexts, disease subgroups, and in cases where disease manifestations ebb and flow, and where human judgment is often desirable even in stable cases. Secondly, even if such a system could be upgraded in real time and designed to assess the patient's condition through remote monitoring on an ongoing basis, while providing for a personalized rehabilitation training and evaluation plan, can current health services be harnessed to continuously update the AI robot approach if needed?. Moreover, while this system may be more convenient and helpful in optimizing the allocation of diminishing medical forms of self-care including exercise, and resource accessibility, it may inadvertently have the opposite impact on many older impaired adults who are needing secondary or tertiary health care support in other realms or instances where their health condition is not stable.

In addition, while the use of technology in the form of games is cited to have the advantage of increasing a patient's interest in exercise training, and program adherence,[16] thus hastening recovery in the face of an injury, will this approach work as well within the rehabilitation needs of many older adults as it does for younger adults or adolescents? Even if 'games' or other similar remotely delivered directives are beneficial because they encompass the ability to provide for timely results feedback, and may be deemed recreational or entertaining, rather than therapeutic, can those who are recovering from a stroke, surgery, trauma, or are in pain, or have visual impairments and others ably make adjustments to their training plan if unsupported by a knowledgeable provider as proposed by Tang et al.,[17] At the same time, even if targeted training with monitoring could help to both detect as well as foster correct rather than unsafe actions, while helping to selectively strengthen those components of muscle that are especially weak, hence further reducing the probability of any repeated injury, is this practical in all cases, for example in the context of hip fracture recovery in the frail elder.

Another question is whether AI applications may be uniformly useful in the rehabilitation of traumatic brain injury, even if they employ well designed brain-computer interfaces, noninvasive brain stimulation, and wearable-assisted devices[18] without more careful research. Moreover, even if exoskeleton assisted walking devices assist spinal cord cases to advance functionally and improve lung capacity,[19] are these approaches practical in the long term or should these approaches be studied more widely before applying their selected features and integrated these with personalized data inputs that may yet be undetermined. The blanket usage of such approaches, while currently appealing, may also pose possible challenges in terms of patient specific risk factors such as bone fragility, non-personalized goal-setting plans, while potentially excluding the key recovery role of active movement, human therapists, family members, and alternate evidence based medical services. The role of privacy issues, data based on less than robust generalizable studies and factors such as reimbursement and confidentiality may also warrant considerable attention.

In the meantime, and in the mental health sphere, where there is a great need, AI has been conceived as having the potential to provide more fruitful diagnostic insights and therapeutic opportunities than has been the case to date. One idea proposed in this regard by Qiao et al.,[20] is to combine AI and the idea of emotional intelligence to foster nursing related mental and physical health care. Tested in the context of athletes the authors found AI interventions could be applied successfully to enhance or yield better treatment outcomes and quality of life than not. However, it has been pointed out that even here the ability of the interventionist who is experienced with AI may be prove to be a highly salient and influential factor.[21] Another application of AI for dementia that may impact health positively reveals robotic pets to have a beneficial impact on alleviating stress and anxiety in this group,[22] but this should be examined further, as the use of any robotic device for securing the comfort and support of an older or impaired adult may engender- rather than mitigate- stress.

In another physical sphere it does appear the ability to optimize implant alignment,[23] as well asrobotic rehabilitation training of lower limbs along with synchronizing acupuncture exercise therapy could enhance the hip joint activity function, life quality, and quadriceps muscle group function of elderly postoperative patients with hip fractures.[23] This might be extremely valuable given the generally very low certainty of evidence available for supported discharge and current multidisciplinary home rehabilitation approaches for hip fracture injuries[24] now found to be largely flawed and limited.[25] This needs to be tested more widely and whether this is practical in diverse settings and how the results do compare to traditional practices. In

Citation: Marks R. Artificial intelligence and rehabilitation: what's new and promising. *Int Phys Med Rehab J.* 2023;8(2):135–140.
DOI: 10.15406/ipmrj.2023.08.00348

the meantime, a role for an app. known as Dr. Bart which could be helpful here and appears promising for purposes of alleviating hip or knee osteoarthritis pain, symptoms, and day to day function,[26] should likewise be examined further in light of literacy gaps, preference for active providers, possible hearing loss challenges, a lack of technical skill, language skills, and tech resources. In addition, while automated health behavior change interventions can be designed to facilitate translation and adaptation across multiple behaviors,[27] whether they can accommodate fluctuations in symptoms that are unpredictable remains to be demonstrated.

Another report describing the REHABOT technology approach implies this apparatus is able to facilitate orthopedic or neurologic rehabilitation by providing secure postural support and prescribed weight bearing during ambulation. The REHABOT has also been used for early mobilization and gait training of severely disabled patients at different hospitals in Japan during the last six years. In most of the cases, this training has resulted in earlier improvement of the patient's ambulatory capability. It also appeared helpful for fostering the recovery of those cases with multiple fractures involving the extremities and the spine. It is found to assist with the early mobilization of these cases by initially reducing the weight bearing load on the limbs to 30% of body weight followed by a gradual increase governed by patient tolerance. The average length of training for these two patients was 18 days. The average total distance was 5.5 km and total walking duration was 4.5 h. After the completion of the training the two patients studied were able to walk independently.[28] Whether the approach can be readily applied in other venues or dissimilar samples is currently unknown, however.

The application of virtual reality approaches has also been questioned as a device for fostering older adults' wellbeing,[29] despite their apparent potential due to the numbers of facts that may not yet be apparent in current systems, especially those related to frailty, instability, expectations and acceptability, visual and auditory challenges, and cultural and language attributes of the individual. A recent Cochrane Review further implies that the use of virtual reality and interactive video gaming is not more beneficial than conventional therapy approaches in improving upper limb function in stroke patients. It may however, be beneficial in improving upper limb function and activities of daily living function when used as an adjunct to usual care. Although future research may uncover different findings,[30] there is not yet enough evidence to support the application of virtual reality and video gaming interactions on gait speed, balance, participation, or life quality in neurological contexts, even though theoretically plausible.[31]

Nevertheless, as described by Miyazaki et al.,[32] it appears a weight-shifting-based robot control system can indeed be adapted to improve the weight-bearing rate and balance ability in the static standing position in postsurgical hip osteoarthritis patients, and may prove useful in other comparable situations. Robot-assisted rehabilitation may also offer additional benefits in other cases, such as its usage to achieve repetitive, intensive, and task-specific forms of manual manipulation often performed by physiotherapists.[33] In this regard a robot that employs four parallel intrinsically compliant pneumatic muscle actuators that mimic the actions of skeletal muscles appears useful for fostering advances in ankle motion training. It also includes a technical technique designed to increase the controller's robustness, and that has the ability to obtain an optimal weighting value to foster its learning capacity. Related experimental results further show this system to help achieve better performance indicators and opportunities for tracking performance during repetitive tasks that can be adapted to various robotic rehabilitation situations, including gait training for cases with Parkinson's disease.[34]

It is also suggested that we should take advantage of AI and leverage it not only for assistance in repetitive therapy based tasks, and develop disease specific data-driven decision support platforms for various chronic muscle based management purposes and that can be used for monitoring adverse events, disease status, treatment adherence and needs, and a wide variety of other associated diagnostic and clinical data[35,36] and that can attain proven efficacy as well as cost savings.[32] An analysis of those factors that led to the success of an AI assisted exercise program for pain sufferers might also prove revealing.[37]

Presently, and according to Calabro et al.,[38] the introduction of robotic rehabilitation in standard treatment protocols in the future of stroke rehabilitation seems very likely and promising. However, selected aspects of robot assisted gait training for stroke still need to be improved with new solutions and embedded in clinical practice guidelines, especially in terms of applicability. Another approach termed neuro cognitive robot-assisted therapy applied during inpatient stroke rehabilitation in the sub acute stage is also deemed to promote the early familiarization of subjects with stroke with the use of such technologies, as a first step towards minimal therapist supervision in the clinic, or directly at home after hospital discharge, to help increase the dose of hand therapy for persons with stroke.[39] In the interim, given the multiplicity of determinants that may underlie the development of one or more health conditions that require some form of rehabilitation intervention, and the considerable potential for over whelming patients and their care givers tools such as AI appear to hold considerable promise. This is because they may collectively have the potential for reducing or minimizing the risk of multiple functional limitations and severe disability, and pain, the health issues of most concern to many older chronically ill or injured patients. In addition, their usage may enhance practitioner practices, while reducing their burden as well as societal cost burdens in diverse ways. In stroke alone for example, applications such as robot assisted therapy and virtual reality may be shown to advance upper as well as lower limb function, speech, cognitions, sensory inputs, plus balance and gait that could prove highly valuable. Other topics to be considered are frailty, kidney disease, obesity, metabolic diseases, autoimmune diseases, and lung diseases, among other chronic health conditions.[40]

There is also a need to reduce the current imbalance between the potential uses of AI for diagnostic purposes and drug development, and in some cases surgery through robotics, with more extensive and concrete data that can be applied for both diagnostic as well as rehabilitation purposes among older adult populations with widely differing health and aging profiles. At present early or more accurate diagnoses alone, along with the application of personalized precision management recommendations, while presenting a wonderful advancement in consolidating information, and saving time costs and injury in repetitive or strenuous manual tasks, and others, may be highly challenging to unify and apply effectively given the multiple diverse spheres, systems, and populations that may not have been studied. Moreover, even if all known data can be readily synthesized in the near future, it is yet likely some aspects of relevance in selected cases will be overlooked or remain untested, or misinterpreted due to prompt variations. Moreover, as a result of being unable to capture all variations of note in real time, no universal panacea will be forthcoming for optimally dealing with all situations even with the most advanced AI system without some human intervention for some time to come, especially in light of multiple ethical considerations.[41] In the absence of robust evidence from multiple sources on any chronic health topic affecting older adults, as can be seen in almost all Cochrane Systematic reviews, the sole use of AI to advance rehabilitation efforts is also not recommended in light of any possible limitations in data aggregation realms, as well as any possible

incompatibility of the cumulative data with either the patient's profile or the provider's instrumental, technical, ethical, or regulatory values and knowledge. This also applies to diagnostic interpretations and treatment recommendations for patients with both acute and chronic illnesses. The concerns are also evident if the AI applications are used as to generate recommendations under physician control, if these are incompatible with presiding social systems, policies, financial, legal, and regulatory factors. In both acute and chronic illnesses prior to the widespread rollout of AI, a call for more studies has thus been put forth to identify the challenges that may raise concerns for implementing and using AI applications more universally.[42]

Discussion

The emergence of artificial intelligence has led health policy makers and others to examine the benefits of this novel approach. Of the many topics that have been subjected to recent discussions, results of the current search showed topics with the most compelling growth to be AI for big data analysis that can be used to draw comparisons and make predictions, the use of therapeutic robots and robotic prosthesis, robotics-assisted stroke rehabilitation, diagnoses using various forms of scanning and detection of biochemical markers, and its application in minimally invasive as well as various other forms of surgery. Also emerging are discussions that acknowledge the importance of personalized or precision based medical care, as well as population-specific care, and early detection of diseases that are generally incurable such as dementia.[25] In terms of rehabilitation efforts, fewer ideas than anticipated when compared to the volume of diagnostic data were observed, as well as a highly diverse set of strategies for rehabilitation purposes, regardless of health condition, have been put forth. In addition, whereas AI is currently used as a screening device, a tracking device, a therapeutic device, a prognostication device, and its benefits for stroke, diabetes care, fracture surgery and arthritis care have been advanced, as well as neurological and heart diseases, its predictive validity in the realm of rehabilitation remains to be determined,[43] and especially examined in long term studies.[44] It can however be used as a form of social support and educational inputs that appear promising. Moreover, by gathering and employing a large amount of organized data and abundant computational resources, one or more AI approaches appear to hold great promise in effecting significant advances in both prevention as well as rehabilitation spheres, regardless of health condition.[45]

It also appears possible that multiple adjunctive therapies, for example those designed to reduce pain without use of drugs and are more passive than not including electro acupuncture laser therapy, selected manual therapies, infrared radiation, and pulsed electromagnetic fields may be helpful for use in the home and help reduce both distress as well as health costs and therapist burden. The use of robots and mobile robotic exo- skeletal AI applications also shows promise but their reliability needs to be established through careful and well-founded meticulous clinical validation processes in order to have positive impacts on the rehabilitation process, while improving the desired outcomes of the therapy as well as interactions among the patient, and the team of health professionals.[46] Although we have not conducted any in depth analysis of any of the currently available articles, other areas of AI that show promise include the ability to isolate and monitor therapeutic progress and provide data on biological marker trajectories without clinical visits, and to similarly advance education about a health condition or technique vicariously.

However, despite its immense potential, more research is clearly needed to generate large data sets in most spheres pertaining to rehabilitation procedures relevant to large numbers of older adults with one or more health challenges, either acute or chronic or both, as the ability to translate the theories about the scope of AI and ML in the rehabilitation realm of the older adult is largely limited in this respect.[47] In addition, the training of personnel such as surgical nurses as regards AI and the role of this including robotic nurses and how to program these-if indicated- remains an area of concern.[48]

At present, more robust clinical data across many spheres of health, including later life, that can yield large reliable data sets that cover the most universal features of rehabilitation need are clearly required to successfully advance the health opportunities for aging populations at high risk for so many diverse chronic health situations and experiences in a meaningful and safe manner. Their application must also prove to minimize costs, have no adverse climate change impact, be practical, and be mindful of past and pervasive health disparities, equity issues, and complex cultural and genetic influences. Health systems employing AI must also remain accountable ethically, and be mindful to preserve confidentiality at all times as well.[47] Colleges training future health workers should review and revise curricula to account for AI and its scope of possibilities as well as limitations. Engineers and other involved in AI should seek the inputs of current providers, policy makers, ethicists, health organizations, as well as diverse patient populations. Given the foreseeable challenges in advancing AI successfully in the rehabilitation sphere, in older populations, where time is of the essence, perhaps more emphasis on AI and its application to primary prevention is indicated.

In the meantime, it appears safe to say that virtual and augmented reality applications and others are clearly increasing in the realm of efforts to foster the older adults' physical and cognitive well-being in multiple training and rehabilitation settings. Yet, these are clearly still in the early stages of development in terms of affording concrete efficacious bias free universal cost effective action plans to apply in diverse healthcare settings and among multiple age associated disease and injury manifestations and practitioners and health organization policies and infrastructure and resources.[49–51] As well as ethical and legal concerns, few primary prevention and natural healing opportunities appear to prevail in age related discussions of AI. Rather medical, surgical, and drug based tertiary interventions and downstream diagnoses precision discourses are commonplace. This raises concerns about how AI is being used to advance elder care across the lifespan, and whether the predictive models in AI systems may be flawed, as well as amplifying health related inequities, privilege, disability, the digital divide, plus an implicit as well as explicit age associated bias towards passive types of rehabilitation support for older ill or disabled adults plus an almost exclusive focus on tertiary prevention, and efforts to redistribute limited human service providers through AI based technological avenues, rather than relying on human wisdom and its apparent satisfying attributes.[52,53] However, more well designed randomized clinical trials are needed to advance health care for the older adult despite the promise of AI.[54]

Conclusion

This brief, designed to garner an emergent view of some articles pertinent to the use of AI and ML in rehabilitation contexts as these apply to common health conditions affecting older adults, while limited and somewhat developmental as well as theoretical, has revealed:

I. AI is largely explored and currently applicable to selected diagnostic procedures and the integration of large data sets that can provide for more advanced health predictions than subjective and traditional methods alone.

Citation: Marks R. Artificial intelligence and rehabilitation: what's new and promising. *Int Phys Med Rehab J.* 2023;8(2):135–140.
DOI: 10.15406/ipmrj.2023.08.00348

II. Very little has been done to focus on rehabilitation of any condition other than stroke, or to identify possible adverse events that may ensue from ill considered AI/ML applications, for example applications of virtual reality for stroke victims who may have perceptual or frailty challenges.

III. As applied to rehabilitation in older populations, while highly promising in multiple domains, AI usage needs to be based on more carefully construed generalizable research that stems from evidence based practices that prevail, involvement of health care workers as well as older health challenged personal based inputs, along with efforts to generate a more inclusive standardized and set of data base health indicators and measures, and uniformly categorized validated reports.

IV. Until more substantive evidence that can truly represent the complexity of multiple age associated health challenges of older adults more accurately, and reliably, for example in acute care or long-term settings, an efficient clinician or integrated team may be more effective at identifying immediate needs and directing these accordingly in real time than current AI data bases alone.

V. The needs of those who require life-long or specialized care, who are often excluded from randomized controlled clinical trials, or whose data are rejected as outliers in various reports, should not be neglected in the desire to acquire a 'magic bullet' that promises to restore health optimally in all realms and in all venues, such as AI technologies.

VI. To yield optimal future results in any area of rehabilitation needed by the older adult, individual preferences for AI need to be considered, as well as health personnel ability to apply AI in an era of resource scarcity and community situated disparities and service gaps, cultural diversity, and limited continuing education opportunities.

Acknowledgments

None.

Conflicts of interest

The author declares no conflict of interest.

Funding

None.

References

1. Ellahham S. Artificial intelligence: the future for diabetes care. *Am J Med*. 2020;133(8):895–900.
2. Landry MD, van Wijchen J, Hellinckx P, et al. Artificial intelligence and data-driven rehabilitation: the next frontier in the management of cardiometabolic disorders. *Arch Phys Med Rehabil*. 2022;103(8):1693–1695.
3. Liu K, Yin M, Cai Z. Research and application advances in rehabilitation assessment of stroke. *J Zhejiang Univ Sci B*. 2022;23(8):625–641.
4. Ramesh AN, Kambhampati C, Monson JR, et al. Artificial intelligence in medicine. *Ann R Coll Surg Engl*. 2004;86(5):334–338.
5. Tzelves L, Manolitsis I, Varkarakis I, et al. Artificial intelligence supporting cancer patients across Europe-The ASCAPE project. *PLoS One*. 2022;17(4):e0265127.
6. Karpov OE, Pitsik EN, Kurkin SA, et al. Analysis of publication activity and research trends in the field of AI medical applications: network approach. *Int J Environ Res Public Health*. 2023;20(7):5335.
7. Tieri G, Morone G, Paolucci S, et al. Virtual reality in cognitive and motor rehabilitation: facts, fiction and fallacies. *Expert Rev Med Devices*. 2018;15(2):107–117.
8. Aichner F, Adelwöhrer C, Haring HP. Rehabilitation approaches to stroke. *Springer Vienna*. 2002;63:59–73.
9. Adly AS, Adly AS, Adly MS. Effects of laser acupuncture tele-therapy for rheumatoid arthritis elderly patients. *Lasers Med Sci*. 2022;37(1):499–504.
10. Zeleňák K, Krajina A, Meyer L, et al. How to improve the management of acute ischemic stroke by modern technologies, artificial intelligence, and new treatment methods. *Life (Basel)*. 2021;11(6):488.
11. Secinaro S, Calandra D, Secinaro A, et al. The role of artificial intelligence in healthcare: a structured literature review. *BMC Med Inform Decis Mak*. 2021;21(1):125.
12. Kaelin VC, Valizadeh M, Salgado Z, et al. Artificial intelligence in rehabilitation targeting the participation of children and youth with disabilities: scoping review. *J Med Internet Res*. 2021;23(11):e25745.
13. Bragazzi NL, Bridgewood C, Watad A, et al. Harnessing big data, smart and digital technologies and artificial intelligence for preventing, early intercepting, managing, and treating psoriatic arthritis: insights from a systematic review of the literature. *Front Immunol*. 2022;13:847312.
14. Cai L, Liu Y, Wei Z, et al. Robot-assisted rehabilitation training improves knee function and daily activity ability in older adults following total knee arthroplasty. *Res Nurs Health*. 2023;46(2):203–209.
15. Koo KI, Hwang CH. Five-day rehabilitation of patients undergoing total knee arthroplasty using an end-effector gait robot as a neuromodulation blending tool for deafferentation, weight offloading and stereotyped movement: interim analysis. *PLoS One*. 2020;15(12):e0241117.
16. Gu Y, Xu Y, Shen Y, et al. A review of hand function rehabilitation systems based on hand motion recognition devices and artificial intelligence. *Brain Sci*. 2022;12(8):1079.
17. Tang Y, Chen Z, Lin X. Characteristics and rehabilitation training effects of shoulder joint dysfunction in volleyball players under the background of artificial intelligence. *Comput Intell Neurosci*. 2022;2022:4512795.
18. Wang Q, Sun W, Qu Y, et al. Development and application of medicine-engineering integration in the rehabilitation of traumatic brain injury. *Biomed Res Int*. 2021;2021:9962905.
19. Xiang XN, Zong HY, Ou Y, et al. Exoskeleton-assisted walking improves pulmonary function and walking parameters among individuals with spinal cord injury: a randomized controlled pilot study. *J Neuroeng Rehabil*. 2021;18(1):86.
20. Qiao Y, Zhang L, Zhang B. Rehabilitation treatment of muscle strain in athlete training under intelligent intervention. *Comput Math Methods Med*. 2022;2022:5403681.
21. Alsobhi M, Sachdev HS, Chevidikunnan MF, et al. Facilitators and barriers of artificial intelligence applications in rehabilitation: a mixed-method approach. *Int J Environ Res Public Health*. 2022;19(23):15919.
22. Petersen S, Houston S, Qin H, et al. The utilization of robotic pets in dementia care. *J Alzheimers Dis*. 2017;55(2):569–574.
23. Schwarz GM, Simon S, Mitterer JA, et al. Artificial intelligence enables reliable and standardized measurements of implant alignment in long leg radiographs with total knee arthroplasties. *Knee Surg Sports Traumatol Arthrosc*. 2022;30(8):2538–254.
24. Yan W, Cui SY, Murong JY, et al. [Effect of rehabilitation robot rehabilitation training synchronizing acupuncture exercise therapy on postoperative rehabilitation with hip fracture]. *Zhongguo Zhen Jiu*. 2021;41(4):387–390.
25. Tran BX, Latkin CA, Vu GT, et al. The current research landscape of the application of artificial intelligence in managing cerebrovascular and heart diseases: a bibliometric and content analysis. *I Environl Res Publ Hlth*, 2019;16(15):2699.

26. Pelle T, Bevers K, van der Palen J, et al. Effect of the dr. Bart application on healthcare use and clinical outcomes in people with osteoarthritis of the knee and/or hip in the Netherlands; a randomized controlled trial. *Osteoarthritis Cartilage*. 2020;28(4):418–427.

27. Bickmore TW, Schulman D, Sidner C. Automated interventions for multiple health behaviors using conversational agents. *Patient Educ Couns*. 2013;92(2):142–148.

28. Siddiqi NA, Ide T, Chen MY, et al. A computer-aided walking rehabilitation robot. *Am J Phys Med Rehabil*. 1994;73(3):212–216.

29. Dermody G, Whitehead L, Wilson G, et al. The role of virtual reality in improving health outcomes for community-dwelling older adults: systematic review. *J Med Internet Res*. 2020;22(6):e17331.

30. Keshner EA, Lamontagne A. The untapped potential of virtual reality in rehabilitation of balance and gait in neurological disorders. *Front Virtual Real*. 2021;2:641650.

31. Laver KE, Lange B, George S, et al. Virtual reality for stroke rehabilitation. *Cochrane Database Syst Rev*. 2017;11(11):CD008349.

32. Miyazaki S, Yamako G, Arakawa H, et al. Weight-shifting-based robot control system improves the weight-bearing rate and balance ability of the static standing position in hip osteoarthritis patients: a randomized controlled trial focusing on outcomes after total hip arthroplasty. *Peer J*. 2023;11:e15397.

33. Preminger JE. Should significant others be encouraged to join adult group audiologic rehabilitation classes? *J Am Acad Audiol*. 2003;14(10):545–555.

34. Capecci M, Pournajaf S, Galafate D, et al. Clinical effects of robot-assisted gait training and treadmill training for Parkinson's disease. a randomized controlled trial. *Ann Phys Rehabil Med*. 2019;62(5):303–312.

35. Zhang Y, Yu H, Dong R, et al. Application prospect of artificial intelligence in rehabilitation and management of myasthenia gravis. *BioMed Res Int*. 2021;2021:5592472.

36. Iwasa M, Takao M, Soufi M, et al. Artificial intelligence-based volumetric analysis of muscle atrophy and fatty degeneration in patients with hip osteoarthritis and its correlation with health-related quality of life. *Int J Comput Assist Radiol Surg*. 2023;18(1):71–78.

37. Anan T, Kajiki S, Oka H, et al. Effects of an artificial intelligence-assisted health program on workers with neck/shoulder pain/stiffness and low back pain: randomized controlled trial. *JMIR Mhealth Uhealth*. 2021;9(9):e27535.

38. Calabrò RS, Sorrentino G, Cassio A, et al; Italian Consensus Conference on Robotics in Neurorehabilitation (CICERONE). Robotic-assisted gait rehabilitation following stroke: a systematic review of current guidelines and practical clinical recommendations. *Eur J Phys Rehabil Med*. 2021;57(3):460–471.

39. Ranzani R, Lambercy O, Metzger JC, et al. Neurocognitive robot-assisted rehabilitation of hand function: a randomized control trial on motor recovery in subacute stroke. *J Neuroeng Rehabil*. 2020;17(1):115.

40. Subramanian M, Wojtusciszyn A, Favre L, et al. Precision medicine in the era of artificial intelligence: implications in chronic disease management. *J Transl Med*. 2020;18(1):472.

41. Niel O, Bastard P. Artificial intelligence in nephrology: core concepts, clinical applications, and perspectives. *Am J Kidney Dis*. 2019;74(6):803–810.

42. Esmaeilzadeh P, Mirzaei T, Dharanikota S. Patients' perceptions toward human-artificial intelligence interaction in health care: experimental study. *J Med Internet Res*. 2021;23(11):e25856.

43. Loos NL, Hoogendam L, Souer JS, et al, the Hand-Wrist Study Group. Machine learning can be used to predict function but not pain after surgery for thumb carpometacarpal osteoarthritis. *Clin Orthop Relat Res*. 2022;480(7):1271–1284.

44. Pedersini P, Valdes K, Cantero-Tellez R, et al. Effects of neurodynamic mobilizations on pain hypersensitivity in patients with hand osteoarthritis compared to robotic assisted mobilization: a randomized controlled trial. *Arthritis Care Res (Hoboken)*. 2021;73(2):232–239.

45. Nomura A, Noguchi M, Kometani M, et al. Artificial intelligence in current diabetes management and prediction. *Curr Diab Rep*. 2021;21(12):61.

46. Vélez-Guerrero MA, Callejas-Cuervo M, et al. Artificial intelligence-based wearable robotic exoskeletons for upper limb rehabilitation: a review. *Sensors (Basel)*. 2021;21(6):2146.

47. Kumar Y, Koul A, Singla R, et al. Artificial intelligence in disease diagnosis: a systematic literature review, synthesizing framework and future research agenda. *J Ambient Intell Humaniz Comput*. 2023;14(7):8459–8486.

48. Ergin E, Karaarslan D, Şahan S, et al. Can artificial intelligence and robotic nurses replace operating room nurses? The quasi-experimental research. *J Robot Surg*. 2023:1–9.

49. Dilip G, Guttula R, Rajeyyagari S, et al. Artificial intelligence-based smart comrade robot for elders healthcare with strait rescue system. *J Healthc Eng*. 2022;2022:9904870.

50. Jovanovic M, Mitrov G, Zdravevski E, et al. Ambient assisted living: scoping review of artificial intelligence models, domains, technology, and concerns. *J Med Internet Res*. 2022;24(11):e36553.

51. Tack C. Artificial intelligence and machine learning | applications in musculoskeletal physiotherapy. *Musculoskelet Sci Pract*. 2019;39:164–169.

52. Chu CH, Nyrup R, Leslie K, et al. Digital *ageism: challenges and opportunities in artificial intelligence for older adults*. *Gerontologist*. 2022;62(7):947–955.

53. Zhou J, Wang Z, Liu Y, et al. Research on the influence mechanism and governance mechanism of digital divide for the elderly on wisdom healthcare: the role of artificial intelligence and big data. *Front Public Health*. 2022;10:837238.

54. Ma B, Yang J, Wong FKY, et al. Artificial intelligence in elderly healthcare: A scoping review. *Ageing Res Rev*. 2023;83:101808.

Citation: Marks R. Artificial intelligence and rehabilitation: what's new and promising. *Int Phys Med Rehab J*. 2023;8(2):135–140.
DOI: 10.15406/ipmrj.2023.08.00348