Machine Learning Algorithms and ACL Injury: A Sporting Minority Report?

Rowan Olafson

University of Calgary

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While Machine Learning has been around nearly since the advent of digital computers, in the last 20 years these specialized algorithms have been seeing widespread use (Fradkov, 2020). Researchers in Kinesiology have begun using this technology to tackle one of the biggest issues in sports - ACL injury. ACL injuries have varied outcomes, but almost always result in the loss of playing time and long-term consequences for the athlete, both financially and in sporting opportunities. ACL injuries carry a heavy financial cost to the health care system, can result in major losses of money for both athletes and sporting clubs and reduce overall quality of life in those affected (Filbay et al., 2022). Primary prevention is key in nullifying the effects of ACL injury, but how can we prevent these from happening? Using ML, researchers have been searching for a method of accurately predicting future ACL injury risk to allow for more targeted and specific prevention strategies. To gain a better understanding of this topic and its future use, we will discuss what ML is, how this technology is being applied to the problem of ACL injuries, and how this approach lends itself to specific advantages or drawbacks.

So, what exactly is ML? The central idea of ML is to emulate how biological organisms process sensory information and use it to adapt their responses in a changing environment (El Naqa & Murphy, 2015; Fradkov, 2020). This flexibility of process is absent in traditionally coded programs, which are designed to produce a specific outcome from specific input. ML is a computational process by which an algorithm uses input data to generate a desired outcome or output (El Naqa & Murphy, 2015). These programs are not hard coded to produce these outcomes, rather, they are made to "learn" through repetition and feedback, and alter their architecture to adapt to the programmer’s desired outcome (El Naqa & Murphy, 2015). By weighting the output of these algorithms based on how close they are to the desired response, programmers can use a “reward system” to inform the algorithm on how they want it to change its responses. This restructuring or adaptation allows ML programs to not only produce optimal outcomes for the dataset it was trained with but also allows it to generalize and produce outcomes with novel datasets. There are 2 main upsides to this method of data analysis; these programs can sub-in for humans and work with large datasets that would otherwise be complex and extremely laborious, and ML programs have the ability to detect more subtle and complex patterns in the data, which humans may otherwise miss (El Naqa & Murphy, 2015).

When applying ML to ACL injury, researchers have approached this issue in two main ways. The first approach is using ML algorithms to analyze datasets, with several different parameters that are associated with ACL injury and develop risk profiles for athletes who either have or do not have these risk factors (Jauhiainen et al., 2022; Taborri et al., 2021). These types of studies then recommend the implementation of specific training programs to reduce the risk of ACL injury in athletes assessed to be at risk. By designing training programs with direction from the algorithm, researchers can proactively treat the risk factors for identified for each individual (Taborri et al., 2021). The second approach is using ML to validate existing risk factors associated with ACL injury or identify new ones (Jauhiainen et al., 2020; Kokkotis et al., 2022). By utilizing several different prediction models, researchers were able to find a set of consistent injury predictors. Importantly, while the actual predicting power of the models may vary, the consistent appearance of specific factors lends credence to their association with injury (Jauhiainen et al., 2020; Kokkotis et al., 2022). This second approach allows for the improvement of the prediction models of the first approach. By feeding these algorithms with more specific risk factors, their predictions will likely improve (Jauhiainen et al., 2020).

A major issue with this line of research is the type of data used to inform the prediction models. While these prediction models can be highly accurate with the data they are trained/presented with, the quality of that data will affect the outcome of the prediction. The data these algorithms have been trained on have been called into question. As outlined by Jauhiainen and collaborators (2022), previous prediction studies relied on biomechanical assessment data in conjunction with anthropometric and strength data to make predictions of injury risk. For example, the authors note that knee abduction movements have been used as a proxy for knee injury risk as movements with high amounts of abduction have been associated with ACL injury in the past. While risk factors like knee abduction have been identified in previous studies, these studies have often been extremely small only provide a statistical association with injury, and do not necessarily provide strong predictive powers(Jauhiainen et al., 2022). Additionally, the external validity of ML algorithm predictions has been called into question (Martin et al., 2022). These programs are not universally usable for all athletes in all parts of the globe. While some studies have demonstrated external validity from their original participants, authors are careful to generalize their results completely and often restrict their claim of validity to a specific region (Martin et al., 2022).

ML is an extremely useful tool, however, it needs to be applied properly to achieve accurate results. These methods have shown promise in helping further the field of sports medicine, and may eventually help to reduce injury burden by allowing practitioners and coaches to treat injury risk factors proactively. With where we currently stand in the use of ML, we must stay mindful of what type of data we train these algorithms with, and avoid spreading claims of injury prediction beyond specific groups. With further refinement of this technology and the way we use it, we can surpass these obstacles. At the moment, ML use in the space of injury prediction and prevention requires more research, yet it is a promising new tool that may help revolutionize the way we think about injuries in sports.

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