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Artificial Intelligence (AI) and Data-Driven Rehabilitation: The next frontier in the management of cardiometabolic disorders

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It is well known that cardiometabolic diseases (CMD) such as myocardial infarction, stroke and diabetes are associated with excess mortality and morbidity, and it is broadly accepted that an individual's lifestyle and activity levels are major risk factors.[1] This is particularly true for patients who are largely sedentary, have limited mobility, or who find it difficult to maintain adequate levels of physical activity much less achieve the recommended moderate-to-vigorous physical levels for cardiometabolic health. Accordingly, an important challenge for rehabilitation professionals is supporting patients into becoming more active and choosing a healthier lifestyle.[2]

Lifestyle modifications associated with dietary habits, hypertension, dyslipidemia and cholesterol control, tobacco cessation, and alcohol moderation, are all key to addressing CMD disease progression. Additionally, exercise performed at sufficient frequency and intensity, can meaningfully reduce many deleterious health effects related to CMD. For instance, achieving recommended levels of physical activity is associated with a 23% reduced mortality, a 17% decreased incidence of heart disease, and a 26% decreased incidence of Type 2 Diabetes

Mellitus.[3] Overall, a strong correlation exists between adherence to cardiovascular rehabilitation and reduced major adverse cardiovascular events in persons with established heart disease.[4]

Why do people, and particularly CMD patients, have difficulty adhering to cardiac rehabilitation recommendations?

Despite strong evidence, patients who present with (or increased risk for) CMD diverge widely in their adherence to prescribed exercise and lifestyle changes. It would seem rational that people with CMD, or at risk of developing CMD, would alter their modifiable risk factors related to movement behaviors to increase quality of life and reduce poor clinical outcomes. However, large proportions of eligible patients do not (or cannot) enroll in supervised exercise programs, or simply drop out early from supervised and/or informal programs. Data from a Canadian study revealed that among roughly 12 000 patients with heart disease who enrolled in a cardiac rehabilitation and secondary prevention program, 41% were non-adherent to cardiac rehabilitation, and the estimate further rose to 59% of non-adherence among patients with Type 2 Diabetes Mellitus or obesity.[5] Adherence to cardiac rehabilitation programs in older populations remains a vexing proposition for rehabilitation professionals.[6,7,8]

Patients' rationale and pattern of adherence to exercise prescriptions is a multifaceted and a complex interaction among several factors; in other words, the degree to which an individual adheres to established exercise protocols is a balance between intrinsic or “modifiable” factors, and external and “non-modifiable” (or at least difficult to modify) factors. We argue, as many have before, that the interactive network of genetic, socioeconomic, cultural, and behavioral factors explains much of the variance in adherence to exercise protocols across sub-groups within the CMD population. It stands to reason that if the summation of an individual’s intrinsic and extrinsic factors could be assessed and matched to a large sample of other similar patient profiles and outcomes, a predictable pattern could emerge, which in turn may help guide rehabilitative clinical decision making. Although the data would need to be extensively sophisticated, such information would be valuable in aligning, modifying and/or managing targeted evidence-based exercise protocols.

The rise of artificial intelligence and data-driven rehabilitation

Artificial intelligence (AI), and more specifically deep learning/artificial neural networks, are all forms of AI that use complex computational modeling. AI enables the discovery of correlations in datasets that are far too large and complex to analyze by using conventional statistical methods,[9] and have mostly been applied to augment diagnostic accuracy. We suggest however that AI represents an opportunity to optimize real-time clinical decision-making within the context of cardiometabolic disease management. We envision that clinical decision support systems could be feasibly applied to optimally match therapeutic exercise programs to patients with CMD, in the same way as clinical decision support systems have been developed to provide optimal matching system for the nutrition plan needed by patients diagnosed with cancer.[10] Frameworks for different machine learning-based approaches for computer-assisted patient rehabilitation have been proposed[11, 12] although they have necessarily had much uptake thus far in clinical practice.

The application of AI in the broad field of cardiac rehabilitation is in its nascent phase, and while we suggest that it represents an opportunity to meaningly improve clinical outcomes in CMD, we also fully recognize the constraints. There is a clear need for more high quality, unbiased, and large scale clinically oriented research with which to build reliable AI algorithms; however, accessing such data will require overcoming legislation and regulation barriers that create limited access to sufficient administrative data in terms of its volume, velocity, variety, and veracity.[13]

AI is the next frontier in the management of cardiometabolic disorders

There are a number of well-established, evidence-based, international clinical guidelines and recommendations that target CMD.[14, 15] Despite the plethora of guidelines, enrolment and patients' adherence to guideline-based exercise protocols remain low, which in turn has spawned the development of a number of clinical decision-making tools. One example is the EAPC EXPERT tool [16,17, 18,] which supports health professionals by 'automatically' prescribing personalized exercise recommendations for patients with CMD based on their unique characteristics and risk profile, according to updated clinical guidelines. Despite the high utility, uptake of the EAPC EXPERT and other similar tools has been limited, possibly due to lack of feedback loops regarding clinical outcomes or changes after prescription. We suggest that an AI-augmented decision tool can exploit large amounts of historical and prospective data to facilitate the prescription of dynamic and personalized exercise programs with the highest likely success rate for enrolment and adherence.

AI has already been suggested as a powerful tool to predict outcomes in support of decision-making in other fields in medicine [19, 20], and so by extension, AI applications to predict patients' adherence to exercise or rehabilitation intervention is realistic, appropriate, and long overdue. Given growing number of people living with CMD, we believe that AI can be a powerful tool to determine optimal ways that improve clinical outcomes and improve quality of life among this population. The question that we, as a global community of rehabilitation stakeholders must ask, is not 'whether' we are prepared to adopt AI in our clinical decision making – rather, the question is simply 'when' we will be ready and at what scale are we prepared to do so. In our opinion, AI is the next frontier in providing real-time, optimized clinical decision support if we are to bend the curve in the rising tide of CMD.

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