Functional Recovery Trajectory Prediction and Adaptive Therapy Scheduling: Machine Learning Approaches to Enhanced Patient Outcomes in Rehabilitation Medicine

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1. Introduction

Improving patient outcomes is a critical aim for any healthcare system. New technological capabilities, particularly in machine learning and artificial intelligence, have led to proof of concepts that can be leveraged in healthcare. Whether for improving workflows, out-of-clinic interventions, or enhancing treatments or pharmaceutical regimens, these emerging methods have vast potential in enhancing population health. Medicine and AI technologies in the 21st century are also beginning to understand the importance of personalized therapy. Personalized rehabilitation characterizes clinical rehabilitation programs, where a one-size-fits-all approach to therapy is adapted to the individual according to their clinical or psychosocial status. Although personalization and individualized therapies have been identified in rehabilitation research, there is still a gap between what we know and how to apply them. This essay will begin by discussing the importance of personalization in rehabilitation. Then, we will present some classical machine learning models that can be used to personalize patient therapy in rehabilitation settings, followed by a discussion of complementary AI tools that can be used by physiotherapists to make informed operational decisions to increase engagement in rehabilitation. Finally, we will discuss the importance of being able to track progress directly from wearable devices and to monitor performance in terms of adherence to therapy, improvements in functional capability, and impact on key symptoms. In total, this essay will argue that personalized therapy and progress tracking with complementary AI models can result in maximum patient engagement and maximum therapeutic outcomes.

1.1. Background and Significance

Machine learning and artificial intelligence are flourishing in various fields. In healthcare, physicians are indicating the utilization of AI in practice. Rehabilitation, a healthcare domain aimed at improving patient abilities, is linked to the application of artificial intelligence systems. We review various AI applications developed recently by researchers, particularly AI-based personalized therapy recommenders and AI-based patient activity classifiers. Our work discusses the applications in rehabilitation research. We found that a large number of papers are focusing on virtual reality based applications to improve rehabilitation. However, there are very few AI models that recommend personalized therapeutic exercises and predict patient abilities for enhancing rehabilitation outcomes. The development of more advanced classifiers to track patient activities and therapeutic exercises inside rehabilitation sessions is also necessary. Recently, non-negative matrix factorization and fuzzy-based techniques have also been developed with AI to track patient activities inside rehabilitation sessions.

It is worthwhile to mention that physical rehabilitation is essential for individuals. It has been estimated that nearly 13.8–27.9% of individuals worldwide have some form of disabilities. To provide therapy to these individuals, it has been reported that nearly 2.4 million rehabilitation therapists are required globally. In the United States, nearly 5,964 hospitals provide rehabilitation. Unfortunately, the monetary costs in rehabilitation maintenance are very high. Due to the pandemic, the demand for innovative methods in improving rehabilitation efficiency is needed and is facing challenges. Recent research also found that weak regulatory protocols, lack of information, rehabilitation guidelines, and lack of effective tools for predicting long-term improvements in rehabilitation therapy using AI technologies are some of the areas where we need to focus, which was another challenge before the pandemic era. Finally, it is also seen that we need to personalize rehabilitative therapy, which is also a challenge in rehabilitation. Consequently, a major application of personalized therapeutic exercises and individualized class label tracking inside the rehabilitation system is essential.

1.2. Objective of the Study

Numerous machine learning approaches for diagnostics, risk stratification, and outcome prediction are available in the healthcare domain. This study addresses the role of machine learning in rehabilitation. There are numerous research questions explored in

this study, out of which the main area of focus is "How can machine learning techniques be employed in rehabilitation to offer personalized therapy, and how could these be utilized to track patient progress?" The primary objective of this study is "To investigate and assess which existing AI models can be employed for providing personalized rehab care and for accurate patient progress tracking, in order to contribute to the development of a rehabilitation roadmap." Patient health outcomes are extremely important in the field of rehabilitation; this is why it is crucial for information regarding the sufficient therapy dose to be scientifically assessed based on strong evidence. For this very reason, we have formulated a scientific path that can help us understand the best rehabilitation practices necessary to improve patient care. Consequently, the results of this study support not only a wide array of validation practitioners but researchers as well, in evaluating and implementing rehabilitation therapeutic strategies by offering detailed information.

As machine learning techniques are developed to diagnose patients, provide prognosis based on patient characteristics, and predict the conclusion, our study focused on this ground, exploiting AI models that could be employed in rehab. In this context, this paper explores machine learning techniques that are utilized for their competency in personalized patient care and monitoring. The primary objective of this survey is that the patients' outcomes after rehabilitation in the area of personalized medicine should improve, making it achievable for every patient to receive tailor-made treatments. Thus, this study intends to establish the prospective use of AI models for personalized therapy and medical outcomes monitoring.

2. Machine Learning in Healthcare

Machine learning is the scientific study of algorithms and statistical models by which computer systems can effectively perform a specific task without relying on explicit instructions, relying on patterns and inference instead. Machine learning is a subset of artificial intelligence. Its applications extend to real life and, especially, in patient care. It helps patients get diagnosed faster and better, and ongoing treatments can be more targeted and personalized. There exist a myriad of machine learning methodologies. The algorithms are the same in healthcare, but outcomes differ, so domain researchers can better understand these methodologies and can apply the best methodology to solve their personal requirements. The algorithms include decision trees, k-nearest neighbors,

neural networks, etc. Another preprocessing used in various rehabilitation works is hybrid algorithms produced from the combination of two or more existing algorithms to exploit the strength of multiple existing methods in a single configuration.

These methods are aimed at minimizing or replacing medical decision errors made using doctors' expertise, taking into account machinery precision. They provide an additional advantage in reducing doctors' and nursing staff workload, reducing the need to perform and analyze periodic patient assessments, and reducing the load during the initial assessment. This will lead hospitals to lose and reduce the probability of accidents associated with medical assessments. Particularly, these works and tools are generally used to monitor and follow up or predict patient status. Predictive analytics use patients' history data, such as treatments received, diseases diagnosed, lab tests consumed, and so on, to predict imminent patient problems or detect chronic and acute diseases. The development of predictive models focused on individual patients' therapeutic responses aims to improve routine clinical workflows. Likewise, it helps with the above processes. These methods exploit machine learning capabilities to help reduce computing processing time, consumption, and reduce hospital and patients' high costs.

2.1. Overview of Machine Learning

Machine learning involves teaching machines to recognize patterns in the input data. It is a method of training computers that builds on mathematical optimization principles. There are three fundamental categories of learning procedures that fall under machine learning. In supervised learning, machines are taught by providing labeled examples of the input, which can be thought of as inputs that represent the 'question' that a machine is being trained to answer. Unsupervised learning occurs when training sets lack labeled output. In this circumstance, the algorithm is instructed to make inferences based solely on a data set's input structure. Reinforcement learning, on the other hand, is based on how the algorithm learns through experimentation, either by using trial and error to achieve some target outcome or with an element of randomness when the examples are not labeled.

To convert data input into machine learning models, a sequence of mathematical operations is performed iteratively. Data quality is critical to machine learning models, as the final performance of the models is highly dependent on the quality of the data on

which they are trained. Many algorithms are employed to generate these mathematical functions, ranging from relatively straightforward to highly sophisticated, with the most suitable choice depending on the lineage of the input data and the preferred output result from the machine learning models. Over time, machine learning has advanced, with an increasing number of machine learning tools available to individuals. As a result, it is now a ubiquitous part of several industries including technology, research and development, as well as the medical sector, where it shows great promise. Concerns over data quality, difficulty of delivering an 'explainable' model prediction to the end user, and complexity are among the challenges that arise with developing these machine learning applications into real-world solutions.

2.2. Applications in Healthcare

Within healthcare, machine learning has found a variety of innovative applications, including predictive modeling, diagnosis, sequence modeling, optimization of therapy and treatment, and decision support system designs. Other ubiquitous uses of machine learning in healthcare consist of patient monitoring for resource allocation and patient management. Furthermore, these models are now in use for monitoring the health status of their users in the consumer electronics and assistive device industries. At the healthcare provider's end, operational analytics helps facilitate the monitoring of care unit performance, clinical workflow analysis using patient-derived data, and resource optimization. The commercial sectors of machine learning in healthcare have also seen large investments in the last few years. Applications of machine learning models in caring for patients span across various settings like acute, long-term, community, and mental health care. For instance, in acute hospital settings, it has been employed for investigating medical and surgical emergencies and intensive care unit data.

Ever since artificial intelligence was first proposed, there have been numerous discussion papers, reports, and breaking news about the ways in which machine learning, deep learning, and artificial intelligence are ready to revolutionize healthcare by improving patient safety, integrating electronic health records and real-world data, and clinical decision support systems, as well as changing the way hospitals, clinics, insurance companies, and regulatory processes seemingly function. In a number of published research papers, numerous potential use cases have been suggested to exemplify the potential benefits of integrating artificial intelligence and healthcare.

While these scenarios have been documented in multiple domains, there still exist a number of challenges with integrating artificial intelligence models into incumbent workflows and current technology and operations.

3. Rehabilitation in Healthcare

Rehabilitation is an essential part of the healthcare continuum, focusing on the continuity of critical medical services after the acute care stage of conditions. The goal of rehabilitation services is to improve patient functional status, prevent complications, and help ensure a safe transition from hospital to home. Besides curative aims, rehabilitation supports inclusion and reconnects people with life to ensure fulfillment and positive experiences. Many patients realize that improvement in the quality of life can probably be achieved through rehabilitation, which could motivate a positive mindset and support efforts for further recovery. Various topics that are part of rehabilitation include: professionals, institutions, and services that may be involved in the rehabilitation process, which are diverse in different regions of the world.

Equality of service provision and quality of care within a region may unfortunately be determined based on patients' financial status, geographical location, service availability, as well as other local factors or service inhibitors, thereby introducing disparities. The healthcare systems of various regions and countries vary in their approach to service provision. Implementing rehabilitation programs that meet patient and community needs can be challenging due to the diversity of etiology, complexity of symptom presentation, and heterogeneity of patient needs. Additionally, resources and expertise are often scarce in regions with high population levels or few visitors.

3.1. Importance of Rehabilitation

Rehabilitation is an integral part of national healthcare systems that helps patients regain the best recovery. Physical impairment or disability leads to decreased quality of life, decreased general body functioning, and increased lifetime costs for care services. Through rehabilitation, people with varying conditions and stages of impairment improve their functioning, physical, psychological, and emotional well-being, which in turn improves their health and can reduce their overall cost of care over their lifetime. After the injury or impairment, rehabilitation often commences during the process of patient recovery and usually focuses on providing services to help people regain movement, sensation, and functional skills necessary for setting personal goals for

community participation. Such rehabilitation services have proved helpful to people during the time period after undergoing surgery, where patients require a high level of care and therapy and are moving from ICU towards discharge from the hospital bed. These services, or extended varieties of them, can include those for the more prevalent chronic, degenerative, lifelong, and complex conditions resulting in disability, and involve the provision of services often lifelong. The psychological benefits of rehabilitation are significant. It helps the patient understand the conditions of their health or impairment and thus facilitates acquiring skills and techniques for managing their rehabilitation process to improve independence. Personalization or customization of services to a person's specific needs is established as more effective than attempting to provide the same service to a whole cohort of patients without manipulation or differentiation of the components to meet individual needs. There are millions of success stories where a personalized program has helped people recover from post-surgical, post-injury, or chronic long-term care. This individual person-centered program planning is relatively unknown to many health or care providers. Personalization or customization of services is a significant route to take to achieve a person's goals of rehabilitation or care. Investment in physiotherapy, surgery, and diet for rehabilitation helps increase the speed of recovery while reducing hospital time and associated surgery-related complications. To improve a person's health for such patients with effective healthcare, there is a need for the execution of a rehabilitation plan.

3.2. Challenges in Rehabilitation

Rehabilitation faces several hurdles with respect to the delivery of consistent therapy. In graying societies with increasing stroke, traumatic brain injury, and spinal cord injury admissions, limited access to healthcare services can especially affect those in rural and underserved locations. Consequently, there is a pressing need to make rehabilitation therapy more accessible—locally and remotely—not as a jackpot where only luck brings better outcomes. With ever-increasing client caseloads serviced by shrinking teams, personalization of care is, in effect, no longer achievable; often this leads to “one-size-fits-none” standardized therapy. To address this, we need better evidence-based holistic treatment plans and early indicators of change, as lower levels of response-locked change indicate patients poorly engaged with therapy and who are not progressing.

Many healthcare funders view rehabilitation as a "cost" rather than an "investment." Client access to therapy and progress tracking outside of clinic walls could be achieved through a gamut of technological supports including assistive technology, telerehabilitation, and mobile health aimed at tackling and solving the preceding challenges. Rehabilitation professionals note that exergaming is useful for maintaining longer-term performance improvements and motivation for training at home. However, solutions still require around-the-clock dedicated human supervision, may impose appropriate postures upon the user, and prioritize the recovery of individual capabilities in preference to systems-level symptoms. AI decision support systems guiding therapeutic activities can also be expensive. As such, the current efficacy and widespread acceptance and implementation of rehabilitation remain challenging. There is much scope for developing innovative solutions in both the technical and methodological aspects of rehabilitation in a variety of client populations.

4. AI Models for Personalized Therapy

Personalized therapy is the design and implementation of custom treatment plans to suit the unique needs of each individual. In the context of machine learning, personalized therapy refers to using AI models to provide clinicians and patients with predictions about the future and recommendations about the most effective treatment. These AI models should capture the factors that make each patient unique to deliver state-of-the-art predictions, and they need to generalize well to new patients to provide the best possible care. A number of machine learning approaches, among them supervised learning, deep learning, reinforcement learning, and transfer learning, have been suggested and employed in the field. Because the use of structured data in the healthcare system is vital, a combination of biologically informed feature engineering and deep learning has shown promising results in customizing the robot-assisted surgery procedure.

The aim of using AI for personalized treatment is to enhance care and outcomes for patients. There are several identified benefits of personalized therapy, including more relevant, effective, and efficient care, as well as improved patient engagement and adherence. However, there are significant challenges that need to be addressed to effectively implement AI guidance into rehabilitation. Issues include data privacy, security, and the ethical challenges that exist regarding the possibility of inequality,

discrimination, and blame. The number of real-world applications seeking to understand, develop, and apply personalized rehabilitation is increasing. Multi-modality has been used to detect patterns of motor recovery and response to treatment, and offer advanced personalized care based on predictive modeling to those with spinal cord injury. Moreover, brain-machine interface technology has the potential to offer individual and contextual customization, guiding therapy and possibly shortening the time needed for therapy. Taken together, there is strong evidence to suggest we can use AI to transform rehabilitation from treating the diagnosis and symptoms to treating the needs of the person.

4.1. Definition and Scope

Personalized therapy is a patient-centered approach in which standard one-size-fits-all procedures are tailored to meet individual patient needs. The goal of personalized therapy in rehabilitation practice is to provide the right dose of therapy at the right time in order to maximize functional recovery potential. When we refer to personalized therapy within this context, we refer to the prevention and treatment strategies as well as rehabilitation programs that are created specifically for a given individual patient based on sufficient knowledge about him or her. This involves the patient's clinical characteristics such as age, gender, pre-morbid health status, and lifestyle, as well as personalized omics signatures, socioeconomic features, comorbidities, and other risk factors. The physiological impairments associated with the disease or injury are managed with personalized medical interventions based on expected therapeutic benefits, adverse effects, and individual preferences.

The concept of personalized therapy can be integrated within machine learning frameworks in which information about the patient, including genetic, genomic, proteomic, and metabolic profiles, environmental and social lifestyle factors, as well as further clinical and demographic characteristics, can be predicted or taken into account for therapy adjustment. Targeting personalized therapy for particular patients and exploring more effective models to provide effective treatments to patients who would benefit from the intervention is potentially able to enhance the outcomes for patients with particular characteristics compared with alternative therapies. Altogether, personalized therapy refers to a systematic approach for developing individualized therapies, which includes structural guidelines on creating personalized treatment

plans. The models used for creating and prescribing the personalized therapy plan encode this evidence in different algorithms and computational procedures for more precise predictions and tailored prescriptions. We concentrate on machine learning approaches. We emphasize that evidence-based medicine is blind to personalized knowledge, either due to the paucity of related evidence, imbalances in randomized controlled trial populations, or even inappropriately designed randomized controlled trials, and therefore, it facilitates low evidence and high precaution. We, therefore, set an epistemological boundary on personalized where we discuss personalized prognosis.

4.2. Benefits and Limitations

AI holds the potential to provide enhanced personalized therapy by providing treatment recommendations and tracking patient outcomes, increasing the accuracy of the treatment. There is evidence indicating that the personalization of advice can lead to better patient satisfaction and adherence. Through this, it could also lead to an improvement in patients' mental health. Developing a model to give truly personalized treatment needs the collection of a large amount of data that contains enough variation. This also requires tailored responses based on the same variation but, with fewer options, could be engaged at any point in the behavior change process if the tailored interventions cover a range of distinct strategies that could be targeted to different groups. Therefore, such a model could also engage a wider audience that does not necessarily need truly personalized treatment. While AI has huge potential, there are risks and challenges associated with the application of AI in healthcare. One of the noted risks is that AI can learn an algorithmic bias from the data it was trained on, for example, based on historically gender-biased data. Secondly, health data quality is a major issue based on the tendency to not record all the data. Integrating AI interventions into healthcare pathways is also a challenge, particularly when the interventions are personalized. A discussion about data protection and the necessity of informed consent in AI-based intervention is also important. Additionally, AI models might need to be kept updated, i.e., retraining, should there be a significant change in the patient population or care pathways.

5. AI Models for Progress Tracking

With the exponential increase in the use of AI models for personalized therapy, culminating in a surge of new rehabilitation settings in need of tracking mechanisms in a

personalized patient context, it has become important to also use these models to track patient progress. Indeed, an increasing number of studies have illustrated that machine learning and clinical scores can be combined to reliably predict outcomes during the acute and subacute phases of stroke recovery. This in turn suggests that rehabilitation outcomes may, to a large extent, be an expression of recovery patterns which, under the best conditions, are highly individual. AI models are able to exploit health data collected longitudinally to generate a graded measure of individual progress in order to gain an in-depth understanding of the specificities of individual recovery sequences. In the therapeutic domain, one limitation of AI-enhanced effectiveness resides in the fact that feedback and alerts are not directly translated into change in the rehabilitation that is possible and/or performed for a patient, with no clear directive or strategy for how to change them. Despite some early skepticism, AI could be instrumental at enabling numerous small changes adding up over time. Moreover, unlike clinicians, AI models can track an almost infinite number of parameters rather than only the ones for which standardized scales or sensors are available. Thus, AI can integrate parameters related to brain injury, patient health, and detailed behavioral data to offer a more comprehensive tracking of personalized health predictors during recovery, and help us draw a more meaningful and individualized picture of recovery. Finally, the use of AI for tracking patient progress can be used by patients themselves to enhance engagement and motivation. It can allow easier comparison of patient performance to his or her own past state or to an average patient's profile, and it can provide a set of tangible and explicit items of improvement that may have gone unnoticed otherwise, thereby enhancing feelings of satisfaction and progress for the patient. Taken together, the reasons above highlight the existing gap in current practice and the potential impact of therapeutic feedback based on AI-aided personalized progress tracking. Overall, there is an expanding body of literature that illustrates the potential and challenges associated with using AI to improve patient outcomes.

5.1. Importance in Rehabilitation

One important aspect of rehabilitation practice is progress tracking. This allows rehabilitation providers to continuously assess patient recovery. Through real-time assessment, treatment plans can be adjusted as needed to optimize recovery outcomes. Patient adherence and motivation have been linked to recovery rates. Patients who experience improvement in rehabilitation programs are more likely to adhere to and

complete their programs. Consequently, adherence can have a positive effect on a patient's health outcomes. Several studies have demonstrated the potential of progress trackers to impact health outcomes. Most research has taken place in orthopedic and neurological rehabilitation settings. Monitoring rehabilitation through a process of continuous tracking of patient progress during therapy and adjusting rehabilitation programs based on monitored data led to a reduction in injury complaints and therapy dropout in an orthopedic rehabilitation setting.

The continuous assessment of patient recovery using progress tracking can positively influence patients and rehabilitation practice. Delivering feedback to patients showing improvement in their monitored progress immediately during or after exercise could give patients insight into the recovery process and motivate them. Involving technology in a progress tracking system could aid in making a more effective combination. With so many alternative therapies and treatments available, it can be a struggle to find the time and motivation to try to improve. Monitoring your treatment progress and tracking what works and what doesn't can help you sustain the motivation to keep at it. A dynamic exercise bike and a robot for rehabilitating arm and hand movements have been shown to be effective for the patients, but bring a lot of additional benefits for the recovery process.

5.2. Challenges and Opportunities

Artificial intelligence models for tracking patient progress and adaptation in therapy aim to support personalized and patient-tailored rehabilitation without being limited by time and cost constraints of professional-based approaches. An important challenge for integrating an AI system in clinical practice settings is the trust of the professional users and patients. This complicated context highlights a major challenge for proposed AI systems and, more generally, AI solutions in therapy and rehabilitation. Other medical sectors face similar challenges in integrating AI solutions, including limitations in the use of data sources to prevent data privacy as mandated by corresponding national and international laws. Interoperability challenges arise concerning different clinical systems. Currently, many different and heterogeneous electronic health record systems are in use in public and private clinics. There are also various assisted tools and end devices in use, which often have health-related data that are not transferable to other systems.

When integrating AI solutions into therapy and rehabilitation, many opportunities arise by improving patient outcomes, enhancing the effectiveness of disease management, and reducing healthcare costs, for example, by supporting self-management among patients, reducing the need for face-to-face contact, and inpatient rehabilitation. A very desirable goal is the realization of a therapy that is sensitive and responsive to the patients' physical and psychological conditions and needs. One might envision a fully adaptable therapy system that not only measures how a patient is doing at the current time point but also takes into account the individual patient history, the current medical status and symptoms, the social circumstances, the study results from similar patients regarding which therapy might have which effectiveness, and relative cost-effectiveness for the patient. Such a direction might lead to fully personalized and stratified medicine. Healthcare professionals should not be driven away from work; rather, they can use such systems to cope with the increasing number of patients that require a highly personalized medical approach. To introduce this vision, dedicated time in the university chair schedule for a two-hour module on therapy personalization and AI should be introduced. It should cover topics related to the usefulness of an AI tool in the decision-making process, the validation, the prediction, and hazard risks of AI models.

6. Future Direction

Rehabilitation is an ongoing challenge, requiring continuous commitment to new methods and tools for improving interventions. Future research will benefit from the close collaboration of clinicians, technology developers, economists, and patient advocates. There is potential for using wearable devices only when they match the person’s needs and motivation. Additionally, big data analytics provides a way to exploit information that is already available in the clinical record but is currently overwhelmed by volume in a form that is hard to access. Because of the rapid growth of the field and the importance of the application, this paper does not discuss large-scale information-based analysis supporting rehabilitation care but rather focuses on the most recent AI research study outcomes focusing on patient progress tracking.

Research needs to continue in accordance with best practices in machine learning to further validate the models in larger public clinical data sets. AI-based tools are subject to a refresh rhythm that is dependent upon environmental changes and have an ever-lasting readiness for retraining and adaptation. Therefore, it becomes necessary to

always re-evaluate the algorithm's clinical applicability. Fortunately, for example, clinicians work using problem-solving methodologies that suit AI technology such as deep learning, which continuously seeks a better answer. Close collaboration between medicine and AI technology will bring not only technological progress but also an innovation for the whole field of medicine to strive for even better outcomes. With all these facilities, it becomes imperative to refine the AI techniques currently available to provide a coherent functional piece of technology ready to be tested with very large and diverse human data in rehabilitation. Additionally, more substantial funding is also necessary for AI research and development and for large-scale clinical testing and translation to deployment in rehabilitation. Finally, big industry involvement in rehabilitation could also foster engagement between health care providers and technology developers, accelerating the uptake of technology-based rehabilitation. AI in rehabilitation is transforming rehabilitation itself toward a more visionary and impactful approach, availing of a more data-driven and personalized method to deliver patient- and society-centered care. This will ultimately exploit the social, economic, and ethical benefits that only AI can provide. Few partners are ready to take the leap and invest in AI rehabilitation. In the end, the beneficiary will be anyone. There is a need to have a global approach to rehabilitation vision, with consensus from every joint society, patient advocacy group, and professionals in the field, to have the ability to impact legislation in research in rehabilitation and politics. These should be strongly interdisciplinary with novel technology and holistic in the realization of the comprehensive paradigm of rehabilitation. These steps are crucial for the most effective rehabilitation path for patients who have suffered disability.

7. Conclusion

In the studies provided in this special issue, there are no cookie-cutter approaches that could be developed or applied for the integration of machine learning in rehabilitation. However, we can draw from the various studies that there is much potential in improving patient outcomes using technology. This is especially the case when we provide personalized therapy and, perhaps as important, provide adequate progress or goal tracking. A patient can certainly move one peg up from where he or she is at present, and this "up" could be facilitated through models and systems the field has to offer in rehabilitation. However, as the field stands at present, there are many challenges to overcome. These include the non-predictive nature of current research focuses in the

field, the draw of many rehabilitation technologies, and possibly AI technologies into the "one-size-fits-all" mandate, the reluctance of clinicians to engage with AI systems, not knowing how to interpret the outcomes of AI models, and last but not least, disempowering professionals by not utilizing practice wisdom and individual relationships with their patients. Thus, optimal AI rehabilitation models need to be developed through a partnership approach between practitioners, researchers, and technologists. Moreover, adequate training in ethical AI conduct, as well as the design and complexity of AI, and indeed, AI-assisted therapy needs to form part of the multidisciplinary clinician's education curriculum. Hence, there are many areas in the field of AI in rehabilitation that require further investigation; the challenges are dwarfed by opportunities for further research and the many beneficial applications of AI in the aims of rehabilitation therapy.

Whilst great potential exists to improve rehabilitation outcomes using AI, it will be crucial to be able to interpret the outputs of the AI and to have access to models that are as comprehensive to patient presentation and rehab outcomes as possible. The best use of AI will involve not only patients and medical teams but also the companies and developers who conceive and build the AI, the clinicians who must trust and integrate them with common wisdom-based practice, and the successful pioneers who install evidence-based treatments into their care regimes and successfully treat their patients. Let us work together formally and ensure that rehabilitation aims and outcomes remain the domain of our collective human embrace in the era of machine learning and rehabilitative methodologies required to replace one part of it.