Role and scope of artificial intelligence in physiotherapy: A scientific review of literature

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Abstract
As unprecedented development and growth in human social and economic systems followed the invention of the steam engine, recent emergence of artificially intelligent machines has enabled human cognitive capacity to recognize previously hidden patterns within massive data sets. These changes are influencing all aspects of society, including but not limited to our social, economic, education, health, legal and moral systems, and may have a more significant impact on human progress when compared to the mechanical revolution brought about by steam engine. Clinicians in the near future will find themselves working with information networks on huge scale, causing need to use artificial intelligence (AI) for patients' healthcare. This paper focuses on describing the possible influences and scopes of AI-based technologies on physiotherapy practice, and the subsequent ways in which physiotherapy education will need to change in order to graduate professionals who are fit for practice in a21st-century health system.

Keywords: artificial intelligence, machine learning, patient care, physiotherapy, education

Introduction
For thousands of years the human progress has showed a trajectory showing only a gradual increase over time. There has been very little change in the material aspects of ordinary people's lives over the course of successive generations [1]. From the time period of approximately 200 years before because of the industrial revolution, there was a sharp increase in human social and economic development, along with the sharp veering of curve of population growth and productivity in an almost vertical direction (Figure-1).
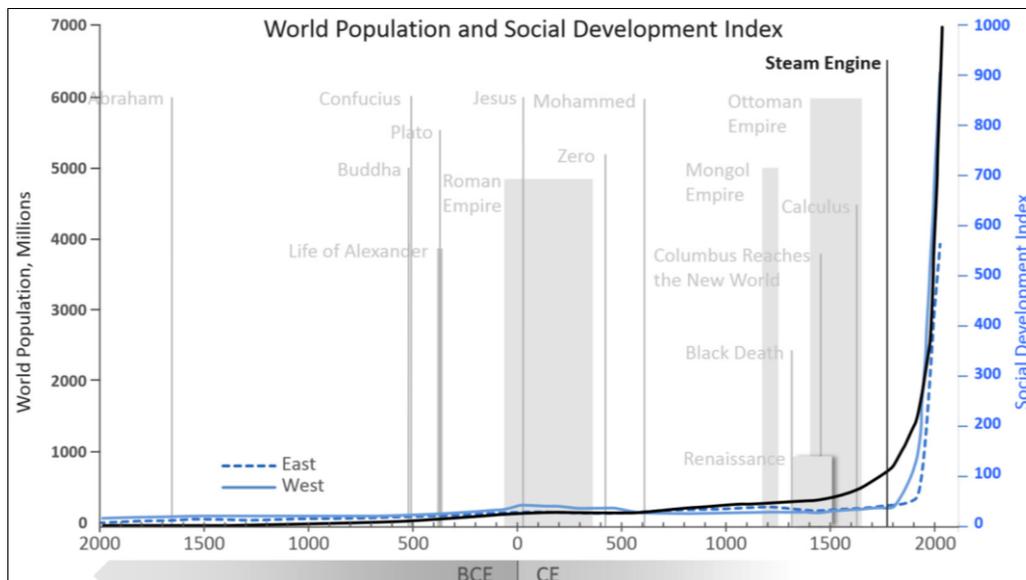

Fig 1: World population and social development index [1]

The industrial revolution brought with it a range of technological advancements and methods to generate enormous quantities of energy, improving the amount of work that could be performed by human and animal labor. This introduction of machine power significantly increased our capacity to shape our physical environment and created the conditions for the mass production of material goods, thereby improving the quality of life across all aspects of human life and across all levels of society [2]. Now at the start of 21st century, we are at an inflection point beyond which we will see human cognition first augmented, and then surpassed, by artificially created intelligence. This is going to lead us towards transformation of our social and economic conditions which are going to be no less profound than those that were introduced by the industrial revolution due to the steam engine.

Artificial Intelligence (AI)
Artificial intelligence (AI) describes a computer's ability to perform tasks normally requiring human intelligence – that is, machines that can 'think'. It is technically defined as the development of technology which is used to perform

technological operations requiring involvement of human intelligence. AI is a cross-disciplinary field of research that attempts to understand, model and replicate intelligence and cognitive processes by invoking computational, mathematical, logical, mechanical and biological principles and devices [3].

Recently Artificial intelligence is playing major role in advancement of technology. Machine learning is one of the key components of artificial intelligence and it provides us with the ability of both supervised and unsupervised learning for training our model. They can be used for better training and prediction of our system. The AI technology today can be in different forms such as software programs as well as hardware interface to develop a system which is capable of learning from their own datasets.

The combination of these three characteristics leads to an increase in the ability of AI-based algorithms to reach conclusions in uncertain contexts. In addition, increased power and sensitivity of the associated hardware, such as better and cheaper sensors, fast networks, smaller gyroscopes, and the global positioning system (GPS), makes the AI qualitatively different as compared to the past. These enable AI-based systems to perceive their physical environment, locate themselves on earth, connect to and establish relationships with other connected devices, and understand their own position in space [4].

Artificial Intelligence (AI) and Medical Science

In today's era, AI-based research has led to the use of expert systems that guide clinical decision-making. Development of computer vision algorithms can outperform human beings in the analysis of CT and MRI scans providing better diagnostics and prediction of patient outcomes and enhanced administration and planning in health systems [4]. Because of AI research, there are important advances in the areas of information retrieval and retention, problem-solving and reasoning, image recognition, planning, and physical manipulation [3].

Applications of AI based systems are continuously evolving in the field, making it essential to maintain the balance between their safe use in clinical operations and the technological advancements. It seems necessary to rationally recognize and evaluate the advantages and insufficiencies of present medical AI systems. In most cases, AI-based systems improve clinical decision-making using multiple layers of information and pre-specified algorithms [5]. Furthermore, the high efficiency and stability of AI are very suitable for large-scale screenings of diseases where characteristic morphological changes are present. These scenarios have a relatively low risk of medical accidents and are having a substantial value of easing the contradiction between the overwhelming need for healthcare and the limited medical resources. There is consistent increase in use of digital health technologies to strengthen health systems in many low- and middle income countries. However, it is found that due to diversity in clinical practice guidelines across contexts and populations there is addition in complexity of medical practices globally. Such critical challenges may affect the applications of AI in clinical settings, including the humane aspects of caregiving, effects on patient-provider communication and safety and efficacy of health services [5, 6]. These kinds of issues suggest the need for a more careful analysis of different ethical aspects before adopting AI in clinical practice. There is a growing

understanding of how to design systems that can lead to better insights and improved treatments while minimizing risk and protecting personal data.

Artificial Intelligence (AI) and Physiotherapy Clinical Practice

The impact of AI-based technologies in clinical practice and the subsequent ways in which physiotherapy education might change in order to graduate professionals who are fit for practice in a 21st century health system. Supervised learning in machine learning is where the computer has access to labeled examples. For example, physiotherapists use knowledge of similar patients to produce a differential diagnosis. Deep learning is one specific type of such supervised learning where layers of algorithms (neural networks) to process information in a manner similar to how the brain works [7].

The success of machine learning depends on the accuracy and amount of data available to teach the system. Predictive modeling where prediction of an event or outcome based upon the available data is done and can be a useful tool in providing preventive and immediate care for patients having certain conditions [8].

Examples of predictive modelling include but are not limited to examples of predicting development of diabetes mellitus, predicting asthma exacerbations from telemedicine data, predicting treatment outcome for depression etc. "Stroke Recovery Predictor" is one such beautiful application developed by an Indian physiotherapy researcher to predict the extent of recovery of stroke patient based upon the details related to hospital stay duration, duration of stroke, barthel index score, etc [9, 10]. Such an application of AI can help in estimating the recovery in neurological patients having stroke and can guide process of rehabilitation.

One more such useful application of AI based technology in assessment of posture of a patient is Open Pose, which is developed by a team of developers from India. It is an open source library developed in C++ for the posture detection. It is used by importing open pose and later image is passed as NumPy matrices, which is then converted to human key points. It is combination of Caffee, OpenCV and OpenCL which is used for rendering of passed image. It is used in different fields such as hand gesture detection, Basketball games for prediction of basket throw and various other sports activities. It is also easier to use because of its capability to replace methods which involve high cost along with more equipment and time for processing [11].

Addition of "ChatBot" system in AI based applications guiding the patients through rehabilitation can use cognitive therapy for understanding of psychology of patients for faster healing of them and to maintain regularity and thereby increases the adherence to treatment [11]. It can also be able to keep track of their routines and it will chat with them on regular basis for collecting more data for processing of psychology. Thus, in addition to providing support to physiotherapist in diagnosis and treatment adherence, such system can help maintaining emotional stability of the human for healing. The clinicians can be helped by incorporation of AI-enhanced analysis of large patient data sets into their clinical decision making.

Along with emerging trends in AI, newly-constituted care teams where patients interact with providers across a wide range of professions, some of which themselves are only

beginning to emerge. For example, patients may work directly with data scientists who will help them analyze and interpret the enormous amounts of personal and health-related data that they gather themselves [12]. The role of the patient will change as they become true participants in clinical decision-making, possibly even becoming team-leaders as they delegate responsibility for various aspects of their care to different providers, as and when they deem it is necessary. Thus, the nature of the professional role may need to be re-evaluated as specialized knowledge becomes increasingly available outside of the disciplines. This will lead to decision-making that is distributed across different providers and services, some human and some machine, with the patient in control [12, 13].

In new age healthcare teams, clinicians will need to learn how to smoothly pass control of patient related care between themselves and other team members (including data scientists and software developers) and smart machines [13]. Success of healthcare delivery will be increasingly dependent on a teams' ability to identify the collective intelligence of the system or network, rather than being dependent on the expertise of an individual or single profession. Therefore, in this context the clinician will need to learn how they can work alongside intelligent machines, not just because AI will augment our physical and cognitive abilities but also because it will soon be difficult to function at all without them.

Artificial Intelligence (AI) and Physiotherapy Education
When we think about the role and importance of learning about the implications of AI in clinical practice for physiotherapy, we must ask certain questions to ourselves as physiotherapy educators. Questions such as "Shall students need to know how to interpret algorithmic decisions and more importantly, know when to ignore them?", "Shall we continue teaching students to interpret X-rays when algorithms are already better at image recognition?", Or, "Shall students learn research skills when search, filtering, aggregation and synthesis algorithms do a better job of summarizing a body of work?" are only a few examples of the kinds of questions.

We need to understand and adjust to the fact that 21st century healthcare systems will be patient-driven and that care teams will be cross-disciplinary, loosely connected, and will be including smart machines empowered with AI. Fundamental reforms to how we think about professional practice are necessary for preparing graduates for clinical practice in the 21st century rather than iterative changes to our current clinical and educational paradigms [13, 14]. The physiotherapists may find themselves to be well-trained, competent, and irrelevant; if the technical components of the discipline are outsourced to intelligent machines. We should ask ourselves that how can we adapt physiotherapy education system so as to deepen and strengthen the human-based components which are difficult for AI-based systems to replicate. We also make ourselves adaptable to imbibe and integrate the technological and data literacy which are necessary order to understand and work with smart machines.

The current education system is largely memorization-based which must transit to one that integrates three fundamental literacies across the core physiotherapy curriculum; (a). Data literacy, (b). Technological literacy and (c). Human literacy [15]. Having to work more collaboratively with AI-based systems, future physiotherapists will need the technological literacy that enables them to understand the vocabulary of computer science and engineering to enable them for communication with machines.

As machines are getting smarter and the pace of change is accelerating, the relative value of a professional degree is seemingly reduced [12]. In response, our ability to access professional education continuously throughout our working lives must become increasingly important. We need to stop thinking of physiotherapy education as time-limited degree programme that people graduate from once in their lives. We should reconsider physiotherapy education as a platform for lifelong learning where learners are provided with customizable modules which they can access when they need to [16]. As the pace of AI implementation in health systems is rapid, it will soon outpace the retirement of practicing clinicians, and therefore it is not going to be enough to focus only on training future healthcare professionals. During an era of profound transformation that requires the retraining of many thousands of clinicians, neglecting professional development may be problematic [17]. It is therefore essential that we cultivate a mindset of flexibility in currently practicing and studying physiotherapists that enables them to adapt to a rapidly changing workplace.

As machines are taking over the computation and reasoning tasks which were previously performed by human beings, the clinicians need to have the human literacy about things those are beyond the reach of machine learning algorithms. This will help them to develop skills in empathy, teamwork, creativity, design, ethics, and entrepreneurship. The integration of these literacies within and across the core curriculum will help future therapists develop the creative mindset and mental flexibility to invent, discover and produce the original ideas that are necessary to supplement the computation and reasoning abilities of artificial intelligence [16]. This way it will be possible to help future clinicians in learning how to collaborate with high-performing algorithms while at the same time accentuating our uniquely human strengths. Without this kind of integration we may find that we have generations of health professionals and educators who are unable to speak the language of 21st century healthcare.

Conclusions
As an influential figure in cultivating future physiotherapists, the educators must strive to provide the things that smart machines cannot; depth of disciplinary expertise and practice wisdom, personal learning pathways, and an emotional connection to students as part of a relationship-centred approach to teaching and learning. While AI-based systems may ultimately take over the mundane tasks of managing the learning process, educators will still need to help students identify meaningful goals, address the emotional aspects of learning, and develop closer relationships with students in order to better support and motivate them.

Acknowledgments

References
1. Morris I. Why the west rules-for now: The patterns of history and what they reveal about the future. Profile books, 2010.
2. Brynjolfsson E, McAfee A. The second machine age: Work, progress, and prosperity in a time of brilliant technologies. WW Norton & Company, 2014.
3. Frankish K, Ramsey WM. The Cambridge handbook of artificial intelligence. Cambridge University Press, 2014.
4. Harwich E, Laycock K. Thinking on its own: AI in the NHS. Reform Research Trust, 2018.
5. Shahid N, Rappon T, Berta W. Applications of artificial neural networks in health care organizational decision-making: A scoping review. PloS one. 2019; 14(2):e0212356.
6. Ganapathy K, Abdul SS, Nursetyo AA. Artificial intelligence in neurosciences: A clinician's perspective. Neurology India. 2018; 66(4):934.
7. D'Amario D, Canonico F, Rodolico D *et al*. Telemedicine, artificial intelligence and humanisation of clinical pathways in heart failure management: back to the future and beyond. Cardiac Failure Review, 2020, 6.
8. Artificial intelligence and machine learning. https://www.csp.org.uk/professional-clinical/digital-physiotherapy/artificial-intelligence-machine-learning
9. Kakkad AD, Rathod PV. A Study to Find out Strongest Predictive Factor for Functional Outcome after Stroke: An Exploratory Study. Indian Journal of Public Health Research & Development. 2020; 11(2):582-587.
10. Stroke Recovery Predictor. https://play.google.com/store/apps/details?id=in.gscpt.pmfsr&hl=en_IN&gl=US
11. Godse SP, Singh S, Khule S, Yadav V, Wakhare S. Musculoskeletal physiotherapy using artificial intelligence and machine learning. Int. J. Innov. Sci. Res. Technol. 2019; 4(11):592-598.
12. Topol EJ. The patient will see you now: the future of medicine is in your hands, 2015.
13. Shrivastava A, Pfister T, Tuzel O, Susskind J, Wang W, Webb R *et al*. Learning from simulated and unsupervised images through adversarial training. Paper presented at: Proceedings of the IEEE conference on computer vision and pattern recognition, 2017.
14. Wartman SA, Combs CD. Reimagining medical education in the age of AI. AMA journal of ethics. 2019; 21(2):146-152.
15. Barradell S. Moving forth: Imagining physiotherapy education differently. Physiotherapy Theory and Practice. 2017; 33(6):439-447.
16. Aoun JE. Robot-proof: higher education in the age of artificial intelligence. MIT press, 2017. Artificial intelligence and machine learning. https://www.csp.org.uk/professional-clinical/digital-physiotherapy/artificial-intelligence-machine-learning.