THE UNIVERSITY OF WESTERN AUSTRALIA

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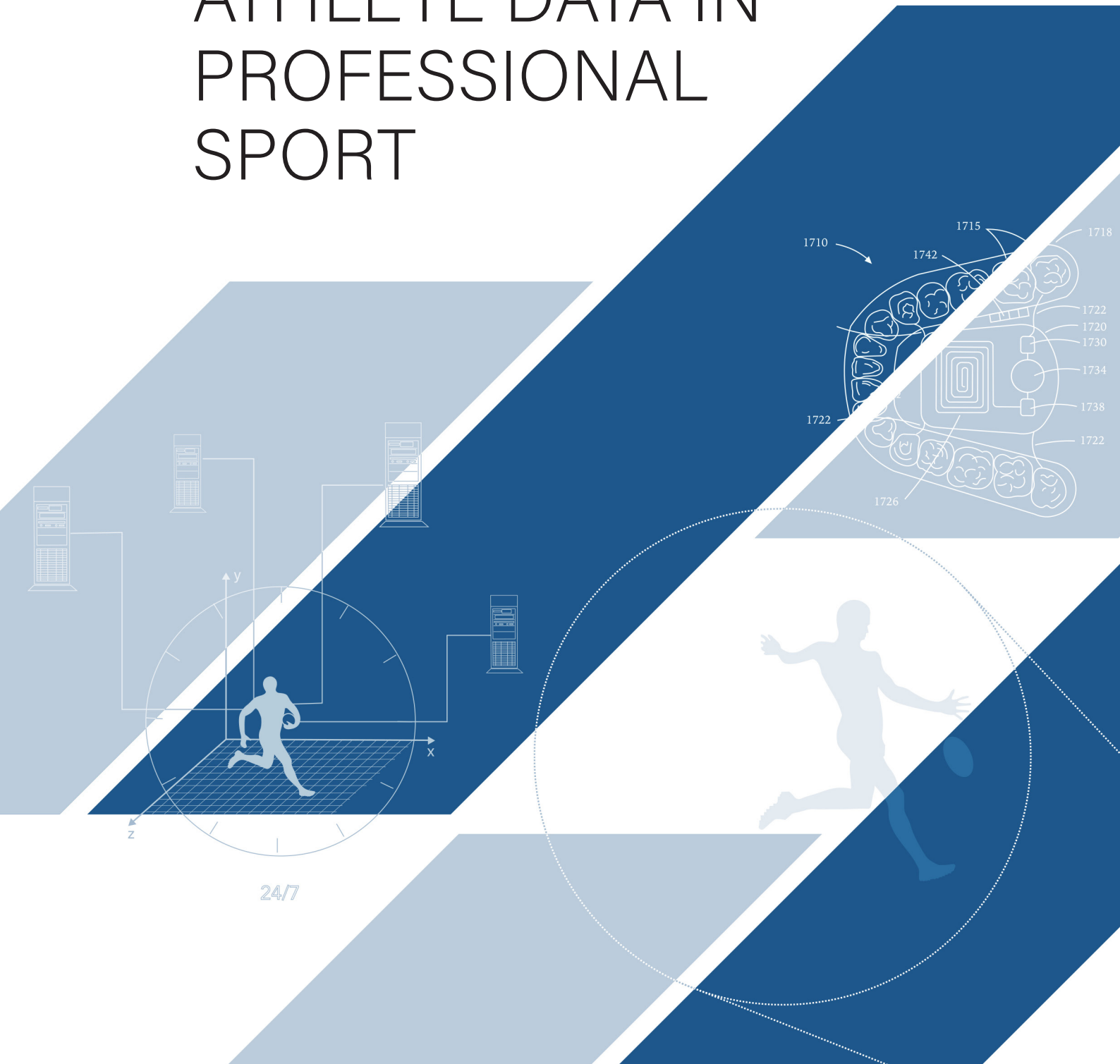
GETTING AHEAD OF THE GAME: ATHLETE DATA IN PROFESSIONAL SPORT



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ACKNOWLEDGEMENT OF COUNTRY

In the spirit of reconciliation, the Australian Academy of Science, Minderoo Foundation, and the UWA Minderoo Tech & Policy Lab acknowledge the Traditional Custodians of Country throughout Australia.

We also acknowledge and pay our respects to the Traditional Owners and Elders past, present, and emerging throughout Australia, and recognise their continuing connection to land, waters, laws, and culture. They hold the memories, traditions, cultures, and hopes of Aboriginal and Torres Strait Islander peoples of Australia.

AUSTRALIAN ACADEMY OF SCIENCE

The Australian Academy of Science provides independent, authoritative, and influential scientific advice, promotes international scientific engagement, builds public awareness and understanding of science, and champions, celebrates, and supports excellence in Australian science. The Academy is a not-for-profit organisation of individuals elected for their outstanding contributions to science and research.

MINDEROO FOUNDATION

Minderoo Foundation is a modern philanthropic organisation that supports a number of global initiatives, spanning from ocean research to ending modern slavery. The Frontier Technology initiative seeks to advance education on the societal impact of new technologies and technological change, through providing grants and donations to leading universities. It also aims to drive policy reform to ensure accountability in the tech ecosystem and protections from harm for the benefit of the public.

UWA MINDEROO TECH & POLICY LAB

The Minderoo Tech & Policy Lab at UWA Law School is an independent, interdisciplinary research institute that scrutinises the global technology industry through the distinctive lens of motion analysis, undertaking pro-public research and innovation in data analytics and governance, machine learning, augmented/virtual/extended reality, biomechanics and bioengineering, and technology law and regulation. The University of Western Australia has a long and proud history in sports science.

A digital version of this discussion paper can be downloaded from: **www.science.org.au/datainsport**

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CONTENTS

FOREWORD

PROFESSOR IAN CHUBB AC FAA FTSE
SECRETARY SCIENCE POLICY
AUSTRALIAN ACADEMY OF SCIENCE

Science is socially, ethically, and politically entangled and can provide massive benefit to communities alongside potentially far-reaching, uncertain, and unpredictable social consequences.

Scientists therefore operate with a 'social licence' that sets the limits of what the community-at-large is prepared to accept and allow to be done in its name.

There is a need, always, to ensure researchers maintain a social licence in the face of opportunities to do more. Just because we can do more doesn't mean we should.

Data collected within the field of professional sport is a case in point. As science has evolved and technology has caught up, more and more data can be collected from professional athletes, ostensibly aimed at improving performance and related outcomes. But because we can collect more doesn't mean that we should. Arguably, collections should also meet the standards expected for studies within research institutions, including review and approval by suitably constituted ethics committees – a feature of human-based research projects in Australia, and a means to ensure that only the most necessary and relevant data is collected from human subjects. There should also be compliance with legal requirements.

This discussion paper highlights an urgent need to improve standards for the collection and storage of data from human subjects in professional sport in Australia. The need extends to ensuring informed consent and privacy is maintained and to ensuring the data collected is used only for its defined and agreed purpose.

The Australian Academy of Science's independence and convening power made us the ideal host for bringing together a broad range of expertise to examine the complex issues surrounding data collection in professional sport.

I would like to thank the project Chairs, Professor Toby Walsh and Associate Professor Julia Powles, for their leadership. I would also like to thank the expert working group for their time, contributions, and hard work. Their commitment resulted in this discussion paper. It is the outcome of their considerable input, and represents their diverse perspectives and expertise.

Finally, I would like to express our gratitude to the Minderoo Foundation Frontier Tech Initiative. Without this support, this work would not be possible.

FOREWORD

KATE JENKINS
SEX DISCRIMINATION COMMISSIONER, AUSTRALIAN HUMAN RIGHTS COMMISSION

EDWARD SANTOW FAAL
UNIVERSITY OF TECHNOLOGY SYDNEY, FORMER HUMAN RIGHTS COMMISSIONER

This discussion paper is a welcome contribution spotlighting the emerging opportunities and challenges in the intersection of technology and athlete rights. While focused on professional team sports, this paper is relevant to those involved in all sports, including athletes, sports administrators, commercial partners, player associations, data analysts, and health advisers.

The Australian Human Rights Commission has a long history of examining emerging and concerning issues affecting human rights. Most recently, then Commissioner Santow conducted a world-leading examination of the human rights implications of new technology including artificial intelligence.[1] The report highlighted how vast quantities of personal information are being collected, aggregated, and then used in decision making that relies on artificial intelligence—with real risks of harm. Commissioner Jenkins leads the Commission's work in sport, including an Independent Review of Gymnastics in Australia, which examined the experience of gymnasts from grass roots to elite levels.[2] The gymnastics review highlighted the risks of a 'win at all costs' culture, where persistent use of authoritarian or highly disciplined coaching styles created a risk to the health, safety, and wellbeing of gymnasts. The Commission is only too aware that a 'win at all costs' approach in any sport comes at an unacceptable cost to the human rights of athletes, including children, also impacting families, sporting codes, and the community.

Just because we *can* collect personal information about professional athletes, doesn't mean we *should*. Sports and business must ensure human rights are considered and protected where athlete data is gathered, used, and shared, including by building in protections that promote transparency, fairness, and accountability. While technology enables data collection about the bodies, minds, and performance of elite athletes like never before, this paper provides an overview of the risks of harm to athletes and damage to the reputation of sports if basic human rights are not protected.

This paper asks Australian professional team sports administrators and coaches to consider the impacts and potential harms of excessive collection of personal information about athletes. It poses important questions about how Australian sporting governance will recognise and protect the fundamental human rights of athletes, equal to their pursuit of financial and sporting success.

While Australia prides itself as a sporting nation, we must ensure those professional athletes we applaud and idolise are not left poorer in the long term for their dedication and achievement. This paper lays the ground work for Australia to lead this important conversation.

EXECUTIVE SUMMARY

This discussion paper aims to ignite a conversation about the current reality that Australian professional sports are collecting extraordinary amounts of personal information about athletes. Concerningly, this data—which is continuous, personal, sensitive, and can be intimately revealing—amounts to excessively more information than has been shown to be beneficial to athletes, or to be capable of responsible, athlete-centric management. Increasingly, the marketing and commercial divisions of sporting leagues/associations and an array of third parties are eyeing this information as a monetisable asset, divorced from the individuals involved. This explosion in the amount of data being generated and in the number of parties who have taken an interest in it has dramatically shifted the risk–reward ratio against athletes. Paying attention to this growing mass of information about the mental and physical health and performance of athletes matters greatly. It has implications within sport and for anyone concerned about the direction of human monitoring in workplaces and public places well beyond the sporting landscape.

The rush to data presents two major problems which warrant serious consideration and a systemic response from the professional sport sector. The first concern is that professional sport increasingly faces a stark resourcing choice between a *data-informed* sports science and sports medicine (SSSM) approach with disciplinary knowledge, evidence, and translation at the centre, or a *data-driven* path where context and expertise are replaced by the centrality of often unproven and unvalidated data and technology. Such a transition risks replacing specialists who are highly trained in particular sports science disciplines—exercise physiology, biomechanics, strength and conditioning, motor control/learning and skill acquisition—with generalists who may be adept in data collection and analytics, but who lack deep domain expertise about the complexities and vagaries of human function, particularly in extreme environments and within small, highly-specific populations. Given the commercial realities of professional sport as a business with soft salary caps, trade-offs, and tight margins (even without the compounding strains of the global COVID-19 pandemic), this is a calculus to approach with great caution.

If the first concern is scientific, the second is human. This discussion paper focuses on data about athletes—people of extraordinary skill and dedication, living short, furious, intense careers at the frontier of human performance. But athletes also have lives before, during, and after sport. And the path of unrestricted data collection is also a path that treats the workplace of professional sport as a 24/7 zone of human monitoring and marketisation. Australian privacy law requires that personal information should only be collected where it is "reasonably necessary" for an organisation's functions or

activities. Following guidance from the leading federal privacy regulator, the Office of the Australian Information Commissioner, personal information that is "merely helpful, desirable or convenient", "being entered in a database in case it might be needed in the future", or collected as part of "normal business practice", simply does not satisfy this requirement. This presents a real and present risk to the professional sport sector, where an extensive—and growing—amount of personal information is collected simply as a matter of routine. The governance of personal information has tremendous implications for professional athletes, but just as significantly, the degree of surveillance and monitoring tolerated in this space foreshadows what will be permitted in community sports, other workplaces, and everyday life.

The sheer complexity and scale of current athlete data collection and processing are increasingly challenging for any individual to comprehend. This complexity is compounded by the power relations that exist between athletes, clubs, and professional leagues/associations, as well as with third-party commercial entities who may sell up, be acquired, or go bankrupt, leaving the products and information they hold subject to a variety of shifting fates. This is precisely the sort of landscape where legal and ethical guardrails and a significant uplift in literacy and governance are necessary to ensure that athletes and athlete rights are protected and promoted, both in their own interest and in the public interest.

EXPERT WORKING GROUP

This discussion paper was prepared, written, and overseen by an Expert Working Group established collaboratively by the Chairs, the Australian Academy of Science, and The University of Western Australia's Minderoo Tech & Policy Lab. The Expert Working Group includes domain experts in sports science and sports medicine, artificial intelligence, law, policy, social science, and governance. It also includes sports practitioners and former representative athletes in professional and high performance/Olympic sport, as well as experts in athlete rights and representation.

CHAIRS

- Associate Professor Julia Powles, Director, Minderoo Tech & Policy Lab, Law School, The University of Western Australia
- Professor Toby Walsh FAA, Laureate Fellow and Scientia Professor of Artificial Intelligence, UNSW Sydney

MEMBERS

- Associate Professor Jacqueline Alderson, Tech Director, Minderoo Tech & Policy Lab, The University of Western Australia; Adjunct Professor, Sports Performance Research Institute New Zealand, Auckland University of Technology
- Professor Lyria Bennett Moses FAAL, Director, Allens Hub for Technology, Law and Innovation, UNSW Sydney
- Professor Anthony Elliott FASSA, Dean of External Engagement, University of South Australia
- Mr Matthew Graham, Director of Legal and Player Relations, World Players Association
- Dr Rachel Harris, Chief Medical Officer, Paralympics Australia; Project Lead, Female Performance & Health Initiative, Australian Institute of Sport
- Professor Kathryn Henne, Director, School of Regulation and Global Governance, Australian National University
- Dr David Hughes, Chief Medical Officer, Australian Institute of Sport; Medical Director, Australian Olympic Team Tokyo 2020
- Professor Mike Innes FASSA, Adjunct Professor, University of South Australia
- Ms Kate Starre OAM, High Performance Manager, Fremantle Football Club AFL Women's Team
- Dr Jason Weber, High Performance Manager; Research Fellow, Minderoo Tech & Policy Lab, The University of Western Australia

All members of the Expert Working Group contributed their time and expertise voluntarily and participated in the project in their own independent capacity. Particular thanks are due to chapter leads: Associate Professor Jacqueline Alderson (scientific and technological), Associate Professor Julia Powles (introduction and legal), and Professor Kathryn Henne (societal and ethical). The Working Group also acknowledges and thanks Dr Hayley Teasdale and colleagues in the Australian Academy of Science for their support and facilitation of the project.

CONSULTATION

The Expert Working Group consulted broadly for input into the discussion paper. The project formally launched with a roundtable discussion held on 23 September 2020, where over 70 attendees discussed emerging issues in the area. Online submissions were welcomed from 30 September to 23 October 2020, in response to a project overview that was published on the website of the Australian Academy of Science. In addition to these open written submissions, a questionnaire was also made available for those operating in the sports ecosystem (e.g. athletes, organisations, and sports technology vendors).

The UWA Minderoo Tech & Policy Lab, co-directed by Expert Working Group members Associate Professor Julia Powles and Associate Professor Jacqueline Alderson, also conducted 25 in-depth interviews with practitioners working within the professional sports ecosystem. These interviews were led by Dr Jason Weber and are summarised in the Appendix.

This discussion paper is the start of a conversation and, as a volunteer-led project, necessarily limited in scope. Future work in this area would benefit in particular from more extensive engagement with current and former athletes and their representatives.

PEER REVIEWERS

The discussion paper was reviewed by the following experts:

- Dr Deidre Anderson, Chair, Rugby League Players Association; Athlete Wellbeing Manager, Australian Women's Softball Team
- Professor Franco M. Impellizzeri, Human Performance Research Centre, Faculty of Health, University of Technology Sydney
- Professor David Lindsay, Faculty of Law, University of Technology Sydney

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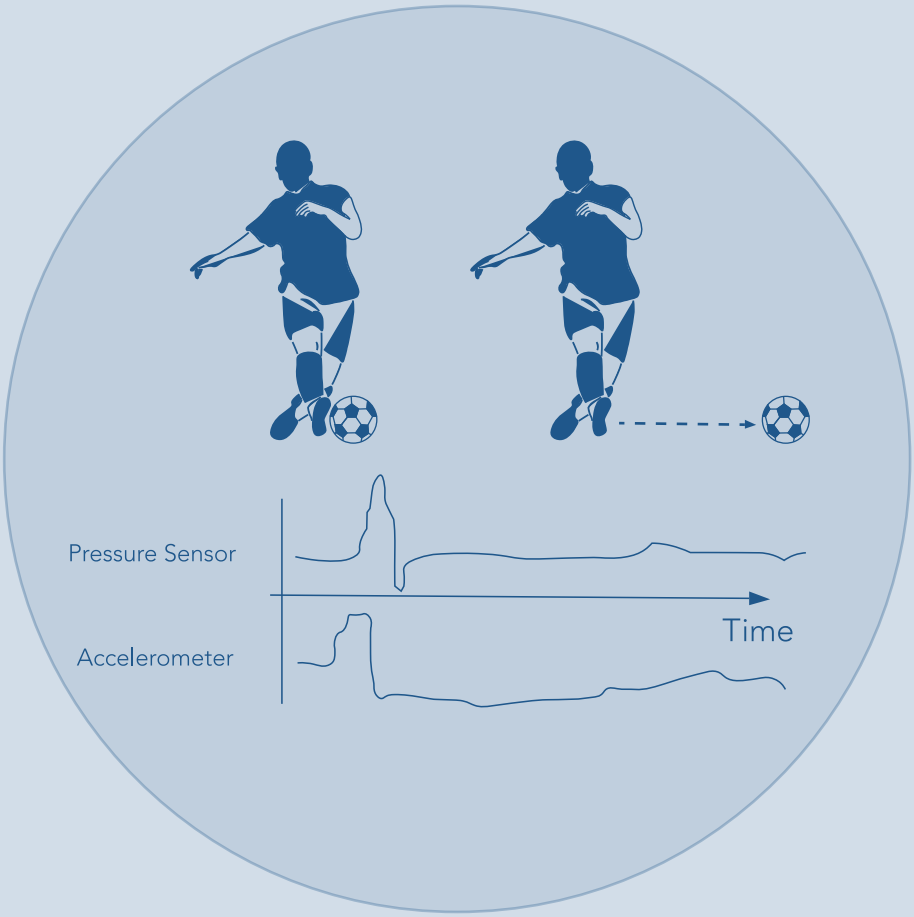
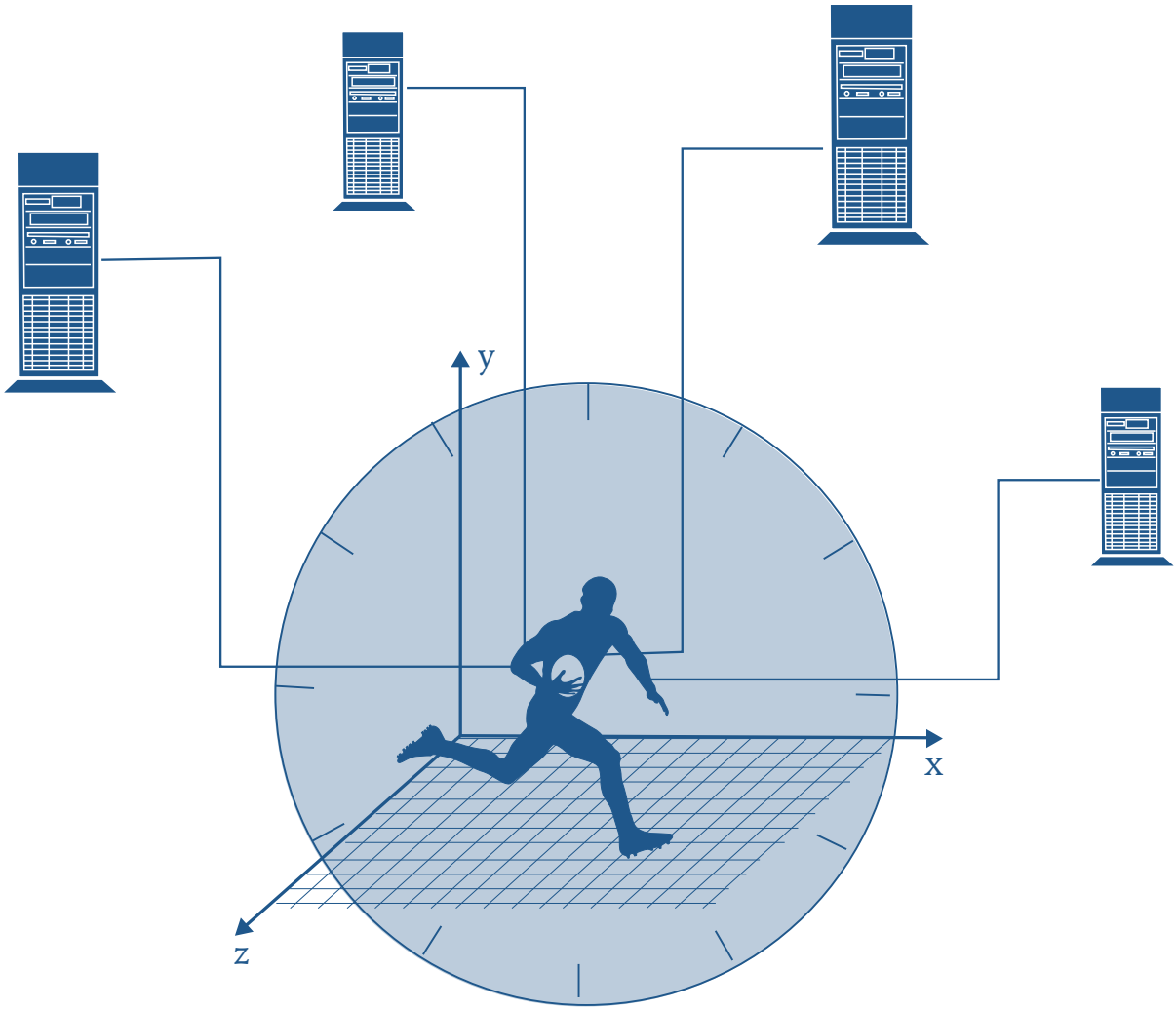
The Australian Academy of Science acknowledges the support of Minderoo Foundation's Frontier Technology initiative, whose funding enabled the Academy to provide project management and communications support to the project. Contributing Academy staff members Dr Hayley Teasdale, Ms Alexandra Lucchetti, Mr Chris Anderson, Dr Stuart Barrow, Mr Paul Richards, Ms Sarah Crowe, Jen van Dijk, Robyn Diamond, and Ms Anna-Maria Arabia are gratefully acknowledged.

NOTES ON THE ILLUSTRATIONS



The illustrations in this discussion paper were developed by visual artist Armelle Skatulski, currently a Techne/AHRC doctoral researcher at the Royal College of Art in London, UK, and a Visiting Scholar at UWA's Minderoo Tech & Policy Lab in Perth, Australia. Armelle has previously researched the datafication of work for the UK-based think-tank, Autonomy, where she produced a schematic mapping of data flows from the worker/'user', the connected workplace, and the networked social factory, to infrastructures of data extraction, analytics, and rent.[3]

Intentionally departing from the aesthetic choices that accompany most discussions of sport and technology, the illustrations are best understood as 'visual quotations' drawn from the world of patents. Retro-futuristic in style, they demonstrate the weird archival quality of patents. While staking sweeping claims to the future, patents are endowed with quaint modes of representation that make them feel like relics of the past. There is an ironic dimension to their documentary value, in that patents are paradoxically both intentional and obscure; hallmarks of privatisation and corporate imperialism, ostensibly proffered to the public domain, but increasingly illegible the more particular their claims become. Setting out these visual quotations in the context of this discussion paper allows us to see the intimacies encroached upon and set in tension with corporate entities' totalising ambition: instrumenting the body, from the roof of one's mouth to the soles of our feet; the dangerous dance of 'possession', analogue and digital; and what it is to be watched over by cold, unblinking cameras and satellites that can capture but cannot see.



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CHAPTER 1: INTRODUCTION

This discussion paper explores and maps the rapid and unchecked acceleration in the collection and use of athlete data, with a particular focus on Australia's major professional team sports, each of which have national competitions and league/association and club structures[α]—Australian rules football, basketball, cricket, football (soccer), netball, rugby league, and rugby union. Much of the discussion also applies to other professional or semi-professional sports in which Australia has a strong international presence, such as cycling, swimming, and tennis, as well as to high performance/Olympic sports, although these are not the primary focus of the discussion paper.

Across professional sports, both in Australia and internationally, there has been an explosion in the capture, aggregation, and processing of athlete data through body-worn sensor devices, athlete management systems, and on- and off-field technologies. Simultaneously, legal, ethical, and data literacy within professional sports is notably lacking. This manifests through a 'get everything you can' approach to data collection, often accompanied by player contracts, vendor agreements, and organisational practices that support continuous data collection both on- and off-field. While other sectors face increasing practices of monitoring and surveillance, professional sport is distinctive in four key ways: (1) the sheer extent of data captured; (2) the intimacy of this collection, which strives to reach into every aspect of the bodies and private lives of athletes; (3) the limited, often tenuous benefits of these data practices to athletes; and (4) the minimal or non-existent privacy and data stewardship practices implemented by practitioners, clubs, and leagues/associations.

With no disincentives and limited perceived risk around amassing ever-more data, accompanied by speculative promises that machine learning and future technologies will reveal novel insights, many sports currently have more data than they can demonstrate is useful, and certainly more than is respectful of athletes' rights across multiple spheres: privacy and digital rights, bodily autonomy, worker protections, and human rights. A sprawling ecosystem of third parties—tech vendors, broadcasters, betting and wagering agencies, fans,

α The notion of what is and is not 'professional sport' is highly contested. The term is not used in this discussion paper to distinguish either elite or paid sport. Instead, 'professional sport' is used as a way of bringing specificity to the discussion, by focusing on the most prominent professional sports in Australia (see https://compps.com.au), as well as the sports within the Australian Athletes' Alliance, each of which is represented by a players' association (see https://www.australianathletes.com.au).

stadium managers, insurers, and drug and sport integrity authorities—are also clamouring to access and leverage data, where it is often seen as a purely commercial asset, rather than as contextual, personal, and often highly-intimate information. The net effect is that these data troves are well beyond anything that athletes themselves, as the people revealed through the data, can meaningfully understand and act on in terms of potential professional and personal consequences.

This discussion paper proceeds from the premise that Australia has a historic opportunity to set forward-looking practices for sports data governance, including legal, organisational, and ethical limits around athlete data collection and use. The focus is on information collected directly from athletes in training and game environments, moving beyond the superficial claim that ubiquitous and extensive human monitoring in professional sport is always justified to athletes under the umbrella objective, without a need for proof, of 'optimising performance' or 'preventing injury'. The aim is to initiate this conversation and motivate an ambition befitting Australia's proud history and leading international role in sport and sports science.

DISCUSSION PAPER AIMS

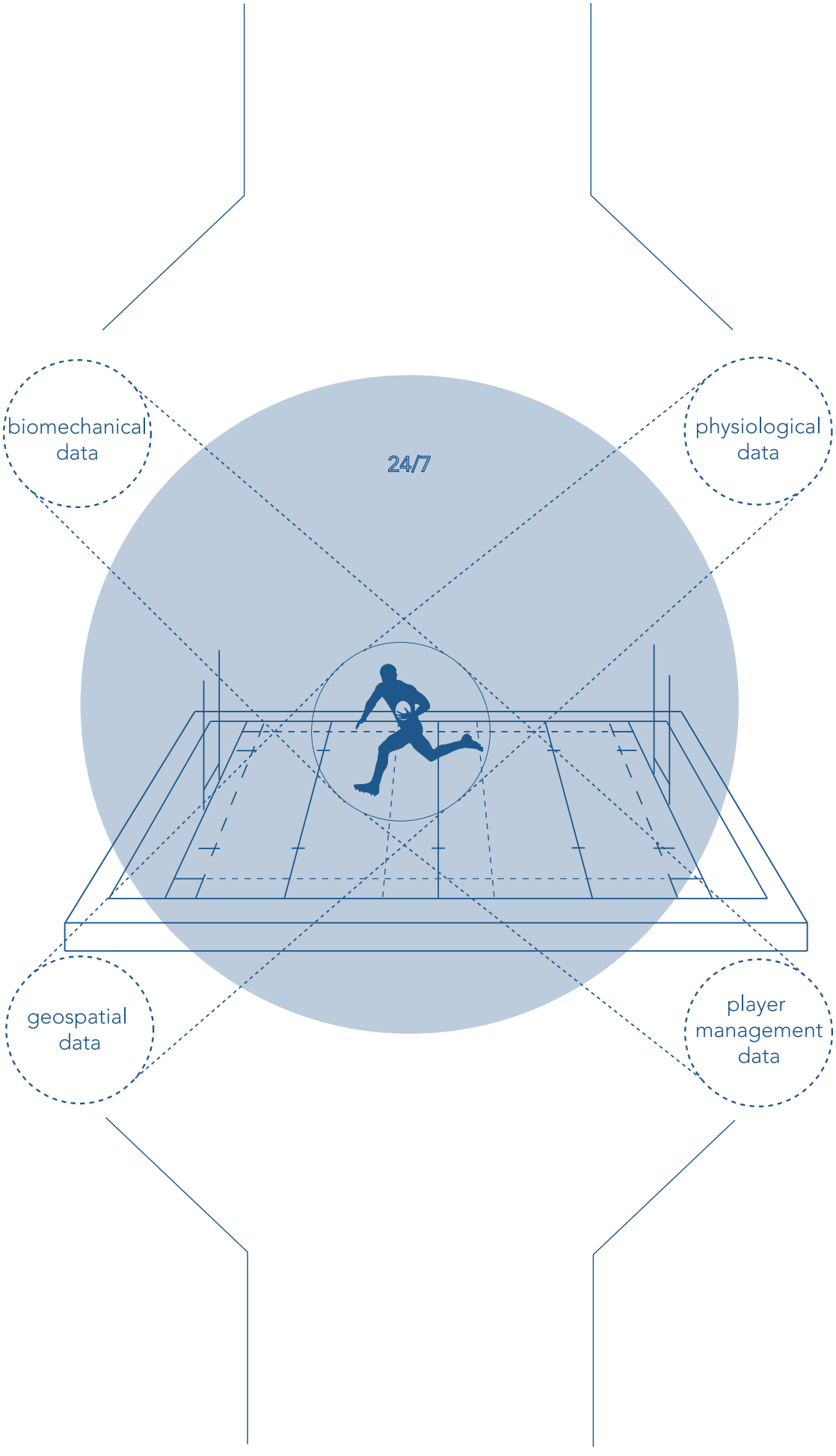
- To stimulate a national conversation on athlete data collection and use, focusing on professional sport as a trend-setter at the frontier of human monitoring and marketisation.
- To position athletes as the focus, recognising their absolute primacy as the source and purported beneficiaries of athlete data collection and use in sport.
- To describe the sheer extent of athlete data collection, focusing on information collected directly from athletes, beyond that obtained by researchers and medical and allied health professionals. In turn, to examine evidence supporting the efficacy of information collection and processing for athlete performance improvement and injury prevention, acknowledging differences between sports.
- To identify that there is an ecosystem of third parties interested in athlete data.
- To describe existing guidance and gaps in terms of legal, societal and ethical, data, and technical literacy in professional sports.
- To identify opportunities for forward-looking sports data governance in Australia.

The discussion paper focuses on foundational questions around the collection and use of information from professional athletes within their immediate coaching, club, and league/association environments. Given the number of concerns that exist around current data practices at this foundational level, the Expert Working Group has maintained this as the predominant focus of the discussion paper. The concerns raised are only amplified and augmented once the broader ecosystem of third-party interests comes into consideration.

OUT-OF-SCOPE TOPICS

To ensure focus, and to prevent distracting the conversation with topics worthy of study in their own right, there are a number of related topics that were not considered by the Expert Working Group. In particular, the following topics are out-of-scope of the discussion paper:

- Practices in community and grass roots sports.
- Practices in high performance/Olympic sports and by the Australian Institute of Sport, state and territory institutes and academies, and national sporting organisations.
- Technologies of sports officiating, including umpiring and rule enforcement.
- Use of data for sports broadcasting, betting and wagering, and fan and audience engagement.
- Use of data for testing and regulating in specific areas, such as doping, sex determinations, and technique and level classification in sports.
- The application of human rights and discrimination laws beyond privacy.
- Practices surrounding the collection and use of athlete data for health purposes by professionally governed medical and allied health professionals.
- Practices surrounding collection and use of athlete data for research purposes by universities and research institutes, which are subject to research ethics processes.


biomechanical data
physiological data
24/7
geospatial data
player management data

CHAPTER 2: SCIENTIFIC AND TECHNOLOGICAL PERSPECTIVE

FROM GAME STATS TO 'ANYTHING GOES': A HIGH-LEVEL VIEW OF THE EVOLUTION OF ATHLETE DATA IN SPORT

As some of the world's great sports enthusiasts, Australians might regard themselves as having a good sense of the role that athlete data plays in professional sport. The story of *Moneyball* made US Major League Baseball statistics famous, but the Telstra Tracker now lights up our football codes and, in stadiums and on screens across the nation, there is an expectation that the traditional sports broadcast and commentary will be supplemented by dynamic game and player statistics.

For half a century, the iconic Australian sports of cricket and Australian rules football have led the way in presenting aggregated game data—balls faced, overs bowled, penalties awarded, marks taken, goals scored. From the early days of pioneering broadcasters and Champion Data, with their manually-tagged game information, to the development of sports tech leaders such as Catapult Sports, Fusion Sports, and VALD Performance, with on- and off-field player metrics, Australia has been at the forefront of the collection and use of athlete data.

The temporal and spatial resolution of this data has increased dramatically. It is now conventional to see measurements of athletes' running speeds, distances covered, acceleration and deceleration metrics—and, in contact sports, the type, position, and number of collisions and tackles. From detailed plots of bat and ball trajectories to heat maps of player field coverage, the augmented experience of gameplay has evolved from macro, end-of-game, summary data to micro, on-field, within-game, detailed data.

But what most Australians—even sporting fanatics, commentators, and athletes themselves—are unaware of is how expansive, invasive, and unchecked this athlete data collection has become.

The first key to unlocking this transformation starts by recognising that not all numbers are the same. To an Australian Football League (AFL) fan, there is little difference between seeing a player's number of goals scored and their number of repeated sprint efforts. But the gulf in the provision of these two numbers spans several decades of technological development and an entirely different mode of data collection. Sitting in the stands, using the same observational

methods employed by Champion Data, you could plausibly keep track of how many goals your favourite footballer has scored. You might also have an instinct for how hard that player has run. But to quantify that instinct and calculate sprint efforts, it takes a body-worn sensor harnessed to the athlete, linked to either a global satellite-based or local navigation system, generating approximately 100,000 positional data points per athlete per game (~2.2 million total team data points across a game), running proprietary software provided by a company such as Catapult Sports or STATSports, being supported by a multitude of custom black-box algorithms, and ultimately calculating an acceleration value that is then measured against a minimum threshold relevant to the particular sport being played.

The second key is that the numbers, and all that goes into creating them, are not confined to the playing field. Game statistics have a start and an end—the game itself. Contemporary data collection practices in professional sport, by contrast, are 24 hours a day, 7 days a week, and cover geospatial, biomechanical, physiological, and player management and wellbeing measures. Data collection no longer stops at the end of a game—it is all the time: training, home, the works.

These momentous transitions—in the vast machinery it takes to generate numbers that are increasingly familiar in professional sport; in the continuous, prolific, back-end data collection from athletes on and off-the-field; and in the unchecked and unregulated nature of the whole enterprise—represent the major evolutions highlighted by this discussion paper. Behind familiar game and player statistics, the *entire ecosystem* of data production and use has transformed, especially over the past decade, to the point that it has become almost unrecognisable. Athlete data has transitioned from rather crude, human-observable frequency counts understood contextually end-to-end by clubs and players, into a complex and opaque sociotechnical system of enormous scale. This system is populated by a vast array of commercial entities and transnational actors and, at the other extreme, is underpinned by body-sensor networks directly measuring individual human function. In its parts and as a whole system, these data practices operate in a way entirely divorced from players and sports management structures.

To ground this discussion paper in real-world insights, researchers at The University of Western Australia's Minderoo Tech & Policy Lab spoke extensively to practitioners who collect and use athlete data in professional sports in Australia and internationally. Those insights informed the points raised in this chapter and the remainder of the discussion paper, and are detailed further in **the Appendix**. Reflecting the complexity and opacity surrounding the collection and use of data, no practitioner in any of these interviews could describe what happens to athlete data once it is 'put in the cloud.' Contrast this contemporary experience with the end-to-end contextual—and even *contestable*—understanding of data experienced by Kate Starre OAM, reflecting on her time in the Australian Women's Hockey Team, the Hockeyroos, right at the beginning of the surge towards increasing data collection in professional sport:

> "Around 1998, I remember as players we would watch and mark up games by scoring details such as whether a trap was successful or not. Ric [Charlesworth, the team's coach,] would post the results on his door for everyone to see and, in team meetings, we would contest the severity of a scored error—whether it was an easy miss or a difficult chance."

WHAT, HOW, AND WHY: MAPPING ATHLETE DATA

In order to understand the scale and ambition of athlete data collection in professional sport, this section addresses what data is routinely collected, how data is collected (i.e. the tools or hardware used to collect data), and why data is collected (i.e. how it is promised to be used, and how it is actually used).

Athlete data (or, more specifically, 'personal information' and 'sensitive information' about athletes—see further discussion in chapter 3) is fundamentally captured and aggregated across four umbrella domains: (1) geospatial; (2) biomechanical; (3) physiological; and (4) player management and wellbeing.

The section that follows outlines the broad characteristics of athlete personal and sensitive information collected in each domain.

1. Geospatial

This domain encompasses any data that describes the geospatial position of a player or game implement (e.g. a bat or ball) relative to a physical environment, such as a sporting stadium or training field. There are two primary ways of recording this data: tracking devices (body-worn and microtechnologies); and video technology.

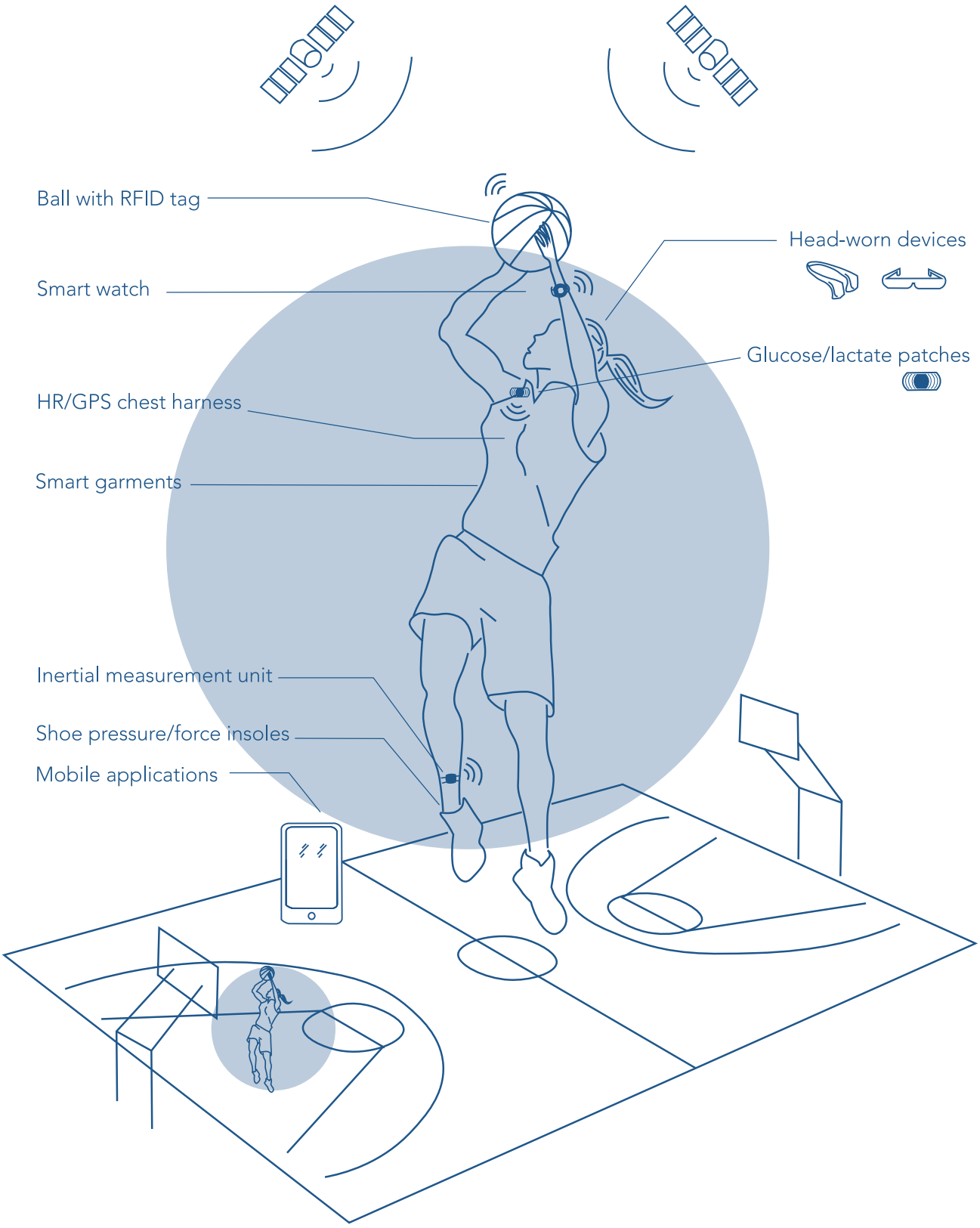
- **Tracking devices (body-worn and microtechnologies)**—A wide array of direct geospatial tracking devices, such as global navigation satellite systems (GNSS—including GPS, GLONASS, Galileo, BeiDou, and other regional systems—often referred to by the collective sub-category GPS), local positioning systems (LPS), and radio-frequency identification (RFID) technologies, are routinely used in sport to collect principally linear kinematic information from players and implements in games and training. Player tracking is the most prevalent application. Body-worn tracking devices provide total distance covered, average speeds, and acceleration profiles derived from data collected at relatively low sampling frequency. Increasingly, GNSS/LPS modules are embedded in custom chest vests alongside a heart rate monitor (included below under the 'physiological' domain), as well as a multi-sensor micro inertial measurement unit (MIMU, described below under the 'biomechanical' domain), which provides measurements of higher temporal resolution to derive acceleration and deceleration profiles. A plethora of studies have investigated the validity and reliability of body-worn tracking devices since they first entered the commercial market, reporting widely variable findings. What is clear is that the derived outputs of wearable microtechnology devices are significantly affected by sampling rates, the type and intensity of movement, manufacturer hardware component integration, and software and algorithm adoption (e.g. filtering characteristics).[4, 5] These are crucial limitations and are further compounded when practitioners adopt a range of methods to interpret and analyse data from these devices, especially as an input for estimating surrogates of athlete 'training load' (see breakout box on surrogates measures) and in making decisions about athlete performance.[6, 7] Alongside player tracking, increasing miniaturisation and improved specifications in sensor technology are rapidly advancing longstanding efforts to develop 'smart implements' that house the requisite components to track high-velocity and high-rotation balls, racquets, and other implements in game environments.

- **Video technology**—One of the most prolific sources of recorded athlete information, two-dimensional (2D) video is widely used in the visual assessment of technical and tactical aspects of performance, and is generally sampled at a higher frequency than body-worn GNSS/LPS tracking devices (standard video at 25-50 Hz; high-speed video > 100 Hz). Video technology poses particular opportunities and challenges due to the level of athlete identifiability it involves and its ubiquity and accessibility well beyond sporting teams—especially by broadcasters and other observers. The extent of its collection and use deserves particular scrutiny from technical, legal, and societal and ethical vantage points, both within and outside the sporting sector. Determining athlete position from video has historically been a labour-intensive manual undertaking, generally limited to short segments of play and small volume areas (e.g. basketball, netball, and tennis courts, as well as swimming pools), and subject to digitising errors and occlusions (e.g. obstructions to the camera view and the influence of water). Advances in multi-view camera calibration and auto-tracking computer vision algorithms are fast addressing these limitations, with automated video analysis offering an alternative to body-worn tracking devices in a number of sports, particularly constrained-space sports such as swimming, football (soccer), tennis, netball, and basketball.[8]

The primary benefit of geospatial technologies is to undertake field or court-based positional analyses of players and teams and better understand athletes' gross linear kinematic profiles such as repeated sprint, acceleration, and deceleration efforts. Historically, geospatial technologies are the most common technologies used to understand patterns of play based on the positions of players and implements. Given the continuous nature of geospatial data collection, it is prolific, highly personal, and widely disseminated as a data source.

SURROGATE MEASURES

Various surrogates measures of athlete training and competition demands, commonly referred to as athlete '**workloads**', '**training load**', or simply '**load**', attempt to capture the incalculable cumulative physiological toll of training and competition. Calculated in a non-uniform manner, 'workload' is one of the most quixotic contributors to athletic performance and injury.[9] Across Australian professional sport, practitioners report adopting their own formulas, ratios, inputs, and 'secret sauce' to deduce workload, in an attempt to identify tipping points at which an adjustment to training or play would be advised. The most popular metric used to assess the impact of workload is the 'acute:chronic workload ratio' (ACWR),[10, 11] which has been widely promoted as a method for quantifying rolling and acute player workloads to help identify and prevent injury risk.[12] While the quantification of the cumulative impact of an athlete's training load is a commonly applied practice of modern-day sports science, workload estimates and ratios are nevertheless controversial. The method of calculating the ACWR and its applicability for use as a causal prognostic factor of injury is not yet supported by methodologically sound evidence and is questioned in the literature.[9, 13, 14, 15, 16, 17] Though the ACWR was initially promoted by the Australian Institute of Sport, the organisation now discourages its use.[18] Nevertheless, it remains a common feature in sporting contexts, and is still included in many athlete management systems and commercial software applications.


Ball with RFID tag
Smart watch
HR/GPS chest harness
Smart garments
Inertial measurement unit
Shoe pressure/force insoles
Mobile applications
Head-worn devices
Glucose/lactate patches

2. Biomechanical

This domain incorporates data relating to how (kinematics) and why (kinetics) a body or equipment moves. Technically speaking, the gross movement captured by geospatial technologies is a form of biomechanical kinematic data; however, this section focuses on more granular biomechanical data specific to an individual athlete. (Curiously, biomechanical information seems to overlap significantly with 'biometric identification' in privacy and surveillance studies, though little attention appears to have been given to the implications of this overlap for sports science). There are three primary ways of collecting biomechanical data. The gold standard in terms of accuracy and quality is laboratory-grade data. Beyond this, there are two broad categories of off-the-shelf biomechanical data collection tools, both of which have exploded in use since the 2000s: dynamometry; and microtechnologies, position encoders, and video-based assessments.

- **Laboratory-grade data**—Multi-dimensional, high-resolution biomechanical data is collected in advanced research laboratories equipped with technologies such as opto-reflective 3D motion capture systems, force plates and other dynamometry equipment, electromyography, medical imaging tools (e.g. ultrasound, DEXA), and 3D scanners. These tools are used to quantify and estimate athlete kinematics and kinetics, tissue forces, and applied loads using validated advanced biomechanical models. Notwithstanding the clear value and high precision of what can be done in a laboratory setting, within Australian professional sport, the time and cost associated with laboratory-grade data collection make it almost completely prohibitive, particularly for entire team assessment. Laboratory-grade data may be used to validate other technologies (e.g. to establish ground truth under the FIFA Quality Programme[19]), or medical practitioners may request it in individual instances for injury risk assessment as well as for rehabilitation and return-to-play (RTP) following injury. Nevertheless, day-to-day collection and use of laboratory-grade data in professional sport are currently limited.
- **Dynamometry**—Isokinetic (a type of muscular contraction which accompanies a constant rate of limb movement) and isometric (the contraction of muscles without any movement in the surrounding joints) dynamometers, primarily in the form of portable force plates, as well as load cell and strain gauge-based testing kits (hand held, racks, and rigs) are ubiquitously used across professional sport. Widely regarded as the gold standard in muscle testing their principal application in sport is for testing muscle strength, identifying strength deficits and asymmetries, and for informing rehabilitation practices.[20, 21, 22] Reliability and agreement of these devices against gold standard criterion is dependent on the use-case application, output variable being assessed, type of dynamometer, muscle group under examination, and testing protocols or standards applied.[23, 24] Despite widespread use in professional sport, there is ongoing debate surrounding the predictive value of isokinetic strength assessment for identifying athletes at risk of injury and the influence of inter-limb strength asymmetry on sports performance more generally.[25, 26, 27]

- **Microtechnologies, position encoders, and video-based assessments**—There has been considerable growth in wearable technology and other sensor- and video-based technologies as tools to estimate athlete and implement motion and force data. One technology that has been adopted extensively in clinical and sports biomechanics is the micro inertial measurement unit (MIMU), which comprises three components: an accelerometer, a gyroscope, and a magnetometer. MIMUs have allowed clinicians, in particular, to quantify walking gait and low-velocity functional assessment tasks quickly and feasibly. Despite being marketed for use in sport settings, historical MIMUs—as multi sensor-fused units—are not fit-for-purpose for most sports due to the lower specifications of the components, which can result in data-clipping due to the high-velocity and high-impact events endemic to the sports environment. In particular, accelerometers have historically been limited to ± 16 g, and gyroscopes to 2,000 °/s, both at lower-than-required sampling frequency for sports application.[28] Similarly, their use in recording upper limb joint angle motion and critical events (e.g. ball release, maximum external shoulder rotation) in sports such as cricket, tennis, and baseball, ideally requires a floor minimum ± 40 g accelerometer specification, and 4,000°/s gyroscope, sampling at a minimum of 200 Hz.

  Despite limitations in their use for quantifying angular motion, the single component of the MIMU that is regularly used in professional sports is the accelerometer (tri-axial linear data). Most accelerometer components that sit side-by-side with a GNSS/LPS module in commercial off-the-shelf tracking devices have a sampling frequency between 100-1000 Hz (real-time transmission versus onboard storage), compared with the 10-20 Hz frequency of GNSS systems. The higher accelerometer sampling rate results in their preferential use when determining individual sprint acceleration and deceleration efforts in most team-based sports and when used as input into 'workload' calculations during games and training.[4]

  Very recently, MIMUs with higher gyroscope, acceleration, and sampling rate specifications have come to market (e.g. Noraxon Ultium Motion, VICON Blue Trident), expanding their utility for professional sports applications. When combined with expected improvements in accuracy, miniaturisation, data transfer capabilities, and sensor fusion techniques, a marked increase in the use of multi-component MIMU sensors in professional sports over the next five years is widely anticipated (instrumented mouthguards being an emergent example).

  Turning to position encoders and video-based assessments: in the controlled environment of a gym, the measurement of bar velocity is synonymous with the discipline of strength training. This type of data provides the coach and athlete with information concerning bar displacement, velocity, and power, offering practitioner insights into an athlete's quality of movement. Professional sports use multiple technologies to measure bar velocity and overall postural form in strength training environments: linear position encoders, accelerometers, wireless infrared optoelectronic cameras, and smartphone apps (using the phone video camera). Linear position encoders have been shown to be reliable and sensitive,[29] with strong criterion validity.[30]

Off-the-shelf biomechanical data collection tools: a cautionary note

Instead of laboratory-grade data, the vast majority of biomechanical data collected in Australian professional sport is based on a proliferation of lower resolution, off-the-shelf, rapid-assessment tools that attempt to replicate lab-based biomechanical variables, often using surrogate measures. One of the sectoral challenges that prompted this discussion paper is the increasing concern of practitioners in the sector surrounding the validity (both as to what the tech purports to measure, and its accuracy against a ground-truth), and reliability (across time and between testers) of these tools.

Capitalising on the desire and need in professional sport to be at the leading edge and not to be left behind, the sports tech market has spawned many unvalidated products for a captive consumer base. These are typically accompanied by dubious marketing claims that the products will either 'improve performance' or 'prevent injury', with limited evidence or independent research to support these claims (likely raising consumer law as well as ethical issues). For the most part, these products deliver surrogate 'workload' estimates of an athlete's status and, with it, susceptibility to injury, as well as poorly, if at all, validated internal tissue load approximations.

3. Physiological

In addition to the standard measures of an athlete's anthropometry (e.g. height, mass, and limb lengths and girths), this domain encompasses all data that seeks to define the body's status either prior to, or in response to, a game or training activity, for the purpose of evaluating the homeostatic impact of exertion (e.g. fatigue).[31]

Of all the personal data collected on professional athletes, arguably none has been more longitudinally and ubiquitously collected than heart rate (HR) metrics, recorded using electrocardiograph sensors (chest mounted) or light based optical photoplethysmography (wrist mounted). As Schnieder and colleagues note in a review of HR measures in sport and health settings, HR and its derivatives are the most common surrogate markers of cardiac autonomic nervous system status.[32] For professional athletes, HR serves as an indicator for aerobic adaptation as well as fatigue.

Physiological HR data is now collected alongside blood-borne markers of exertion (e.g. lactate), mechanical muscle damage and resultant inflammation (e.g. C-reactive protein), oxidative tissue damage,[33] systemic stress (e.g. cortisol), and recovery (e.g. testosterone).[34] In recent years, this domain has also come to include technologies that assess electroencephalogram (EEG) recordings as a biomarker of performance.[35]

4. Player management and wellbeing

The large and rapidly expanding domain of player management and wellbeing includes cognitive, behavioural, and more generalised 'health and wellness' data associated with the global 'wellbeing' of the athlete, often collected within burgeoning integrated databases referred to globally as 'athlete management systems', and within a given sport or club as 'the AMS.' In particular, there has been an increase in the number of interfaces (primarily mobile apps) that encourage athletes to self-report mental and physical health, nutrition, sleep, fatigue, recovery, and injury status. In 2018, the 'Recovery and Performance in

Sport: Consensus Statement' acknowledged standardised questionnaires as a key component of a multivariate system to monitor athlete recovery and overall wellbeing.[36] However, many practitioners in professional sport query the validity of these tools when converted to apps. For example, as one practitioner stated:

> "The challenge is always in the quality of the questions asked within an app, and whether or not they are using validated wellness and health tools. A number of sports and clubs have started to customise and adapt tools, even simple things like the Borg Scale; combining scales, making it colourful and now adding emojis, all of which impacts the validity."

In women's professional sport, these tools have extended to smartphone apps to track menstrual cycles despite little evidence of the impact of menstrual cycles on performance or injury risk.[37] At the national level, this has led the Australian Institute of Sport to establish the Female Performance & Health Initiative as a centralised point of expertise on female health and how it impacts the performance of athletes.

MENSTRUAL TRACKING

Menstrual cycle tracking in female athletes is increasingly common in sport and there are numerous role holders within professional sport that seek to access this type of athlete data.[38, 39] Explicit permissions from athletes are not always collected prior to this information being shared, with most clubs and practitioners relying on an opt-out approach. A number of commercial apps are also being used to record menstrual cycle information which can be integrated into athlete management systems. Various practitioners use menstrual cycle data to influence and guide practices surrounding strength and periodic training, nutrition, and injury risk, often in domains where there is limited evidence to support its application. Many in the sector argue that menstrual tracking data is aiding performance; however, to date, this position is not backed by scientific evidence and considerably more research is required. At a minimum, if menstrual cycle data is collected, a medical practitioner must have oversight to ensure that there is early identification and early management of medical issues. It is also important for athletes to understand who menstrual cycle information is being shared with, and why and what it is being used for.[40] The position of the AIS Female Performance & Health Initiative is that menstrual cycle data collection in female athletes should never be mandatory.[41]

One exploding area of athlete data collection that takes place beyond training and competition is sleep monitoring. Mounting evidence indicates that the optimisation of sleep can significantly enhance athletic performance.[42] However, the merging of the fields of sleep science and athletic performance is relatively new, with more than 80 per cent of the papers applying sleep monitoring to athletes published in the last decade.[43] To accurately measure sleep and the associated parameters (e.g. quantity, quality, and depth) a polysomnogram (PSG) is required. This involves the concurrent recording of eye movement, brain activity, heart rate, muscle activity, oxygen saturation, respiration, respiratory effort, and body movement and sound. Considered the gold standard for measuring sleep, PSG is expensive and complex to administer, requiring specialist expertise that limits its use to specialist sleep research laboratories. These limitations have driven the adoption of both research and consumer-grade sleep measurement tools in professional sport that rely on wearable and near-position (e.g. smartphone) technologies such as accelerometers, gyroscopes, heart rate, sound, and pulse oximeter recordings. At the present time, despite what appears to be increased uptake by professional leagues, clubs, and athletes, the bulk of these products, especially

the consumer-grade products, remain a sub-optimal surrogate for PSG. The devices are not well validated, especially for quantification of sleep quality/depth/staging, have poor transparency of data treatment (e.g. data filtering characteristics) and storage (e.g. cloud-based and accessible to manufacturers), involve proprietary algorithms, and generally over- or under-estimate outputs against established gold standard outputs [44, 45, 46].

Similarly, owing to the rising acknowledgement of the short- and long-term physical and mental health effects of sport-related concussion, neuro-cognitive testing is an additional fast-growing feature of this data domain in all football codes, cricket, and more.[47, 48] Building on the traditional balance assessments of concussion, contemporary tests (e.g. the King-Devick Test) now incorporate video collection in the testing toolkit.[49]

Despite the benefits and concerns surrounding the collection of wellness and wellbeing data, data collection of this type is significantly increasing in professional sport. It is being stored and collated in large and predominantly cloud-based custom athlete management systems and associated with other data to mine for unknown relationships that could be related to injury or performance. Indeed, interviews with athletes and practitioners highlighted incidences and challenges of players biasing or masking their inputs in order to not overtly share their physical or mental health status with medical, coaching, and management staff and other players.

SUMMARY OF STANDARD ATHLETE DATA COLLECTION

Across these four umbrella domains, and excluding other health data collected by medical and allied health professionals (outside the scope of this paper), athlete data that is *routinely* collected across Australian professional sports *at-scale* includes:

- semi-automated or manually-coded summary player and game statistics (e.g. goals scored, serves, assists, time on-field) throughout the game (i.e. traditional game statistics or sports analytics)
- multi-view video footage of athletes during games and in training (i.e. video data)
- geospatial tracking data—primarily GPS/LPS based measures (e.g. distance covered, speed, time on-field) across games and training
- dynamometry-based measurements related to player screening and return to play following injury
- power measures (kinetics)
- MIMU data—predominantly accelerometer data collected at 100 Hz (up to 1000 Hz) for repeated sprint acceleration and deceleration efforts. These units are also used to determine running gait key events (e.g. foot-strike, toe-off) and phases (e.g. stance, flight) and to identify individual athlete gait profiles (e.g. identifying bilateral asymmetry and establishing baseline 'healthy' movement profiles for post-injury return-to-play comparisons)
- heart rate metrics (e.g. heart rate variability) throughout game and training
- self-reported daily wellbeing scores
- nutrition information via photo logging apps that detect meal size and composition

- sleep monitoring data via self-reporting tools or, more recently, via commercially available wearable and near-position devices (e.g. wrist bands, rings, smartphone apps).

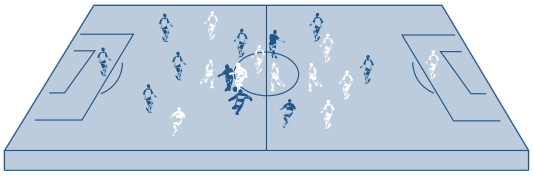
DISCUSSION POINTS

Data is a marvellous magic trick. It can be interpreted to reveal certain things—and what it can reveal, it can do at scale. For an AFL footballer, for example, 100,000 data points can describe where they are on the field in a given game. But what can data *not* reveal? And what if the shadow of that data—the weight of negative space that we *cannot* or *do not* collect—is orders of magnitude again? For an AFL footballer, what about every element of their physical and cognitive response to the dynamics of play and its complex interaction with their own state at 100,000 points in time?

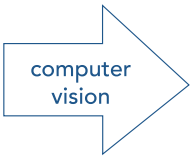
The trick is that the invocation of data and its interpretation can obscure and reduce other forms of knowing and understanding the human condition.[50, 51, 52] In effect, the data that exists about elite athletes is a very wide and very shallow pool, sometimes tending to a mirage. The shallowness reflects the absence of context, of interpretation, of balance. Data can give us a spectral analysis of an eyelash as an insight into a person. It can preserve footprints on the beach as insight into a moonlit stroll. And the people that data is telling us about, in the context of professional sport, are no ordinary people. The highest levels of sporting competition are about extraordinary people doing extraordinary things. They are, by definition, *outliers*. They deviate from the normative population mean and generally defy prediction.

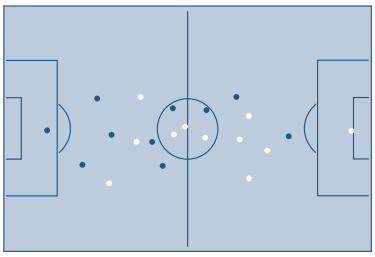
This being a discussion paper, it is apt to include in this chapter a number of provocations and questions that deserve to be asked and debated within professional sport:

- What are the limits of the types of athlete data that are collected in professional sport? What impact does this have on our picture of professional athletes?
- What athlete data do we not collect by necessity or choice? What impact does this have on our picture of professional athletes?
- Is there a type of data collection not included in the above summaries? Does it have a scientifically demonstrated benefit to athletes?
- What effect does the scale of data collection have on the ability to explore, argue, and contest? Does the existence or volume of data effectively become an argument, in and of itself?
- Is there a natural hierarchy between data we can capture, measure, and analyse, on the one hand, and what is unquantified or unquantifiable, including perception, insight, intuition, and expertise, on the other? What are the consequences of this?
- If all of the data described in this chapter was no longer collected, what impact would it have on athletes and on the game?
- Where is this data collection going? Is it good for athletes? Is it good for the game?

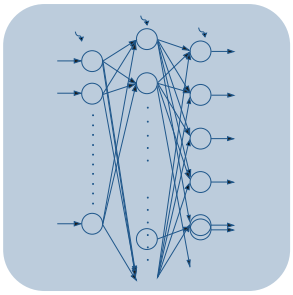


Venue





Tacking data plotted into a diagram of a football pitch



Machine Learning

Algorithm 1300 Template Learning Algorithm

1301. **Procedure** TemplateLearn ($\mathcal{X}$)
1302. Initialize the template with a randomly selected example $\Gamma = \hat{X}$
1303. **while** $\Delta\Gamma <$ *thereshold* or *iteration* < max **do**
1304. **for** each sample Xn om dataset $\mathcal{X}$ **do**
1305. Calculate cost (I, j) = ||Γ(i) - Xn(j)||2 for each player-role pair
1306. Compute Pn using the Hungarian algorithm
1307. Align the example Xn = Pn • Xn
1308. **end for**
1309. Update the template Γ by averaging aligned $\mathcal{X}$
1310. Compute the difference ΔΓ
1311. **end while**
1312. return Γ
1313. **end procedure**

Algorithm for learning a template by aligning a class of sports plays, "System and method for predictive sports analytics using body-pose information."Patent US10824918B2, 3 Nov. 2020, STATS LLC.

THE LURE OF ARTIFICIAL INTELLIGENCE: MACHINE LEARNING IN PRACTICE

More than 25 years ago, a landmark paper raised the spectre of computers and artificial intelligence (AI) profoundly impacting sport and sports science.[53] Today, with the troves of athlete data that exist throughout professional sport, there will be an ever-increasing lure to use that data as the source material for AI tools. It is nevertheless crucial to consider what this data is really measuring and what it is not. These limitations are amplified by the application of AI tools, whose utility depends entirely on what data is available to be optimised.

This section considers the current domains in which AI tools and, more specifically, data analytics and machine learning, are applied in sport, aiming to stimulate discussion on what they are really achieving, and what they are not.

Predictive analytics (individual/team strategy)

The use of statistical algorithms and machine learning techniques to identify individual and team strategies based on historical geospatial data is currently the most developed sphere of AI implementation in sport.[54] Prediction looks to estimate the outcomes for unseen data. For example, based on past results and other features such as whether the game is at home or away, we might predict which football team would win a particular game. Forecasting is a special type of prediction in which predictions are based on time-series data. For example, based on the dates and heights of previous jumps, we might forecast how high an athlete might jump at next month's competition. Forecasting introduces a number of challenges such as deciding how far back to look, as well as identifying and forecasting exogenous features to include. For instance, if wind speed is important to forecasting future jump performance, can we accurately forecast this? As yet, machine learning is not extensively or deeply implemented across the Australian professional sports landscape. However, with the proliferation of geospatial tracking data and video feeds now collected and aggregated as a standard practice and the increasing availability of remote tracking and analytical tools, the broader implementation of predictive analytics is likely to be increasingly attractive to the sector. This raises broader questions of data access, equity, and fair play for leagues, associations, and governing bodies. It also poses the challenge: if performance enhancement through drugs is highly regulated, what about performance enhancement through data?

Labour-reducing tools

A significant use-case for machine learning, in sport as in other fields, is providing labour-reducing assistance via the automation of previously manual tasks such as video digitising.[55] This is best evidenced by the application of pre-trained computer vision machine learning models (e.g. OpenPose, DeepLab Cut) for the purpose of automatic full-body pose estimation.[56] Human manual identification (digitising on film/video) of key anatomical landmarks has been an integral part of biomechanics for over half a century, in order to accurately model joint angles and joint axes of rotation. The application of machine learning models to video footage now allows the auto-detection of approximated joint centres and the subsequent calculation of 2D joint angles, significantly reducing the labour cost for biomechanists and performance analysts. A note of caution here is that computer vision 2D pose estimation models currently lack accuracy, precision, and dimensionality (specifically,

segment position and orientation information) when used in place of traditional 3D motion capture. This can be attributed to computer vision pose estimation tools representing humans as stick figures in 2D or pseudo-3D space (meaning human segments are not represented in 3D; only the global reporting system is 3D). As long understood by biomechanists, the computer vision scientists Zhang and colleagues recently noted, in a paper titled, 'We are More than Our Joints: Predicting how 3D Bodies Move':

> "Body joint locations, however, do not fully constrain 3D human pose, leaving degrees of freedom (like rotation about a limb) undefined, making it hard to animate a realistic human from only the joints".[57]

The pursuit of injury prediction and prevention

Given the dynamic, multi-faceted, and complex nature of injury mechanisms, sports science has long sought to discover the links and patterns that contribute to athlete injury. Supervised and unsupervised machine learning approaches, which may identify previously unknown relationships between datasets and provide new insights, is therefore particularly attractive in this essential area. Very recently, there has been a marked increase in efforts to apply machine learning techniques that claim to predict and prevent injury, as well as to classify individual athletes as being at high or low risk of injury.[58, 59] While a close examination of the methods and techniques currently being applied is beyond the scope of this discussion paper, the methodological quality of the majority of papers is moderate to very low, with limited evidence that machine learning models have been effective in directly predicting and preventing injury to date.[59] Despite the continuing hope of uncovering new relationships that contribute to injury, most of these models do not provide any new insights beyond variables already highlighted by traditional research, such as anthropometrics, playing history, previous injury history, or workload.[60, 61, 62] There is also a risk that the application of machine learning techniques is becoming increasingly divorced from any sort of mechanistic approach to the factors that contribute to injury. This creates compounding problems, especially given (1) understanding causal mechanisms is necessary to designing targeted interventions; and (2) the identification of risk factors is only useful if something can be done about them, beyond simply removing athletes from games or training. Any model that is developed also clearly requires clinical validation prior to implementation.[63]

Higher-resolution on-field insights

One of the most promising emerging applications of AI techniques is in bridging the lab-to-field divide; an ecological validity challenge that has long plagued sport science. In particular, current work is seeking to create AI tools to link lower-resolution on-field data with high-resolution laboratory-grade data, with the ultimate purpose of providing quality on-field insights into both observable and unobservable measures.[64, 65, 66] This is exemplified in the biomechanical domain where, as noted above, Australian professional sports teams have rarely availed themselves of laboratory-grade data due to time and cost. Through AI tools and historical high-resolution sports biomechanics datasets, laboratory-grade data such as ground reaction forces collected using a forceplate, or joint kinetics (e.g. joint moments), can be linked with lower-resolution video and MIMU data.[67] While these advances hold great promise, the remote or virtual nature of applying AI techniques to athlete analysis

presents significant challenges to traditional models of athlete knowledge and consent. These are challenges that professional clubs would do well to address, especially to mitigate problematic access by third parties such as competitors, broadcasters, and betting and wagering associations.

One of the most troubling consequences of the surge towards data collection across all of the domains described above, coupled with the sense of promise surrounding data analytics and machine learning, is that this shifting focus reconfigures the makeup of expertise within professional clubs and their talent pipeline. This is in part a response to the varied success, and notably some significant failures, of SSSM practitioners experimenting with data analytics and statistical methods.[68, 69] Positions once dedicated to specialised sub-disciplines— exercise physiology, biomechanics, strength and conditioning, motor control/learning and skill acquisition—are rapidly and noticeably being replaced by data scientists, data engineers, and computer vision and machine learning specialists. As this trend continues, what is most at risk is the function that experts have long played in *contextualisation* and *translation* of data and, more recently, analytics.

Without the experience of experts to contextualise and translate, athletes risk being exposed to decisions that are informed exclusively by data. As recently observed in the National Rugby League (NRL), this can have dramatic consequences when player complaints of increased fatigue following rule changes in the 2020–21 season were met with flat rejection by the NRL on the basis that "*the data [gross seasonal averages pulled from body-worn GPS tracking devices] simply does not support that assertion*".[70]

WHAT NEEDS TO CHANGE: LITERACY

Epitomised by the ground-breaking establishment of the Australian Institute of Sport, which served as an international exemplar for a national high performance system, Australian sports and sport scientists have been international leaders in the development and adoption of technology. However, in welcoming new technologies, especially in professional sport, there has been a glossing over of many areas of data and technical literacy, as well as legal and ethical literacy. This is manifest in the overriding message we heard from practitioners working in professional sport, that vast amounts of athlete data are currently being collected, and 'we are collecting more than we know what to do with.' This is against a backdrop where training in the technical, legal, and ethical issues surrounding personal information is minimal to non-existent. There was a palpable sense that this might give rise to problems in an industry conscious of the debilitating impacts of controversies and scandal. Many practitioners were unsettled about athletes' lack of awareness or involvement in practices of data collection, use, and decision-making that personally and professionally concern them. At the same time, there was also a generalised sense of the tech and data train having 'already left the station' and, just as in everyday life, a degree of resignation about lack of control over surveillance activities and concomitant privacy and security interests.

Across the board, insights from Australian practitioners, athletes, and representatives showed low literacy around data policy and legal, governance, and societal and ethical considerations. We heard anecdotes of practitioners and sports tech providers regularly leaving clubs with troves of highly sensitive athlete data. Similarly, it was the understanding of many practitioners that

leagues or associations lay claim to data based on their role running competitions or providing league-approved technology such as GPS units. There were very few operational practices to respond to legal and ethical requirements around athlete privacy, athlete security, and athlete rights, with conversations on these topics sparse and rare. As one practitioner with 25 years' experience at the highest levels of professional sport observed:

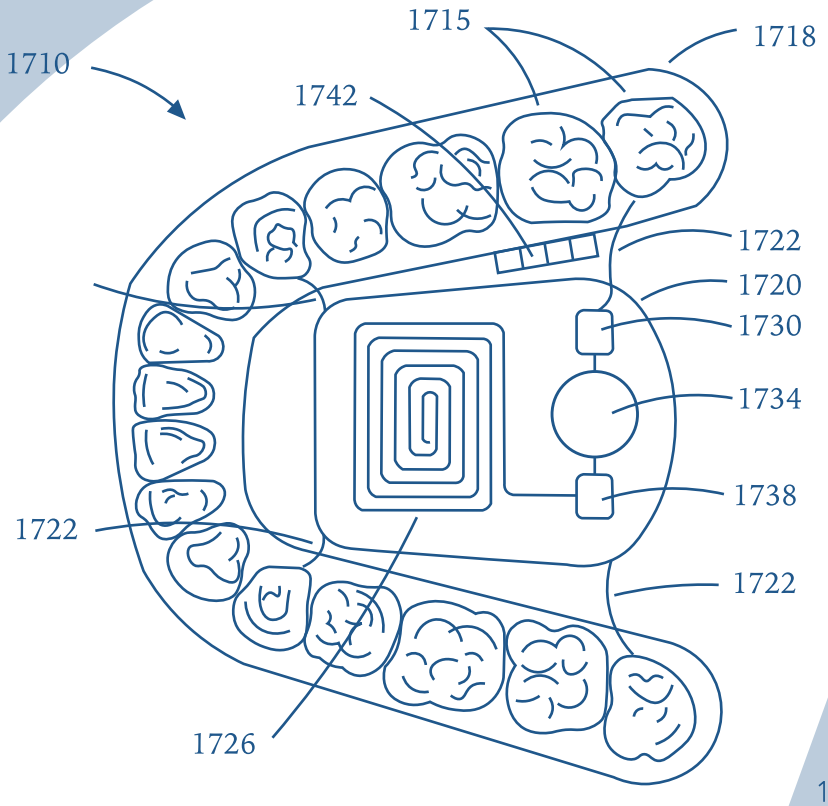
> "Personally, I have always felt a moral obligation to the players with respect to the data we have collected from and about them over the years. However, from both an organisational and accreditation perspective I have never once had a specific discussion, nor had any information presented, that informed me of any legal obligation."

When asked if they knew what happens to athlete data once it is uploaded to a cloud server, not one interviewee could provide a clear answer. Similarly, none knew if their cloud-based accounts were housed in Australia or offshore.

This knowledge vacuum offers a unique opportunity for the accrediting bodies of the sector to provide guidance, training, and support on these topics. Professional sport needs to shift away from its current state of exceptionalism and 'collect it all' ideology to a more informed athlete-focused approach. An opportunity now exists to set world-leading best-practice standards that centre and acknowledge athletes as the source and principal beneficiaries of data about themselves, with associated rights and responsibilities for all those that deal with athlete information.

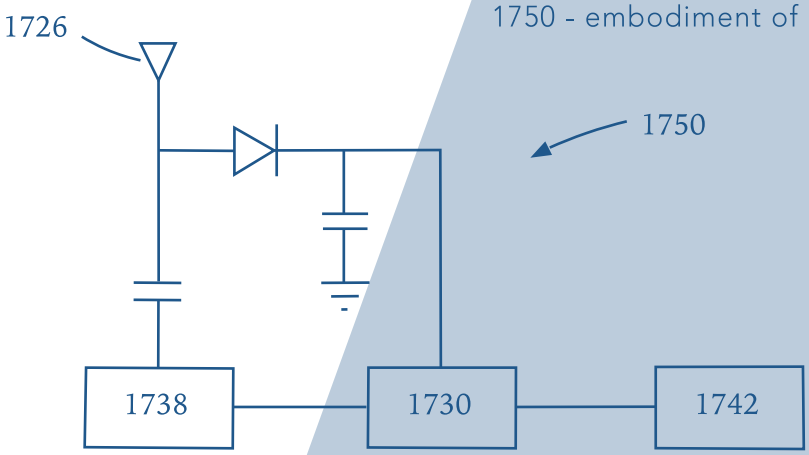
There were several specific areas where practitioners expressed a desire to up-skill and improve professionalism across the sector as a whole. These included:

- improved training related to the appropriate collection of 'meaningful' data (as opposed to 'collecting all the data')
- up-skilling in data analytics (noting recent controversies surrounding inappropriate use of statistics in sporting contexts)
- improved training, knowledge sharing, and centralised standards surrounding the validation and testing of third-party technologies used to collect and report data
- opportunities to learn best-practice for acting on acute issues such as head injuries/concussion[71]
- best-practice guides for dealing with third-party tech vendors, including to ensure appropriate protections of both athletes and clubs
- improved training protocols and transparent standards surrounding the collection, storage, aggregation, and treatment of data, including for third-party tech vendors, and any regulatory body receiving athlete data (e.g. national leagues or associations)
- data governance training and up-skilling with respect to legal concepts including consent and privacy
- improved training and up-skilling surrounding practitioner roles and responsibilities with respect to data management and protection, including re consent, security, and privacy.



Top view of a signalling device that can be placed in a user's mouth, from "Apparatus, systems, and methods for gathering and processing biometric and biomechanical data," patent US 10675507 B2, Jun . 9 , 2020. Current Assignee: Nike Inc.

1710 - embodiment of signalling device
1715 - rear teeth
1718 - retainer
1720 - base
1722 - clips
1726 - RF antenna
1730 - microcontroller
1734 - internal power source
1738 - signal discriminator
1742 - modulator
1750 - embodiment of a circuit



CHAPTER 3: LEGAL PERSPECTIVE

This chapter surveys the Australian law that applies to athlete data in professional sport and considers legal responses to the 'collect everything you can' approach that currently prevails in the sector. Acknowledging that there are numerous different organisations and data types that fall within the scope of this paper, and that each will have features that may alter how the law applies, this chapter aims at identifying in broad terms the major legal issues at play.

The first point of focus is Australia's leading federal privacy instrument, the *Privacy Act 1988* (Cth) (Privacy Act), which governs the major Australian professional sporting leagues, associations, and clubs considered in this discussion paper.[72] The Privacy Act promotes the protection of privacy of individuals, as well as responsible and transparent handling of individuals' personal information by entities.[73] After considering the Privacy Act, the chapter turns to questions of data ownership, legal practices in Australian professional sport in comparison to the United States and Europe, and third-party data access. Though discrimination and human rights laws beyond privacy are out-of-scope for the present paper, both areas of law offer additional support for the central importance of athletes in all considerations of information about themselves.

THE PRIVACY ACT: KEY TERMS

Across the four domains of athlete data discussed in chapter 2 (geospatial, biomechanical, physiological, and player management and wellbeing), all of the information that is collected or generated about identified or reasonably identifiable athletes would fall within the legal definition of "personal information" under the Privacy Act.[74] The vast majority of it would also fall within the more protected subcategory of personal information termed "sensitive information",[74] particularly by virtue of being "health information". Health information includes "information or an opinion about the health... (at any time) of an individual",[75] or about a health service provided or to be provided, or personal information collected, where a health service includes activities intended or claimed to assess, maintain, improve, or manage health.[76]

The rationale for most of the athlete information in this discussion paper being "health information" (and therefore "sensitive information") as a legal matter is quite straightforward. Professional athletes are continuously monitored in order

to generate information and opinions about their physical and/or psychological health (either directly or through various surrogate measures of workload, wellbeing, etc, as discussed in the previous chapter). In particular, athletes are monitored for whether they are performing at or beyond their capacity, as well as for risks of illness or injury that could be caused by exceeding their limits. This meets the definition of health information in the previous paragraph. That this is "health information" is further reinforced by the Office of the Australian Information Commissioner's (OAIC) 'Guide to Health Privacy', which cites information recorded by a fitness club as health information.[77] The lack of efficacy of many contemporary monitoring techniques in clearly assisting the prediction and prevention of injury, or improvement of performance, as described at the end of chapter 2, is beside the point—it is sufficient that this is the *purpose and intent* of the monitoring, informed by claimed measures of the athlete's health.

The classification of most of the information collected on athletes during and outside game and training environments as "health information" is a significant adjustment for the sporting sector. In the vast majority of sports, the term used by the sector to describe large swathes of athlete data is 'performance information' or 'performance data.' However, 'performance' is not a recognised legal category of information. In turn, the sporting sector's misleading use of the term 'health information' or 'medical information' to refer exclusively to information generated in the context of a relationship between a health professional and an athlete is also unsustainable and illegitimate. Health information, as a legal matter, is a much broader concept and, as described, covers most of what the sector presently describes as performance data. The risk of these misclassifications that currently pervade sport are that they lead to overreach, misleading justifications, and scope creep.

The Privacy Act's current requirement that "personal information" be "about an identified individual, or an individual who is reasonably identifiable"[74] has proven to be difficult in some cases (such as pseudonymous data and some machine identifiers, e.g. IP addresses), but is not a significant obstacle in a professional sport context. Given the distinctiveness of professional athletes, the very small population sizes, and the on-the-ground data practices where continuous movement profiles, heart rate traces, and deep and individualised data troves are standard practice, the personal and sensitive information that is retained is *nearly always* identified or reasonably identifiable to individual athletes, so the Privacy Act is widely applicable. For completeness, it should be noted that data falls outside the class of personal information if it is *de-identified*, which would be the case if there is "no reasonable likelihood of re-identification occurring" if the data is released or accessed.[78]

State and territory laws are beyond the scope of this discussion paper. However, these may apply in particular circumstances, such as the provision of health services; the collecting, holding, or using of health information by an organisation (principally from the public sector) in a given state or territory; or the data practices of state or territory-managed sports stadiums.

For athletes that travel internationally for competitions, it is worth noting that data practices required by an applicable law of a foreign country are not considered to breach the Privacy Act.[79] However, if an international peak body, such as the International Cricket Council, requires its own data policy to be

complied with during an international cricket competition being played in Australia, this does not exempt the competition from the application of the Privacy Act.

ADDRESSING THE PRIVACY ACT'S EMPLOYEE RECORDS EXEMPTION

A threshold question for the application of the Privacy Act arises from the fact that professional athletes of the sports covered in this discussion paper are, in many cases, employees. This raises a question about the Privacy Act's 'employee records exemption', which excludes from the Act data collection practices directly related to the relationship between an employer and employee, on the assumption that this is best governed under workplace laws.[80] Unfortunately, the very limited provisions of the *Fair Work Act 2009* (Cth) are not fit for this purpose. In practice, no Australian sporting organisation, club, or players' association treats the athlete data collection practices discussed in chapter 2 as falling within the employee records exemption. This is appropriate as a matter of legal interpretation, as discussed in this section. Removal of the exemption—a reform with a wide base of support—is also under active consideration in the current review of the Privacy Act being led by the Commonwealth Attorney General's Department,[81] and it has also been a recommendation of previous law reform reports.[82]

There are two components of the employee records exemption.[80] The first is an "employee record". Though defined in a way that brings to mind typical human resources-related interactions—salary, leave, tax, superannuation, discipline, termination[74]—in practice, employee records have been widely construed to capture many types of personal information that an employer holds.[83] By contrast, the second component of the exemption—the requirement that an act or practice of data collection is "directly related to ... a current or former employment relationship"—has been very narrowly construed. In particular, the Information Commissioner in *QF & Others and Spotless Group Limited* has interpreted "directly related to" as extending to data practices having "an absolute, exact or precise connection" to the employment relationship, and not merely "an indirect, consequential, or remote effect" on the employment relationship.[81]

Applying these two components of the exemption, it seems clear that in terms of an employee record, the many types of athlete data collected incidentally and ubiquitously from tracking devices, video, and other technologies are held by those athletes' employers and relate to what athletes do as employees, *at a general level*. However, considering the second branch of the exemption, these various practices each go much further than information collected in a way "directly related to" an athlete's employment relationship. While each of these data practices may have an "indirect, consequential, or remote effect" on an athlete's employment, this is unlikely to be a sufficient connection for the purposes of the legal test. This seems appropriate if professional sport is compared to other workplaces. One could argue that bringing each type of data collected on athletes within the employee records exemption would be akin to characterising data practices that incidentally and ubiquitously capture information from the use of computers (e.g. keystroke logging), software

products, and closed-circuit TV cameras on office workers as directly related to their employment relationship.

Athlete employment contracts might, in rare cases, include a fitness-for-work or screening requirement based on specified criteria and on which employment is conditional (e.g. at the commencement of a season). But even if a data practice such as this is considered "directly related to" an employment relationship, it would only cover a tiny subset of current athlete data collection practices. Overall, the athlete data collection practices considered in this discussion paper are not likely to be captured at scale by the employee records exemption.

In any event, commercial uses of data—that is, by a sporting association/league, a broadcaster, or any vendor in the third-party tech ecosystem—would lie outside the employee records exemption.[84] In particular, the exemption would not apply to the uses of data by organisations other than the athlete's employer.

Finally, the employee records exemption does not change Privacy Act requirements related to the *collection* of information. This is because, before data is collected, there is no relevant "record" to which the employee records exemption applies. Such a scenario was relevant to the Australian Fair Work Commission case of *Jeremy Lee v Superior Wood Pty Ltd*, which decided that a sawmill worker was entitled to refuse to consent to fingerprint scanners to sign in and out of work.[85] The Commission found that the practice fell within the standard application of the Privacy Act and not the employee records exemption.

COLLECTION, USE, AND DATA RIGHTS

This section examines mechanisms for how the Privacy Act—and, in particular, the 13 Australian Privacy Principles (APPs) that are listed in Schedule 1 of the Act and function as its operational backbone—regulates the collection and use of athlete data. The distinct legal requirements and restrictions are described and then contrasted, where possible, with typical practices in Australian professional sport.

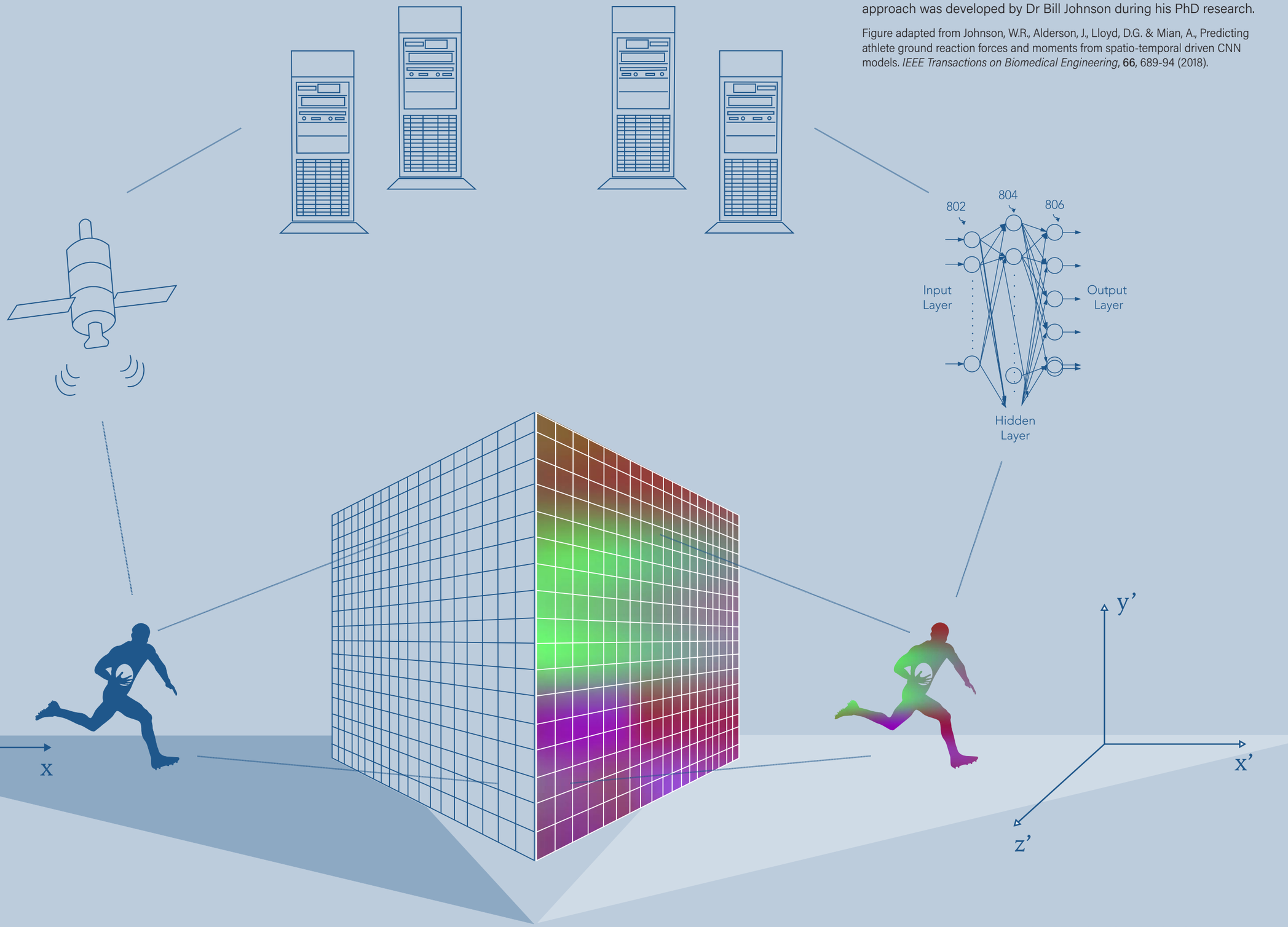
The Privacy Act has different rules for "personal information" and "sensitive information". For example, personal information can be shared by default among related bodies corporate (e.g. between the AFL and AFL clubs), but sensitive information cannot.[86] Sensitive information collection requires express consent, whereas non-sensitive personal information can be collected with a reasonable belief of implied consent. These distinctions are further elaborated in the sections that follow.

1. Collection restrictions

For the purposes of this discussion paper, three of the most pertinent collection restrictions in the Privacy Act concern: (1) transparency and notice; (2) that collection is "reasonably necessary" for an organisation's functions or activities; and (3) that individuals consent to the collection of sensitive information. As this section explains, current practices in Australian professional sport are significantly out of step with each of these three restrictions.

The spectral image integrated into the heart of this schematic represents human motion captured in a static image. Motion coordinates (X, Y, Z) for a sidestepping manoeuvre have been converted to a R, G, B colour code and plotted across time. This approach was developed by Dr Bill Johnson during his PhD research.

Figure adapted from Johnson, W.R., Alderson, J., Lloyd, D.G. & Mian, A., Predicting athlete ground reaction forces and moments from spatio-temporal driven CNN models. *IEEE Transactions on Biomedical Engineering*, **66**, 689-94 (2018).



- **Transparency and notice**—The first of the Australian Privacy Principles, APP 1, requires that organisations collecting personal information must do so transparently. They must have a Privacy Policy explaining what is collected, how it is collected, and the purposes for which it is collected.[87] Under APP 5, reasonable steps should also be taken to provide notification (ideally through a Privacy Collection Notice), of the nature and purposes of *each collection* of information. In practice in professional sport, the collection of athlete data and the purposes of collection are only addressed in a generic manner by clubs and organisations, often as a once-off practice within the context of signing a player contract and agreeing to associated terms. Privacy policies tend to be undifferentiated for different audiences, whether athletes, staff, fans, or casual visitors of a website. Athletes are seldom informed about the granularity and continuous nature of the data collected about them, nor about the complex array of actors who acquire access to generate, aggregate, store, and interpret that data. These on-the-ground practices are very unlikely to justify the extent of data collection currently undertaken in professional sport.
- **Reasonably necessary**—One crucial restriction on professional clubs and, even more so, on sporting leagues and associations, is that under APP 3, organisations must not collect personal or sensitive information "unless the information is reasonably necessary for one or more of the entity's functions or activities".[88] This presents a robust challenge to the 'collect everything you can' mindset. Guidance from the OAIC states that it is not sufficient if the collection is "merely helpful, desirable or convenient"; nor is it sufficient that collection is "normal business practice".[89] The OAIC also states "just because data analytics can discover unexpected or 'interesting' correlations, this does not mean that new personal information generated is necessary to the legitimate functions and activities" of an organisation.[90] Rather, the collecting entity has to be able to justify the reasonable necessity, from the objective point of view of a reasonable person, of collection of particular data for a particular function or activity, including proposed functions or activities the organisation has decided to carry out and for which it has established plans.[88]

  Collecting personal information "in a database in case it might be needed in future", but that is not required for a proposed function or activity, is not permitted.[88, 91] In summary, this guidance from Australia's leading privacy regulator demonstrates that general justifications that information collection will be used to monitor and improve health and performance are unlikely to satisfy the regulatory requirement. Instead, specific, purposive justifications are required, accompanied by regular, evidence-based review. As a constructive tool for addressing this requirement, a Privacy Impact Assessment can help map, in an evidence-based manner, proposed data collection and expected insights in order to assess whether the collection is relevant and not excessive.[91]

  On a fair reading of the law and current practice, it seems clear that professional sports are currently collecting more data than is reasonably necessary to collect, bringing them squarely within the OAIC's indictment of practices that involve collecting personal information in a database just because interesting correlations might be found. Chapters 2 and 4 detail from both a technical and a societal and ethical perspective that the widespread excessive collection of athlete data should be reconsidered. This chapter provides legal reinforcement to that assertion,[77] making it one of the paper's major overall findings.

- **Consent**—With sensitive information, which includes the vast majority of athlete data considered in chapter 2, APP 3 contains an additional requirement of either athlete consent, a legal requirement or authorisation, or a "permitted general situation" (such as a medical emergency) before it can be collected. According to guidance from the OAIC, consent should be express, voluntary (i.e. involve a genuine opportunity to withhold consent), non-bundled, informed, specific, and timed where possible to coincide with the time of collection and, at the very least, be able to be withdrawn.[89] This is a high bar that does not appear to have been genuinely contended with in professional sport, with the exception of when health professionals, researchers, or clinical or university settings are involved. In practice, most sporting organisations would try to rely on an athlete's consent, *given once* at the time of engaging in an employment relationship, which would then be used to collect even sensitive information.

  The scope of the consent is typically poorly defined in player contracts. These contracts consistently mandate the collection of ill-defined data categories that are unique to sport and inconsistent with legal categories—namely, as discussed above, 'performance,' 'management,' and 'health' or 'medical' data (the latter conceived more narrowly than the legal definition of health information; likely to relate only to information physically collected or assessed by a health professional). A number of Australian sports also permit or require that an athlete use a body-worn tracking device or custom chest vest during games and training. Consent is nevertheless complex, as the devices themselves are moving targets, capable of scope-creep as the body-sensor networks of which they are part become more sophisticated and can measure and capture more information.

  It is also important to note that, in practice, the asymmetric bargaining relationship between athletes and their clubs and leagues or associations has generally operated to reduce any meaningful opportunity for athletes to negotiate on the scope of collection broadly, or to resist data collection and use in particular instances. Coupled with a mentality on the part of organisations of 'collect everything we can in case it turns out to be useful,' it is difficult to see how an athlete may freely withhold consent.

2. Use restrictions

Once athlete data is collected, the Privacy Act regulates its use in three main respects: (1) purpose limitation; (2) requiring that reasonable steps are taken to ensure data accuracy, including by allowing athletes to access and correct their information; and (3) requiring that reasonable steps are taken to protect data and destroy it when it is no longer required for the purpose of collection. As with the collection restrictions in the Act, these use restrictions are significantly out of step with on-the-ground practices in Australian professional sport.

- **Purpose limitation**—Under APP 6, athlete information should only be used or disclosed for purposes reasonably expected by the athlete and "related to" (and, in the case of sensitive and health information, "directly related to") the purpose for which it was collected, or otherwise with athlete consent (assuming other specific circumstances, such as a legal requirement, do not apply).[92] Again, in practice, most sporting organisations would rely on athlete consent, express or implied, upon an athlete's entry to a given club or league or association to address the requirement of purpose limitation for primary as well as secondary purposes, and it would be extremely rare to return to the athlete for specific consent for particular uses. This is likely to be an increasingly risky practice, especially given some of the egregious practices from Australian professional sport that were shared anecdotally with members of the Expert Working Group. Examples include when a sporting league or association aggregates and provides identifiable personal information to another organisation, such as another club in the league, without athletes' knowledge and consent. Or when a high performance manager or strength and conditioning coach leaves a club and has no hesitation in taking with them many years' worth of personal information, often being the original and only copy of that data.

  Where an athlete's consent is relied on as a justification for use, it is important to note that consent can be withdrawn, which would prevent further use. This is a continuing right for as long as the information is being used.

- **Data accuracy**—Under APP 10, once athlete data is collected, reasonable steps must be taken to ensure that "the personal information that the entity collects is accurate, up-to-date, and complete", particularly in the context of use or disclosure of that information.[93] In practice, there are few organisational mechanisms in place to ensure the ongoing accuracy and relevance of data. In fact, it is recognised by many in the sector that data quality can be low. The Privacy Act also has provisions such as APP 12 related to providing access to information to individuals to whom the information relates, as well as APP 13, regarding responding to requests to correct information.[94] In practice, these rules are not widely known or practiced in Australian professional sport.

- **Protection and destruction**—Under APP 11, reasonable steps must be taken to protect athlete information from misuse, interference, loss and unauthorised access, modification, or disclosure, and to destroy data when it is no longer required for the purpose for which it was collected (or de-identify if appropriate).[95] When personal information is used by or disclosed to an overseas recipient, similar standards to Australia's APPs need to be in place.[96] Again, in practice, it is not typical for this to be considered in professional sport.

3. Data rights

The Privacy Act creates obligations on clubs, organisations, and third-parties handling personal information. While this creates the prospect of athlete data rights that can be asserted, it is salutary to note that opportunities for athletes to enforce these obligations encounter various limitations. Proposals to help improve this situation are a priority in Australia's current Privacy Act reforms.[81]

- **Practical challenges**—Where obligations around data collection and use are not followed, a direct complaint to the organisation processing the data can be made (and, in most cases, this will be an essential preliminary step).[97] Individuals can also make a complaint in writing to the OAIC about an act or practice that interferes with their privacy.[98] Where more than one individual is affected, a representative complaint may be appropriate.[99] Complaints may be investigated or conciliated by the Australian Information Commissioner and Privacy Commissioner, or the Commissioner may decide on a number of grounds not to go further.[100, 101] The Commissioner has powers to, for example, declare that particular practices cease or that individuals be paid compensation.[102] The most significant hurdle is that, in the case of compensation or when seeking enforcement, a complainant would also need to pursue court proceedings,[103] a process that is ultimately rather circuitous and expensive.

  There may be additional barriers to making complaints in practice, including concerns around practical consequences and retaliation, particularly during an athlete's career.

There are, nevertheless, important athlete data rights that exist in the Privacy Act. These include:

- **Access**—A right to access personal information within a reasonable period from the date of request unless the organisation has a valid reason to refuse, such as an unreasonable impact on the privacy of other individuals.[94] There may be a fee charged, which cannot be excessive
- **Correction**—A right to request that information be corrected if it is inaccurate, out-of-date, incomplete, irrelevant, or misleading.[104] If the organisation refuses to correct the information, the athlete concerned can ask for a statement indicating that the information is inaccurate, out-of-date, incomplete, or it is misleading for them to be associated with the information held. There is no right to demand deletion of athlete data that has already been collected, but there is a general obligation (except in specified circumstances) to take reasonable steps to destroy or de-identify personal information that is no longer needed for the purpose for which it was disclosed[95]
- **Consent**—A right to withhold consent in relation to future collection, use, and disclosure. While difficult to exercise in practice during an athlete's career, athletes should certainly be made aware of this option throughout their careers, and especially on retirement. Greater awareness could increase the prospect of athletes exercising strength in numbers to resist particularly problematic data practices.

Additional rights and obligations may exist, including in state and territory laws, in relation to:

- workplace surveillance (e.g. *Workplace Surveillance Act 2005* (NSW); *Surveillance Devices (Workplace Privacy) Act 2006* (Vic))
- health information, or information associated with the provision of health services (e.g. *Health Records Act 2001* (Vic); *Health Records and Information Privacy Act 2002* (NSW); *Health Records (Privacy and Access) Act 1997* (ACT); *Information Privacy Act 2009* (Qld) (less applicable, as focused on public sector health sector providers)). For example, rights to access health information, in jurisdictions where it is available, could be useful to athletes who wish to take information with them when moving clubs

- data breach notification (*Privacy Act 1988* (Cth) Pt IIIC)
- university and medical research (where ethical guidelines and conditions are in place).

APPLICATION TO TYPICAL PROFESSIONAL SPORTS DATA PRACTICES

It is helpful to return to the beginning of chapter 2, which described the arc of intensified data collection practices over recent decades. Applying the various restrictions in the Privacy Act, a clear distinction can be drawn between long-established and more contemporary athlete data practices. Take first the long-established practices of collecting overall, human observable, outward-facing game and playing statistics. While these practices involve personal information collection and use, they are also naturally limited and are practices that would be widely regarded as being reasonably necessary to the functions and activities of sporting organisations, with purposes that can be clearly described. By contrast, the back-end data collection from tracking devices, video, and various tools in the biomechanical, physiological, and management and wellbeing domains are orders of magnitude more voluminous, intrusive, and revealing than game stats, with much more diffuse and in many cases unproven, and therefore unjustified, purposes. They go well beyond typical practices of information collection in other workplaces and public spaces, and would be widely regarded as being more invasive than is reasonably necessary for the functions and activities of sporting organisations, warranting tighter, athlete-centred governance mechanisms to rectify the imbalance.

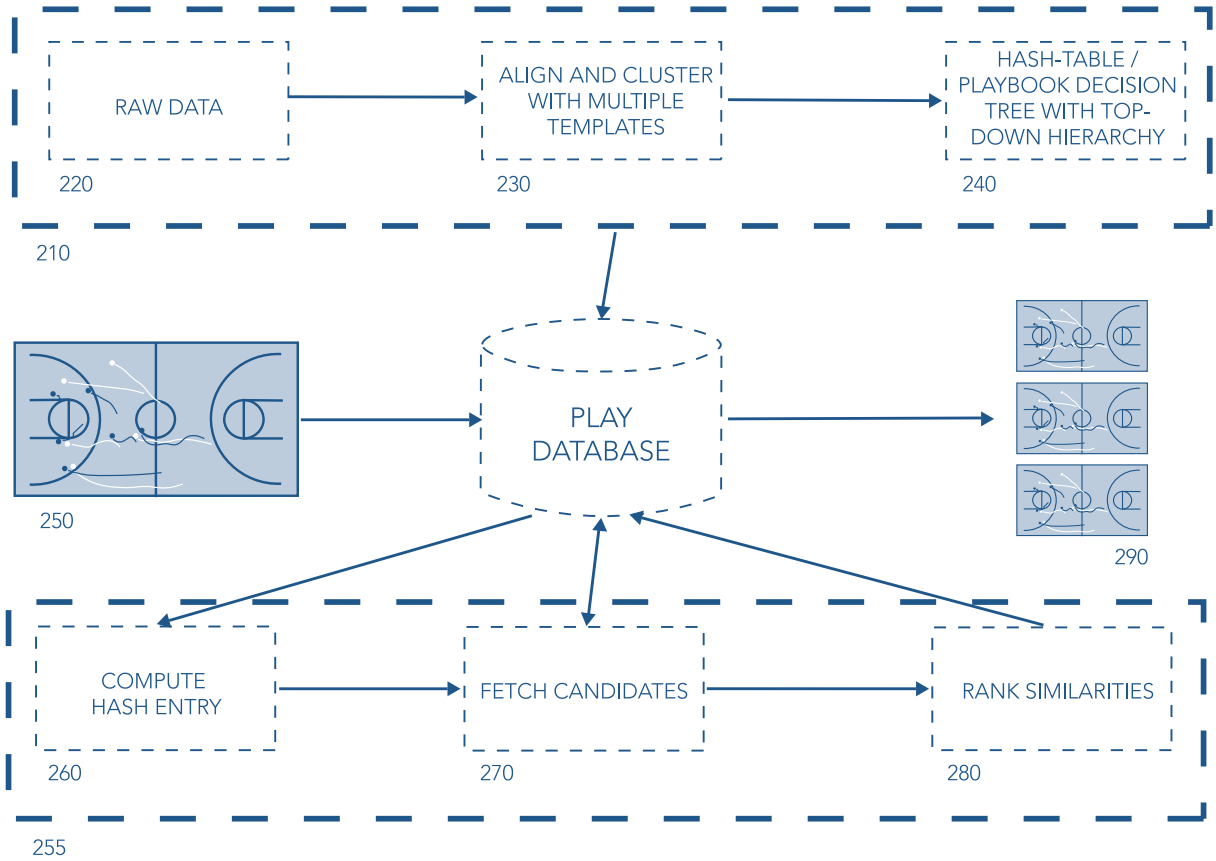


Diagram illustrating a general method for performing sports analytics, from "System and method for predictive sports analytics using clustered multi-agent data." Patent US 10, 204,300 B2, Feb. 12, 2019. STATS LLC.

What is particularly important to observe at this stage of the evolution of sports data practices is that, in most environments, personal information has become divorced from its principal beneficiary: athletes themselves. One major aim of this discussion paper is to identify that athletes, and athletes' rights, are pivotal to setting limits on the collection and use of athlete data. Recognising this offers a clarifying pathway through the problematic legal landscape described above. For example, the underlying reason that organisations are legally restricted in collecting personal information to that which is "reasonably necessary" for their functions and activities is because that *information is personal*—in the case of athletes, it is intimate, revealing, sensitive, and often unique. In recognition of this, privacy regimes, in Australia and elsewhere, place a primacy on an individual's relationship to their own personal information over an entity's relationship to that information. This leads to an important discussion point that has been increasingly occupying professional sport: who owns athlete data anyway?

WHO OWNS DATA ANYWAY? THE CHALLENGE OF ATHLETE DATA OWNERSHIP

It is common colloquially to describe data as being 'owned' by an individual or organisation. This is also increasingly the case in professional sport, especially in tussles over data rights and in negotiating collective bargaining agreements by player associations for different professional sports.

The terminology of ownership can be misleading and inaccurate, particularly when used by or between organisations rather than by an individual to whom data relates.[105, 106] The position is clearest with organisations. Rather than having ownership-style rights to personal information that are enforceable generally, it is more accurate to say that organisations may have rights and obligations relating to information through specific legal doctrines (such as the equitable obligation of confidence) or legislation (such as the Privacy Act and, where relevant, intellectual property law and particularly copyright law). For Australian sporting leagues or associations to assert that these organisations 'own' athlete data therefore misrepresents the position under Australian law, in which there are no general ownership rights for an organisation to claim. Problematically, and likely unlawfully, once this assertion is made, it often precludes necessary discussion and input from athletes with respect to future uses of the data.

By contrast, the ability of individuals to assert stronger rights over information about themselves, including ownership-style rights, has become a lively subject of debate. As well as the contingent rights brought about through existing doctrines and legislation, it may be appropriate for individuals to assert that information about themselves is 'my data,' in the same way that people speak about 'my body.' To this end, the collective bargaining agreements in a number of professional sports, such as rugby union in Australia and the National Football League in the US, contain clear statements and recognition that athletes own their data. This is the case even though neither information nor bodies are commodities in a traditional sense—most notably because of restrictions on their sale, which is not itself necessary to the recognition of ownership. Though this is an area that still requires significant legal evolution, normatively there is an increasingly persuasive case that the law should recognise these claims as reflecting the centrality of each of us, as the primary source and beneficiary of data about ourselves, with associated rights and interests, as well as duties and obligations on others. The relative advantages

and disadvantages of ownership and other legal concepts to achieving this outcome remains a subject of ongoing study and controversy, particularly within the legal academy.

While stronger individual rights over information about oneself would require legal reform before their wider recognition, one potential foundation for ownership-style claims is the recognition of personal information as a thing in action capable of being stolen.[107] Claims by athletes to the unique identifiers and attributes of their elite bodies are particularly acute in this context, given that professional athletes and the constituents that make them are, by definition, outliers from the general population, giving them particular and often unique value.

Additional richness to considerations of stronger athlete rights arises from the extent to which individual pieces of personal information are part of a whole (the individual themselves), and also that individuals are part of communities or collectives—in other words, the extent to which 'mine' is also 'ours'.[108] An evocative example of this latter point is the 'Tracker Data Project', which resituates the geospatial tracking data of famous Australian rules footballer Adam Goodes within Adnyamathanha Kinship, Country, and Language.[109] This is a sport-specific complement to broader movements for Indigenous Data Sovereignty and Indigenous Data Governance, which have now been well advanced by Indigenous and other First Nations peoples across the world.[110, 111]

As a counterpart to athletes' normative claims to having more rights in information about themselves, organisations holding personal data are increasingly recognising their responsibilities as custodians, stewards, or fiduciaries of that information on behalf of the individuals that the information is about. This is consistent with an approach grounded in athletes owning (though not necessarily having the ability to commodify) their data. For example, in a submission to this project, the Centre for Artificial Intelligence and Digital Ethics (CAIDE) at the University of Melbourne argued the necessity of ensuring that organisations facilitate data portability for athletes moving between clubs as well as pathways for data erasure (both of which reflect general privacy reform priorities federally, even if they go beyond existing protections in the Privacy Act). Similarly, in a parallel project being undertaken by the Australian Institute of Sport and the National Institute Network, a set of entities across the country are working to embed a data stewardship approach into their management of athlete information, situating athletes centrally in all aspects of the collection and use of their information.

One of the interesting developments in professional sport internationally is that various collective bargaining agreements are moving into questions of control over data collection, use, and disclosure. This is a potential site for innovation on questions of control and ownership, which ultimately must be a vehicle for clarity about the rights, interests, and responsibilities of different groups. Though athletes are greatly assisted in their engagements in these contracts by their player associations, not all athletes (especially those in individual or non-unionised sports) receive such assistance.[112] For those sports with influential player associations, this is likely to be a rapidly evolving area of development, and is considered in greater detail in the next section.

DOES ANYONE DO IT BETTER? INTERNATIONAL COMPARISONS

Legal frameworks

Australia's federal privacy law is currently under extensive review to ensure that it is fit for purpose. Reform at the state and territory level is also underway or anticipated (especially in Western Australia, which does not have any privacy legislation). Some indications on where Australia will move come from international jurisdictions, such as the European Union's *General Data Protection Regulation 2016* (GDPR), which is regarded as providing the de facto international standard.

KEY DISTINCTIONS BETWEEN EUROPE'S GDPR AND AUSTRALIA'S PRIVACY ACT

- Consent is more strictly defined in the GDPR—it must be a freely given, specific, informed, and unambiguous. It cannot be merely implied, as it can in Australia. Alternatives to consent are also more tightly drafted in the GDPR. Australia is moving rapidly towards an equilibrium with the EU in current reform proposals.
- Documentation requirements for collecting and using personal information are more detailed and prescribed under the GDPR than those required of Australian privacy policies.
- Data Protection Impact Assessments covering the necessity, proportionality, and risk of personal information collection, including risk management processes, are mandatory under the GDPR whenever processing is likely to result in a "high risk to … rights and freedoms".
- The GDPR includes clear principles of accountability, data minimisation, storage limitations, and privacy by design and default.
- Security requirements are stronger under the GDPR and allow for an approved code of conduct or certification mechanism.
- The GDPR contains a clear right to erasure, popularised as the "right to be forgotten".
- The GDPR includes a right to compensation in many cases of infringement.
- The GDPR defines biometric data as "personal data resulting from specific technical processing relating to the physical, physiological or behavioural characteristics of a natural person, which allow or confirm the unique identification of that natural person", and classifies it as "sensitive data".

SYSTEMATIC ASSESSMENT OF PRIVACY IMPACTS

Australian organisations are not required to undertake mandatory privacy impact assessments, contrary to the situation in some other jurisdictions.[113] Nevertheless, a privacy impact assessment is a useful means of systematically analysing data practices, their alignment with an organisation's purposes and functions, their legality, and their impacts on athletes. Privacy impact assessments are thus a useful risk management tool, not only in terms of legal compliance but also community acceptability and reputation management. They can help demonstrate an organisation's commitment to good privacy practices and athlete welfare. The OAIC offers guidance to organisations conducting privacy impact assessments but notes that organisations may choose their own methodology.[114] When arrangements are being considered to share data with third-parties, it is a good idea to undertake a privacy impact assessment. Undertaking a privacy impact assessment at an early stage of such a process ensures that privacy considerations are built into the arrangements made with third parties.

This discussion paper was informed by comparing current practices in Australian professional sport with those in the United States and Europe. From a legislative perspective, while the US (with the exception of California) is famous for having only sectoral privacy laws for health, education, and finance, rather than an omnibus privacy law such as the European GDPR, it has also seen significant experimentation in commercial contracts and policy developments around data. This is demonstrated in the evolution of collective bargaining agreements (CBAs) within professional sports themselves, where influential player associations in the major US sports have ensured some of the most sophisticated responses to challenges around the collection, transfer, and use of athlete data.

Even in Europe, which does not share the same history of collective bargaining in its professional sports as the US or Australia, the impact of the GDPR is seeing increasing efforts by athletes to assert their data rights. A recent example is the move by UK football (soccer) players to assert rights over their tracking data by asserting that its collection and sale amounts to the commercialisation of their personal information without their consent.[115] In particular, these athletes are contesting the use and exploitation of their personal data by third parties (in this case, betting companies) who obtain commercial benefits from the exploitation of player data without contributing to its production or use.

Collective bargaining agreements

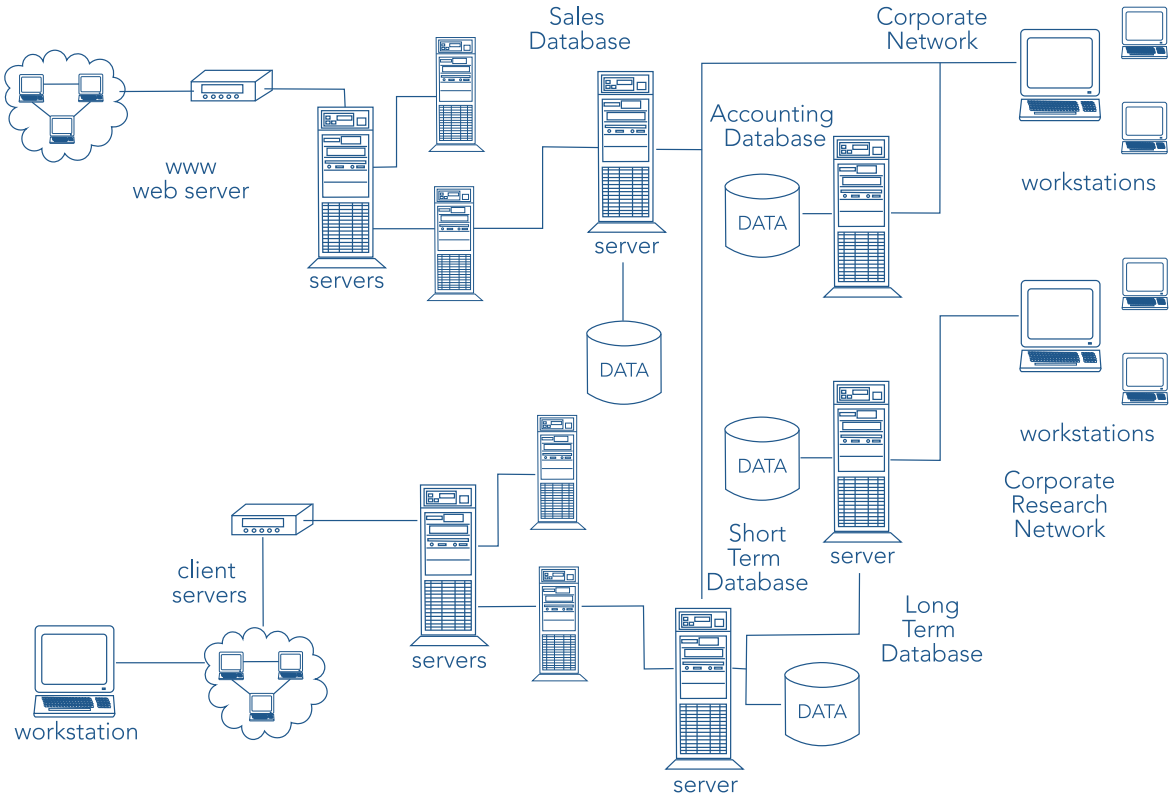
Three of the four largest professional sport leagues in North America have negotiated provisions around athlete data in CBAs. The National Basketball Association (NBA) was the first to do so in 2016, followed by Major League Baseball (MLB) in 2017 and, most recently, the National Football League (NFL) in 2020. Australian leagues and associations started to insert relevant provisions on a similar timeline, with inclusions in the CBAs for AFL in 2017 and AFLW in 2019, and for ARU and NRL in 2018. The catalyst in both Australia and the US has been safeguarding athletes from the potential adverse impacts associated with the use of their data, while on the other hand taking advantage of the potential benefits and opportunities for innovation that may arise. This has been predominantly in the space of body-worn tracking devices and microtechnologies.

One innovation led by the AFL concerned the conditions under which data from approved geospatial tracking devices would be released to broadcasters and clubs.[116, 117] This includes limiting broadcasters' data access to visually identified player position only, without accompanying physiological data or individual metrics. In particular, in response to concern by athletes about how they might be publicly represented, approved broadcasters are only provided with "positive" information, including the top five players per team in terms of distance covered, average speed, and maximum speed—all of which may be integrated with captured game statistics. This is an excellent example that, when athletes are aware of the nature and use of personal information, they have a strong and persuasive interest in imposing limits. These extend to information provided between clubs, as well as between leagues and broadcasters. Finally, a player may request access to the same performance data provided to broadcasters and clubs, including the identified club-level information which is referred to as "his Player Information" or "her Player information". The CBAs are silent on how the data will be managed and used by

the vendors of GPS units, such as STATSports and Catapult Sports. With respect to the AFL/AFLW's access, there is a broad statement that "the data collected by GPS Units may be used by the AFL for research (including Laws of the Game) and integrity purposes"; a catch-all that is applied generously in practice.

Although responding to similar challenges, the protections in place for athletes in major US professional sports are stronger than what presently exists in Australia. For example, in the NBA a dedicated 'Wearables Committee' has been established that comprises representatives of both the players association and the league to review and approve wearable devices that may be used by players.[118] The MLB has similar provisions in place but also contains strong disclosure provisions that require clubs to provide players with "a written explanation of the technology being proposed, along with a list of the Club representatives who will have access to the information and data collected, generated, stored and/or analyzed".[119] The CBAs for both the NBA and MLB prohibit in-game use of tracking data; the provisions therefore focus exclusively on data collection by clubs and this, in turn, can only be done if athletes opt in.

The current NFL CBA goes one step further and even includes sanctions for misuse of player data, with penalties that can be upwards of US$250,000 for repeated violations.[120] An innovative earlier approach by the NFL Players Association (NFLPA) had led to a 2017 tie-up with recovery band company Whoop as the official provider to the NFLPA, under terms where players 'own' and in principle have the right to commercialise the data, while the NFLPA had access for research purposes.[121] This has been mostly superseded by the 2020 NFL CBA, where the NFL now has the right to use athlete data "regarding the performance of NFL games, including players' performances and movements"



Adapted from "Apparatus, systems, and methods for gathering and processing biometric and biomechanical data," patent US 10675507 B2, Jun . 9 , 2020. Current Assignee: Nike Inc.

for broadcast purposes, with any revenue generated being shared with players via a revenue sharing agreement.[120] There is nevertheless a separation from club data (as in the AFL) which is subject to strict oversight via a dedicated committee.[117, 120]

These international developments, in both legislation and in CBAs, may provide the framework for Australian sports to develop their policies more collaboratively with active input from athletes or athlete representatives, educate and inform athletes and other stakeholders about their rights and responsibilities, and provide access to remedies in the event of misuse or abuse.

DISCUSSION POINTS

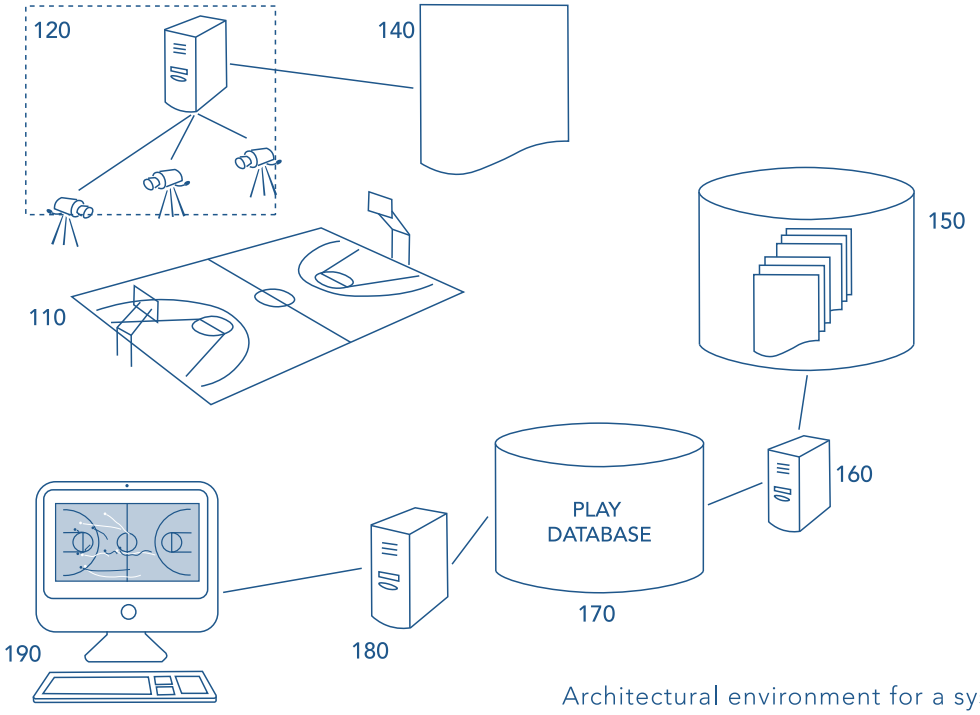
In closing this chapter, a number of points have been raised that warrant further discussion among practitioners in professional sport, and that signal areas for reform and improvement:

- What are the categories of current athlete data collection that are more or less likely to be legally permissible?
- Are there any aspects of athlete data collection that require further guidance beyond general legal restrictions of transparency and notice, what is reasonably necessary, and consent?
- Are there any aspects of athlete data use that require further guidance beyond purpose limitation, data accuracy, and protection and destruction?
- How can the law assist in navigating the transition of technologies from more body-worn to video-based?
- How can asymmetric bargaining relationships between athletes and their clubs and leagues be addressed?
- Who owns athlete data, and what bearing does the answer to that question have on questions of collection, use, and decision-making?
- How can collective data management practices, such as those articulated under Indigenous Data Sovereignty and Indigenous Data Governance frameworks, assist professional sport contexts?
- Are there legal concerns that are common across athletes in a range of different sports and, if so, what mechanisms are available to address those concerns?

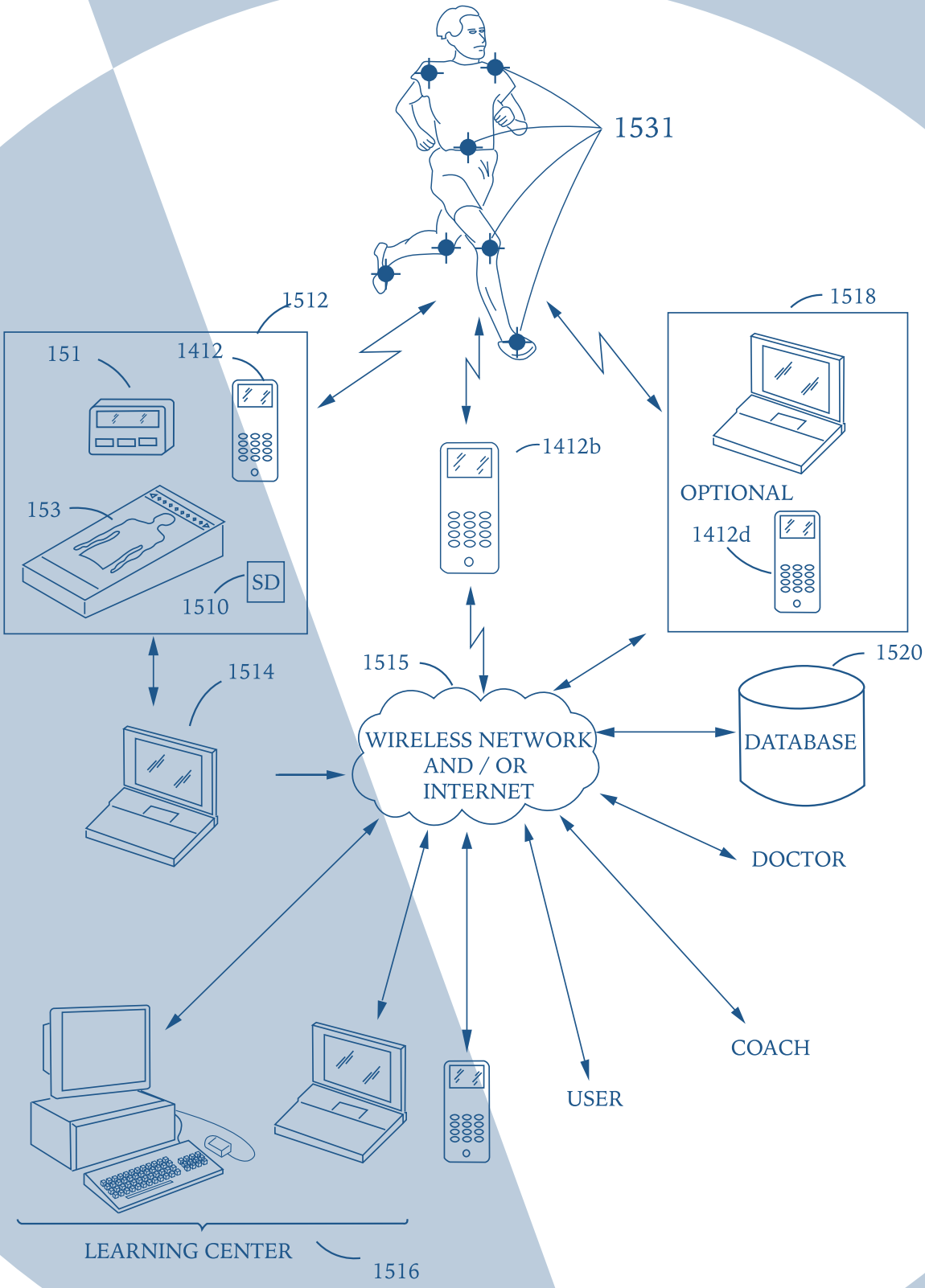
Two major issues deserve additional consideration by those within the sports sector:

- **Third-party data access and use**—Access to athlete data from an assortment of third parties, including tech vendors, broadcasters, betting and wagering agencies, fans, stadium managers, and drug and integrity authorities, has exploded in recent years. Athlete data in the hands of third-party vendors is subject to the Privacy Act, but the extent of transparency and accountability is highly variable, given that the data is collected indirectly and, to compound the challenge, contractual terms, consent forms, and privacy policies tend to be vague and sometimes ambiguous, particularly because they are not tailored to different audiences. Strict confidentiality regimes are in place for data collected for anti-doping purposes, but this is the exception rather than the rule. Given that third-party data access is the greatest external risk to the sports sector, detailed consideration of the players and interests in this area is an essential next step.

- **A sport-specific privacy code**—The Privacy Act is a principles-based law that does not necessarily lend itself well to specific guidance for the applications and scenarios found in all situations. Recognising the possible need for further detailed requirements, the Privacy Act provides for the establishment of binding codes.[122] Codes may also apply to information otherwise exempt under the employee records exemption. One of the most promising suggestions to emerge repeatedly throughout the development of this discussion paper was the recommendation by experts of the desirability and need for a sport-specific privacy code, to document acceptable solutions to bridge the gaps in understanding between athletes and sporting organisations (including governing bodies and clubs), as well as between third parties and both athletes and sporting organisations. Though this will likely encounter challenges of global legal pluralism, a sport-specific code offers the promise of a clear, authoritative, single reference point to guide the sector.



Architectural environment for a system for interactive sports analytics.
From "System and method for predictive sports analytics using clustered mul-ti-agent data." Patent US 10, 204,300 B2, Feb. 12, 2019. STATS LLC.



Adapted from "Apparatus, systems, and methods for gathering and processing biometric and biomechanical data," patent US 10675507 B2, Jun . 9 , 2020. Assignee: Nike Inc.

CHAPTER 4: SOCIETAL AND ETHICAL PERSPECTIVE

Experts have long acknowledged that sport is a social institution that both reflects and informs societal practices, norms, and power relations.[123, 124] Professional sport—and, in turn, its embrace of data—is no exception. Automated data collection and analysis technologies, including the use of machine learning applications to seek to make sense of and predict patterns from data, have been increasingly integrated across aspects of social life,[125, 126] including sport.[127] These technologies and the diverse data they generate have profound implications for social, political, and cultural relations. To extend the discussion initiated in earlier chapters, this chapter reflects on several key areas of concern, such as coercion, security, and power asymmetries, rather than particular ethical issues and approaches. The chapter considers how to enhance governance, with a focus on incorporating responsive and rights-based regulation where possible, acknowledging that ethical considerations underpin these recommendations.

While this paper pays particular attention to the collection of athlete data within individual team and club environments, it is of course true that digital technologies are not merely a supplementary or incidental force to the *doing* of professional sport. Instead, the digital revolution has transformed various aspects of how professional associations, athletes, clubs, and fans operate.[128, 129, 130]

While the convergence of sporting organisations, social media, and data aggregation and analytics has received notable attention,[131, 132] the societal implications of the diversity of data collected and used in professional sport, including the institutional transformations accompanying them, have received less scrutiny. These transformations apply to the sharing and application of data across different domains, including individual athlete development and management, game and team strategy, digital forms of fan engagement, and the wider globalisation of professional sport. Understood in this sense, the combined processes of globalisation and digitalisation are distinctive features of the contemporary sporting world. Moreover, these processes have intensified in recent years, contributing to massive changes in the global sports landscape and new centres of professional development sports, most notably in Asia.

Internationally, globalisation and digitalisation have profoundly changed professional sports, away from national or regional markets to global markets,

with leagues and associations positioning as multi-continental franchises providing various opportunities for the expansion of revenue. From the FIFA World Cup to Wimbledon, the digital distribution of sporting events has become truly global in scope. Major global communication conglomerates—such as News Corp, Time Warner, and ESPN—have become key players in the commercial dissemination of broadcast footage and game and player statistics. The wider use of data has been bound up with the development of new enterprises capable of exploiting technological innovations, catering to specialist sports markets, and providing a range of information and communication-related services to sports fans.

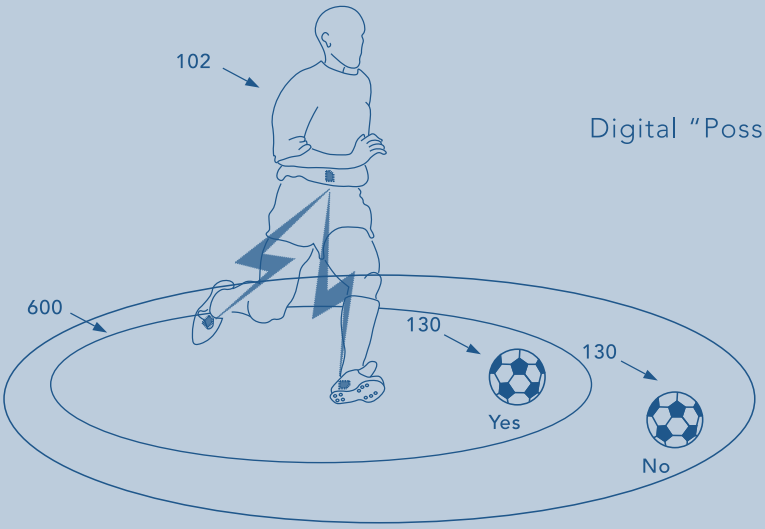
Even though the full implications of each of these shifts are beyond the scope of this paper, the societal and ethical dimensions of data in professional sport cannot be abstracted from the three interconnected processes driving contemporary professional sport today: "corporatisation (the management and marketing of sporting entities according to profit motives); spectacularisation (the primacy of producing entertainment-driven [mediated] experiences); and commodification (the generation of multiple sport-related revenue streams)".[133]

This chapter's discussion of societal and ethical concerns attends to these wider changes as they emerge in relation to athletes' rights and data governance. In doing so, it is important to acknowledge that the professionalisation of sport is not simply about commercial developments; it has also contributed to a more diverse range of athletes being able to compete in sport, particularly women and those from working-class backgrounds.[134, 135] The effects of datafication in professional sport have the potential to play out differentially across social categories of age, disability, ethnicity, gender, sexuality, and race. The possible inequities that may result are key areas of ethical and social concern—as they are in wider debates about technology-related social changes.[136, 137, 138]

CONVERGENCE: WHERE DEBATES ABOUT DATA AND PROFESSIONAL SPORT MEET

As data is increasingly coveted as a basic currency of professional sport, the weight placed on its use brings both advantages and disadvantages. For example, professional sporting organisations increasingly incorporate data analytics in their business plans in order to target new and profitable markets,[132] as well as to analyse their workforce. Increasingly, professional sports find it desirable to recruit individuals with generalised expertise in data handling; however, resource constraints risk placing this investment in direct conflict with the retention of specialised sport science skills. As discussed in chapter 2, using and comparing data to measure and assess the performance of individual professionals and teams can place greater stress on what factors are being measured. When this is coupled with a reduction in the requisite expertise to understand and translate this information for the context of sport, it presents significant risk.

Collecting data on discrete physical attributes may seem to be relatively straightforward compared to making assessments of other kinds of attributes, such as mental or cognitive attributes that make an athlete valuable in a sport. But even discrete physical attributes, once combined, require specialist interpretation by experts with a mechanistic understanding of the human body. Crucial features of professional sport now include: what is measured (and what

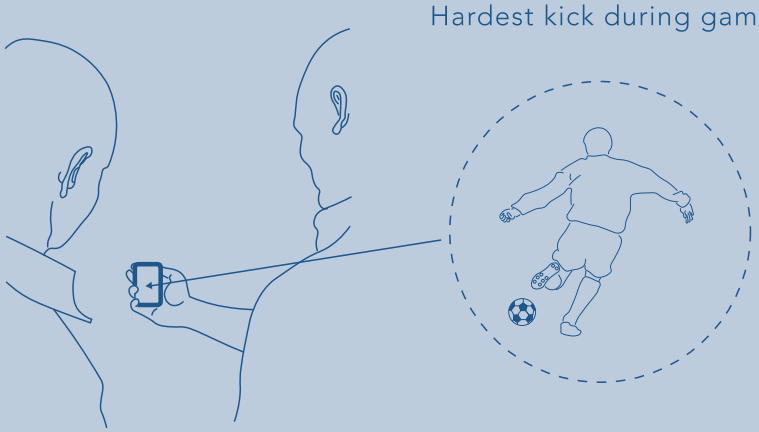


Digital "Possession"

Sensing Architecture

Adapted from "Athletic performance monitoring systems and methods in a team sports environment," Patent US9511260B2, Dec. 6, 2016, Nike Inc.

Hardest kick during game



"Systems, apparatuses, and methods estimate the distance between a player and a ball by transmitting a chirp (sweep signal) to a radio tag located on the ball. During the chirp, the frequency of the transmitted signal is changed in a predetermined fashion. The radio tag doubles the transmitted frequency and returns the processed signal to a transceiver typically located on the player. The currently transmitted frequency is then compared with the received frequency to obtain a difference frequency from which an apparatus may estimate the distance. The apparatus may simultaneously receive the processed signal from the radio tag while transmitting the sweep signal." Abstract from patent US9511260B2, Dec. 6, 2016.

is not), what those measurements are used for (and what they are not), and who (and who does not) use the measurements and derivations from them. As discussed earlier in this paper, the range of data collected at the athlete level can include geospatial, biomechanical, management (including psychological), and physiological (including genetic) data, and it can be used for both assessment and prediction.[139] As certain kinds of data can be directly captured and analysed in ways that other features of performance may not, they have the potential to be more heavily relied on in decision-making, with resultant skews and biases.

The rise of big data is tied to the emergence of new forms of action and interaction in professional sports, new kinds of commercial relationships, and new ways of connecting fans to sports. One common response on the part of athletes has been to embrace what some term the 'quantified self.'[140] The embrace of data by professional sporting associations is already transforming the management of athlete careers—both on and off the playing field.[140, 141] As discussed above, professional teams are using wearable technologies such as GPS trackers and inertial sensors on an as-yet-unrealised promise that they will identify and help manage injury risk factors, particularly through indicators of exertion.[142, 143] Research also attests that athletes themselves have leveraged data to maximise their own brands through personalised appeals to fans.[141]

Shifts in sport reflect trends observed in sectors as diverse as health care, education, medicine, business, and government. Scholars have illustrated that this wider preoccupation with data, particularly in the form of metrics, has the potential to distort judgements about individuals and groups in ways that can undermine performance outcomes and may result in unintended harms.[144, 145] While the verdict is still out in sport, it is clear that the embrace of data without supporting regulatory protections invites similar sets of concerns. A divide between technology- and data-rich clubs and sports, and technology- and data-poor clubs and sports (e.g. in many cases, women's teams and competitions) has started to take shape,[131] contributing to existing disparities across Australian professional sport. These emergent digital divides in professional sport are grounds for concern, and require evidence-led regulatory responses, especially where the benefits of technology and data are not yet proven but accompanied by tremendous hype, and risk wasting already limited resources.

At a practical level, the implications of data management are a foundational challenge, especially given the quantity of sports data being generated. Data security is the most prominent of these concerns, particularly to the executives and boards of sporting organisations. Along with security, other concerns about data governance can cascade. The use of external cloud infrastructure to host and manage data is appealing given its cost and ease of access, a finding supported by our exploration of Australian professional sports. However, these systems are not without significant faults. While outsourcing control over data servers suggests the need for secure storage and auditing techniques, many integrity measures are still not equipped to adequately manage cloud infrastructure[146]—a concern that is especially the case within sports organisations. The prevalence of malicious software (malware) has increased, with novel security threats explicitly targeting cloud infrastructure in ways that may compromise athlete data. The hacking of the World Anti-Doping Agency (WADA) by the Russian group, Fancy Bear, in 2016, indicates the risks that

professional athletes face. After illegally obtaining data on drug-testing and medical information related to four US athletes, including gymnastics champion Simone Biles and leading tennis player Serena Williams, the group leaked the data, suggesting they use performance enhancement drugs. The events required public statements by some of these athletes about medical conditions that required Therapeutic Use Exemptions and prompted further public scrutiny of the substances used by the athletes.[147]

Professional sporting organisations are not unique in terms of these vulnerabilities. An analysis of 18,000 organisations with more than five million hosts across 200 countries found that 84 per cent hosted critical or sensitive information with third-party providers, such as cloud services, content delivery networks, and Domain Name System (DNS) providers.[148] Its assessment of security risks, such as the threat of cyber-attacks and data leakage, reveals that organisations are three times as likely to have high-value assets with severe security issues when hosted externally versus internally. In addition, 35 per cent of surveyed organisations had high or critical vulnerabilities with external service providers, and 32 per cent of organisations hosted data in foreign countries, often with greater vulnerability than their home countries.[148] Given the voracious use of cloud services by Australian professional sports, concerns around the control of athletes' data and associated risks now span personal and organisational security as well as geopolitics.

These challenges are potentially exacerbated by the financial shortfalls that many Australian professional sports have experienced due to the COVID-19 pandemic. The need for cost savings can mean unintended consequences for data security. Amazon Web Services (AWS), the market leader in public cloud services, provides cheap and accessible storage means for professional sports clubs and organisations to store players' data. AWS, however, poses a number of security risks, as its premium services come at a cost, and clients must pay for premium services and are required to manage their security settings adequately.[149] Market concentration also influences cybersecurity threats and vulnerabilities.[150] Accordingly, as a major hub in the cloud computing space, AWS has been the target of a multitude of cybersecurity attacks, most notably the largest Distributed Denial of Service (DDoS) attack to date.[151] Though AWS successfully foiled the attack, its market prominence means a heightened risk of similar vulnerabilities are on the horizon in the future. Though market-leading cloud computing infrastructure may be attractive for sports organisations on a tight budget, these systems may threaten the integrity of the personal data of their athletes.

ATHLETE RIGHTS BEYOND CONTROL: CONCERNS OF COERCION, CONSENT, AND SOVEREIGNTY

As discussed in chapter 3 of this discussion paper, athlete data rights vary greatly in practice, even though some are explicitly articulated in legal provisions. Multiple grey areas emerge from the many ways data is collected and used. Data is relational, with a host of social practices, ties, and interactions embedded within a single data set.[152] This complicates the story of data as something that is always either narrowly 'personal' or broadly 'communal', as various humans, organisations, and actors may become represented and intertwined within digital information.[128, 153] These dynamics are taking shape within professional environments that vary widely in Australia, contributing to the unevenness of athletes' experiences with data and their potential effects

over the course of athletes' careers and beyond. This section reflects on the nature of these challenges in relation to existing frameworks, including rights-based regulation, and principles such as affirmative consent, in the context of professional sport.

Athletes' data can have value within and beyond sport as it is used and shared. Concerns about corporate claims to their data, often styled in proprietary or ownership terms despite dubious legal foundations explicated in chapter 3, have been met with calls for athletes—as the source and chief beneficiary of this data—to have explicit rights to fully access, if not own, particularly biometric data.[154] Despite the seemingly natural primacy of such claims over corporate assertions, practically realising ownership and access as enforceable rights is not always straightforward. Existing data regulation, exemplified by the GDPR, tends to focus on data as a two-party arrangement (i.e. the data subject and the data processor/controller), as well as a readily transactable asset. This framing does not support approaches that recognise the spectrum of composite interrelations that can be involved between data subjects and data or the complex assemblages of actors that may become entangled in informing each data point.[153] Further, it does not allow for inalienability in relation to the intimate digital artefacts of the human body, similar to how we commonly understand our corporeal bodies, organs, and tissue.

Given the various sources and parties involved in data collection and analysis over different time periods and locations, there is a very real challenge in identifying and navigating asserted claims to data, especially since many actors may make them. As Greenbaum asks,[139] "Can a player who was traded demand that the relevant analytics follow him or her to the next team? Can an athlete legally limit his or her opponent's access to helpful data?" Furthermore, how does one assess what constitutes helpful data to athletes and opponents? The answers to these questions are not yet settled, and they are only a few of the many unanticipated consequences that are possible with the rise of data-informed sport. Genuine dilemmas can arise when data reveals unexpected findings, such as health issues or physiological conditions that may apply to an athlete or their family. As Greenbaum notes, the professional sports environment can exacerbate the tenuous and unscientific nature of data's impact: "even when these data are only correlative rather than causative, they will be perceived as predictive" and "could be used, with or without justification, to assume a particular fate for the athlete or a family member, perhaps ending a career prematurely, or creating problems for insurance and employment".[139] The use of such data can have varying impacts on an athlete's career and later on in life, especially as the insights provided may indicate future downward trends in health that affect performance.

Just as importantly, the impact of the insights gleaned through data does not uniformly affect athletes. Differential effects can reflect social categories of difference beyond age, including along the lines of class, disability, ethnicity, gender, Indigeneity, national origin, and race. As athletes in women's sports are increasingly subjected to gender-specific monitoring, seemingly mundane forms of data that can be used to enhance health performance may make some women subject to unfair scrutiny if they reveal findings deemed non-normative—such as indicators of disorders of sex development.

For Indigenous athletes and others from cultural backgrounds that emphasise community as the foundation of identity (e.g. Pasifika athletes), data sovereignty

movements provide important insights for inclusion in sport, including that "Indigenous peoples and nations" have a right "to govern the collection, ownership, and application of data about their peoples, lands, and resources".[155] In other words, questions about how data may be collectively shared, used, or repatriated are essential considerations so that data governance in sport does not replicate colonial legacies of extraction.

In terms of athletes with disabilities, a wide range of complex issues are at play—from issues of regulating fair play to addressing the use of data without paternalism. Deeper consultation with athletes and disability advocates and Paralympic sports organisations is, therefore, a necessary first step to understanding the scope of data protection and governance issues that may affect athletes with disabilities. These dimensions further complicate the possibility of athletes being able to enjoy or exercise robust data rights, which are still in the process of being developed in Australia, compared with other jurisdictions.[156]

The provision of informed, affirmative consent is often considered foundational for the sharing and use of personal data.[157] Sport contexts, however, maintain distinct qualifiers when it comes to data collection and surveillance targeting athletes, which is a trend that has been observed globally and enforced through contracts and participation waivers.[134] The European Union Data Protection Board notes that not all consent is equal: "where a sports club takes the initiative to monitor a whole team for the same purpose, consent will often not be valid".[158] These observations offer important words of caution for Australian professional sport. Individual athletes may be contractually obligated or experience other forms of pressure from coaches or peers to consent to data being collected about them. Coercion, even when not explicit, can contribute to athletes fearing that refusing or resisting data collection may adversely affect their value or their team's performance.

The multitude of data collected with varying sensors and technologies owned and operated by different corporations—each with their own set of terms and conditions—may lead to what Pereira and colleagues call "consent fatigue".[159] In the case of professional athletes, contractual obligations and sport cultures exacerbate these challenges, as athletes may not be the ones who are providing approval for third parties to access their personal data—a situation that privacy and data protection regimes are intended to alleviate, and likely should be reformed to effectuate. These reforms alone, however, would likely not be enough to support athletes in environments of coercion and control. The final section of this chapter therefore posits future directions for more meaningful regulation in the context of Australian sport.

Many individuals are unaware of the full range of data being generated about themselves, the purposes of collection, or the ways in which this data may be used.[160] Recent calls for greater public data literacy note the need for educational programming that extends beyond explaining the technical details of data practices.[161, 162] Pangrazio and Selwyn argue for a "critical literacies" framework to uncover the complex socio-technical relations of personal data while highlighting the needs and interests of individuals.[163] As a necessary foundational step towards stronger data governance in professional sport, these kinds of frameworks would need to target the wider range of actors involved (e.g. coaches, managers, other support staff), not simply athletes.

Given the diversity of athletes in Australian professional sport, it is important to note that both rights and literacy discourses tend to orient around the individual and may not capture how professional athletes relate to data or who has a vested interest in their data. Indigenous and Pasifika athletes, for example, often have strong community ties or kinship obligations that implicate how they understand themselves, their bodies, and their sporting careers, carrying over to how they might envision data rights and control, as well as obligations associated with their data. Without meaningful dialogue and understanding of these perspectives, the implementation of rights regimes and literacy frameworks might undermine the range of claims they may have regarding their data and desired outcomes for their use.

Socioeconomic inequalities also influence how athletes may pursue data rights or advocate for them. Although some professional athletes in Australia do secure lucrative contracts and have support from their clubs to express beliefs, many professional sportspersons are still precarious workers and have relatively little negotiating power in terms of their employment.[164] Aspiring high-level athletes rarely reach the upper echelons of competition, even though they pay significant costs, both physical and financial, for the opportunity to do so. Such power imbalances can foster conditions that can have a chilling effect on athletes' ability and willingness to express concerns or make demands around the use of data collected from them, particularly when compared to how professional athletes in the United States have expressed strong opinions on surveillance and racial justice within and beyond sport.[165] Corporate partnerships with US university sports sanctioned by the National Collegiate Athletic Association provide a cautionary tale of what can happen when athletes have no place in discussions: not only do these agreements allow sponsors to access and use student-athletes' data with few to no protections in place,[166] they also further entrench athletes' depowered disposition within data-sharing systems as they expand.[167]

Recognising that many Australian athletes have limited agency within professional sport points to the need for wider regulatory change. While better and wider data literacy may be necessary (see chapter 2), efforts must be attentive to the need for more situated understandings of data in the specific contexts of sport, which can vary. For example, if athletes were to have baseline knowledge of how measurements are made and relate to their performance and greater knowledge of how other parties are using their data, they would be in a stronger position to engage—but only if other enablers are put in place. Professions that similarly have a mixture of physical key performance indicators and health-related monitoring—such as astronauts, first-responders, and pilots—benefit from more established governance approaches to data, which may prove instructive. However, stronger athlete-centred governance is necessary for these changes to be realised. With continued developments in relation to the use of algorithms in decision-making, the challenge of conveying the basis of forming decisions and what some describe as the reticence in accepting the decisions informed by machine learning is also likely to persist.[168] Literacy alone will not ensure good governance. A more iterative and collaborative approach that works with athletes and sport organisations as partners is more promising.

PRESERVING A LEVEL PLAYING FIELD: THE CHANGING LANDSCAPE OF FAIR PLAY AND INTEGRITY

The rise of data-informed sport raises emergent questions about maintaining fair play in professional sport—if not now, then in the future. Fair play as an ideal is often evoked as a core value in sport; however, scholars acknowledge it has never been clear, nor is the social good it delivers.[169] In fact, its use as the grounds for regulation has been particularly difficult to operationalise and has often been problematic in practice.[134] Given the dominance of fair play as a regulatory principle in sport, its shortcomings could carry over into efforts to preserve the integrity of competition in more data-saturated contexts.

Consider some of the existing concerns linked to maintaining a level playing field in sport, including:

- the ingestion of substances that may enhance or impede performance—authorities have taken action to regulate substances that may enhance performance through increased efficiency of the musculature system, aerobic capacity, or mental acuity
- the use and modification of playing equipment—over time, the size of balls, bats, clubs, boots, and protective equipment have evolved through regulation of their dimensions to provide a balance of effectiveness of performance and safety of the players. Within this, concerns about 'technological doping' related to performance-enhancing equipment, such as concealed engines in bicycles, have also been addressed
- the environmental conditions that may affect the performance of individuals and teams differentially—professional leagues have taken action to ensure teams play in what can be regarded as roughly equivalent conditions with comparable resources.

While concerns around performance-enhancing substances have received significant regulatory attention, sport integrity agendas have meant a more expansive approach to understanding what constitutes cheating and how to preserve the credibility of competition. Despite these shifts, approaches still emphasise a relatively narrow focus on individuals. Existing interventions aimed at preventing doping in sport tend to frame "individuals as cheats" and to focus on "holding individuals accountable", which often "obscures the organisational dimensions of performance enhancement" and competition.[170] In doing so, regulatory efforts have struggled to hold organisations accountable or achieve widespread prevention. Furthermore, the emphasis on individuals has directed attention away from the structural inequalities that contribute to unfair competition.[134, 164, 171]

The explosion in data collection and the promises generated by the application of advanced analytics and machine learning to aggregated datasets add new dimensions to these ethical concerns. They raise questions that exceed the traditional scope of fair play, bringing the divide between the 'technology-haves' and 'technology-have-nots' into stark relief. If a coach is monitoring the physiological capacity of team members, for example, to design a training regimen to enhance strength and agility, would fair play require or prohibit that data to be made publicly available and, in turn, available to the coach of a competitor? Suppose a coach or team doctor is monitoring the sleep patterns or the psychological mood swings of team members to ascertain circadian rhythms in the team. In that case, the availability of the data to an opponent

might enhance the competition to recognise particular times when teams were vulnerable to change; should this data be available or prohibited? The capture of performance data in its various forms—batting averages, bowling averages, mid-field passes, speed of reaction and propensity to 'yipping' (in golf)— would similarly provide important information for competitors. It could also be used to train models and to assist in predicting an opponent's performance.

Limiting concerns around data to their performance-enhancing effects invites challenges for regulating data in sport. Current integrity models, many of which are frameworks inherited from anti-doping and anti-corruption frameworks, are not equipped to address data-related challenges on the horizon. They would need to be adapted to focus on holding participants other than athletes and organisational actors to account—which would be a key focus in the context of data given the power relations involved and athletes' limited practical influence on how their data are used. It would therefore be a miscalculation to try to adapt existing approaches without considering the range of other regulatory models available or before considering the wider implications for sport governance.

As spectator sport is a field in which the general public learns how to relate to authority and negotiate rules,[172] the implications of revising regulatory approaches to integrity should not be understated. The ethical dimensions of data governance in professional sport are not only multifaceted and complex, but they also have the potential for far-reaching cultural and societal effects.

WHAT NEEDS TO CHANGE: GOVERNANCE

Although the challenges of professional sport are distinct, developing approaches to sports data governance can benefit from wider debates that go beyond traditional conceptions of judgment, ethics, and responsibility.[173] Given the potential for data-informed machine learning systems that can be used to make decisions about individuals autonomously and opaquely,[174, 175] scholars have emphasised the need to better understand the ethical character of data-informed systems to anticipate and mitigate any potential harms they may cause.[176, 177] Others have highlighted that addressing the harms of machine learning systems requires more than merely encoding ethical constraints; instead, they contend there are significant practical challenges—both technical and organisational in nature—when trying to operationalise ethical considerations into tangible outcomes.[178, 179] Others argue that the discourse of ethics has been co-opted by technology corporations to justify self-regulation and market-driven governance rather than meaningfully addressing the substantive concerns of the technologies.[180, 181, 182] Still other critics highlight the complexities of using algorithms in decision-making management and the need in coaching to be aware of the difficulties of forming decisions based on big data, including the reticence of many athletes and fans in accepting the decisions that are provided by machines.[183] These recent debates point to the need for more expansive thinking about regulatory relationships beyond ethics and formal rules.

Regulatory governance experts have long conveyed similar points: that regulation is more effective when it is understood as actions taken to steer the flow of events and undertaken by various private and public actors, including, but not limited to, government.[184] Governance captures "the management of the course of events" within a system.[185] While ethics are important, more effective

regulatory strategies in complex systems acknowledge the need for multiple tools and strategies that value regulatory pluralism. Regulatory pluralism encompasses a "much wider range of policy mechanisms" than traditionally assumed of law and policy, including "economic instruments, self-regulation, information-based strategies, and voluntarism".[186] These insights have direct application for data governance in professional sport—an arena where a wide range of actors need to be held accountable and encouraged to comply with shared rules.

In developing regulatory approaches with pluralistic toolkits, there are existing areas from which to learn. Although anti-doping regulatory models are not fit for purpose in terms of enforcing data-informed concerns around fair play, they do have established practices of data sharing, including across jurisdictions, and have had to address major concerns and breaches around data security. The limitations and failures of the global anti-doping regime also point to the need for modes of governance that are more athlete-centric.[134] Some national anti-doping agencies are already making these kinds of adjustments to better share information with sport participants and build trust. Trust has become a central concern across various domains of data governance, including within sport contexts. It is essential to ensuring systems continue to run smoothly—in both an interpersonal and a technical sense.[154, 167] The pursuit of more athlete-centred approaches can facilitate trust in meaningful ways. However, as US examples attest, negotiating these terms are more likely in professional leagues with stronger player representative bodies.

Developing more athlete-centred approaches to data governance in Australia is challenging. Athletes are diverse and have various interests. The forms of leverage that player associations can exercise vary across the professional landscape. In addition, athletes in many sports enter elite player pools before becoming professional. Introducing forms of data protection and education in these environments would depend on professional league structures and their scope. These issues are further complicated as the national regulatory environment around data continues to change, particularly as the Australian Government continues to advocate for expanded surveillance and information sharing powers, most recently through the Surveillance Legislation Amendment (Identify and Disrupt) Bill 2020. While the debates about the Bill do not address sport, there are precedents that demonstrate the need to be responsive to these developments. For example, the enhancement of the Australian Crime Commission's intelligence powers enabled its investigation into athletes and sports organisations, which contributed to the Essendon Football Club supplements scandal breaking in 2013.[187]

A forward-looking approach to data governance in Australian professional sport is desirable and arguably necessary. It requires coordination with accrediting bodies and the high performance sporting system to ensure governmental input. Bioethicists studying biometric data in sport have called for the establishment of independent governing bodies made up of data scientists, players association representatives, regulatory experts, and sport administrators who may be tasked with the duties such as developing best-practices, establishing the expectation of data governance principles and protocols—increasingly the norm in other professional domains—and reviewing policies for data collection, management and protection.[154] To this should be added the domain experts in sports science.

As the scope of this discussion paper is wider, other areas need to be considered, including:

- an overreaching regulatory framework guided by evidence-informed research (not simply sport norms) and designed to incentivise best-practice, protect the interests of weaker actors, and prevent capture by dominant interests. Such a framework might guide practical interventions by governments and professional sports bodies to ensure the validation, intelligibility, and fairness of any technologies that are used, the protection of individual and collective rights, and education and literacy, with athletes learning not only digital skills but also how to develop a critical perspective on digital technologies
- processes for monitoring developments in the field. For instance, how AI and machine learning are being used in different sports, the validity of different tools, and which third parties are becoming influential and amassing power across sports
- a forward-focused data expert consortium to facilitate knowledge-sharing on industry practices to inform guidelines
- meaningful consultation with diverse groups of athlete representatives to understand the range of interests that athletes have in their data over their life course
- an ombudsman role to support staff in navigating systems and to support the realisation of human rights, privacy, and security protections
- the need to explore education and accreditation mechanisms around data management in sport, to ensure a culture of accountability and data literacy.

As starting points, these governance interventions facilitate being responsive to current and emergent issues related to data and its increasing use in professional sport. Moreover, they enable attending to issues of confidentiality, privacy and security without being narrowly tailored around these concerns. Instead, they create space for greater autonomy, collaboration, and a shared language to address a wider range of societal and ethical concerns now and in the future.

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APPENDIX: SUPPLEMENTARY INFORMATION

In order to obtain sector-specific information from practitioners to contextualise participant experiences in professional sport, a total of 25 informal semi-structured interviews were undertaken. Views were obtained from practitioners drawn from accrediting or regulatory oversight bodies; a number of Australian professional sports; the National Basketball Association, National Football League, and Major League Baseball in the United States; and the English Premier League in the United Kingdom. Interviews were conducted by Expert Working Group member Dr Jason Weber, working as a Research Fellow with the Minderoo Tech & Policy Lab at The University of Western Australia. In some interview instances the Research Fellow was joined by one or both of the Lab Directors, Associate Professors Powles and Alderson. A semi-structured interview was chosen as the qualitative method of inquiry over a structured survey as it combined a pre-determined set of open questions (questions that prompted discussion) with an opportunity for the interviewer to explore particular themes or responses further. One intention of the interview process was to obtain insight into how Australian professional sport data collection practices and environments compare to those in Europe and the United States. In order to preserve anonymity of interviewees only broad themes and aggregate data are presented.

This information provides broad brush insight for the discussion paper. **It is not intended, nor designed, to be a formal qualitative research undertaking**. Consequently, while insightful, the following information should only be regarded as general commentary from a sample of practitioners engaged in the professional sport sector.

INTERVIEWEE DEMOGRAPHIC OVERVIEW

- A total of 25 interviews were conducted comprising 23% female and 77% male interviewees.
- 72% of the cohort nominated Australia as their primary residence location with 28% identifying Europe or the United States.
- 14% of the interviewees indicated they had extensive experience working in European professional sport.

- Interviewees were drawn from practitioners with direct working experience in 11 professional sports (male and female leagues), including: Australian rules football, rugby union, rugby league, basketball, cricket, athletics, soccer, golf, netball, American football and baseball.
- The average age of the interviewees was 40.4 ± 5.9 yrs. The interviewees had an average of 14.5 ± 5.7 yrs experience working in the professional sport sector.
- The interviewed cohort had worked with an average 2.6 ± 1.3 professional teams during their working career to date.
- The interviewees self-classified into the following roles to describe their current position:
  - Performance Director 57%
  - Sports Science Director 19%
  - Head Strength & Conditioning Coach 14%
  - Administration 14%

INTERVIEW APPROACH

Five generic questions were asked throughout interviews lasting approximately 30-60 minutes. Following the presentation of the generic question each interviewee was asked if they wanted to make further comment on the topics raised and, if so, an open unstructured conversation with the interviewer followed. Critical themes and quotes were noted by the interviewer in a generic document that de-identified the interviewee. For accuracy the interview was recorded where an interviewee provided permission. These recordings were then deleted once the recording was reviewed and relevant responses obtained and/or confirmed. All responses and relevant thematic interview data was aggregated and compiled as summarised commentary. Supporting representative quotes are included as supporting statements; however, the source of the quote, inclusive of any identifying remarks has been redacted to ensure anonymity. The responses are as follows.

One overarching theme of the interview responses was clear: namely, that practitioners in Australia were significantly behind their international colleagues in terms of literacy with privacy and data protection requirements surrounding personal information collection and use.

- Practitioners with experience working in European professional sport were very aware of the requirements of the EU's General Data Protection Regulation (GDPR). This was driven directly from senior management within individual clubs.

> Example quote from practitioner working in Europe: "*Six years ago, data security was non-existent. Now with the implementation of GDPR, several larger environments have gone to the extent of full-time compliance officers to ensure nothing compromises the team.*"

- Practitioners with experience working in professional sport in the United States were very aware of the potentially litigious implications surrounding personal information collection and use; a position very much facilitated by player managers and agents, whose role is to advance the rights and interests of players. Similar to European observations, the broader awareness of data protection requirements appears to be driven in the US by senior management and relevant sports governing bodies.

  Example quote from practitioner working in the United States: "*Any data that is collected via wearable sensors is incredibly closely managed by senior management including legal counsel and IT management in order to ensure adherence to guidelines.*"

- Practitioners with experience working in professional sport in Australia (exclusively) have a limited awareness of data privacy and security, with the most literate practitioners being those that have graduate-level academic research experience (likely as a function of exposure to institutional ethics processes).

  Example quote from practitioner working in Australia: "*Personally, I have always felt a moral obligation to the players with respect to the data we have collected over the years. However, from both an organisational and accreditation perspective I have never had a specific discussion nor had any information presented that informed me of any legal obligation.*"

QUESTION RESPONSES BREAKDOWN

Details of the five primary questions and summary results are provided below. All generic questions were answered on a scale of 1-5. The scoring of question responses was generally designed to increase in number to reflect increased knowledge and/or information. Given that practitioner responses varied considerably based on geographical working experience, a sub-group score is provided for Australia and, comparatively, the US/Europe.

Legal literacy

Question: "How well do you understand the laws pertaining to data collection within your country?"

Mean sub-group score:	
Australian professional sport	2.2 ± 0.8
US/Europe professional sport	4.4 ± 1.1

1. Not interested
2. Barely aware
3. General interest, personal view
4. Very cognisant
5. Actively implement laws

Data privacy and security

Question: "Are laws associated with data privacy and security discussed in your workplace?"

Mean sub-group score:	
Australian professional sport	1.7 ± 0.9
USA/Europe professional sport	4.3 ± 1.5

1. Never
2. In passing
3. One-off conversation
4. Manager provides operational guidelines
5. Workplace is extremely strict

Athlete engagement

Question: "How engaged are the athletes in the data collection and analysis process?"

Mean sub-group score:	
Australian professional sport	3.6 ± 0.5
US/Europe professional sport	3.5 ± 0.5

1. Not interested
2. Barely acknowledge the process
3. General interest
4. Ask plenty of questions
5. Very engaged, follow

Permissions

Question: "How rigorous is the permission structure in your environment for the collection of data?"

Mean sub-group score:	
Australian professional sport	1.6 ± 0.8
US/Europe professional sport	3.9 ± 1.4

1. Non-existent
2. Own decision
3. General Manager
4. CEO / senior management
5. Board or external oversight

Data locations

Questions: "How many cloud-based accounts do you use in your environment?"

Mean sub-group score:	
Australian professional sport	3.6 ± 0.5
US/Europe professional sport	4.3 ± 0.8

1. 0
2. 1
3. 2
4. 3
5. Greater than 3

DISCUSSION AND SAMPLE COMMENTS

- Despite what is acknowledged to be a limited sample, there is unquestionably a significant distinction between the responses of Australian professional sport practitioners and those with overseas experience. Interestingly, by contrast, athlete engagement is almost identical across jurisdictions.
- The last decade has witnessed an explosion in the quantum of data being collected in professional sport regardless of geographical location. However, one very interesting insight to emerge from the follow-on interviews is that there appears to be an emerging trend of reducing data collection to that which is minimally necessary and meaningful in some of the more mature codes internationally, rather than the approach that prevails in Australia of 'collect everything you can.'

  Example quotes from individual practitioners, reflecting emerging shift towards data minimisation: "*Our data collection model has evolved over the years. We have had periods where we have collected in all domains, but now our data is far more centered on biomechanical and management data.*"

  "*We try to limit the total requests on players for data, ensuring the level of imposition on the athlete is appropriate for the returns we get. That said, we do collect in all domains.*"

- The extent of information availability to athletes varies widely across sports and geographical location, and in some cases involves the potentially unlawful sharing of information across teams.

  Example quote from practitioner working in Australia: "*Identified test data is shared between teams to provide transparency between players as to who is and is not hitting targets. While the players know about it, I'm not sure they were ever asked.*"

- When asked if people know what happens to their data once it is uploaded to a cloud server, no-one was able to provide a clear answer. Interviewees were unaware if their cloud-based accounts were housed in the same country they operated in or if they were held in off-shore servers. No interviewees were able to provide specific information concerning data hosts, and for those that believed data was held off-shore, none were able to provide a specific location.

  Example quotes from practitioners working in Australia: "*As coaches who use cloud-based servers, we are aware the data is being used by the host companies to generate new products.*"

  "*As a national body we take the management of player data seriously. While not specifically discussed, our practices are aimed at protecting the athlete. However, I can tell you that our use of three-party cloud-based servers is assumed to be secure.*"

- Interviewees' assessment of athlete engagement in data collection practices did not appear to differ across Australian and overseas professional sporting codes. There was general acknowledgement by those who had worked in team sports that individual athlete engagement across the player group was variable but that the degree of engagement was consistent, i.e. there was no impression that athletes care about one type or set of information more than another.

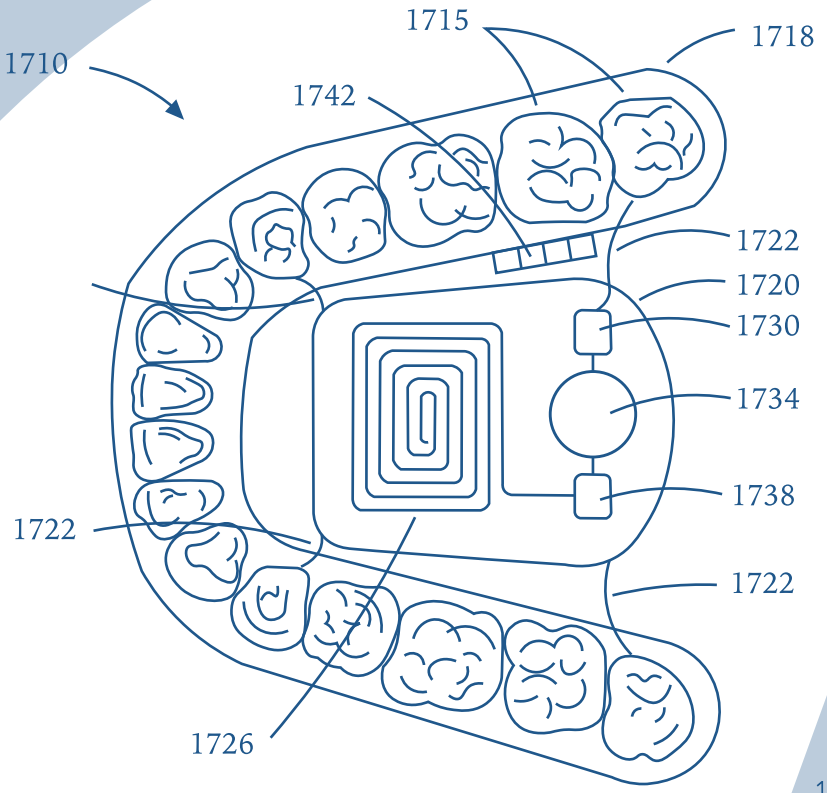
  Example quote from practitioner working in Australia: "*There is a broad spectrum of engagement. The most naturally driven and intelligent athletes are drawn to understand what they have done, how it is relevant, and how it impacts their specific plan to improve. Individuals who have been recruited without any background in elite preparation tend to be dismissive of data early, with a small proportion of those taking greater interest as their careers develop and/or they come up against challenges like injury.*"

- A lack of direction, understanding, and knowledge surrounding data privacy and security practices was a repeated area of concern raised by Australian-based practitioners.

  Example quotes from practitioners working in Australia: "*There is no specific discussion or operational directive from the organisation about data security or privacy. All of our contracts do contain a Confidentiality clause, but I'm not sure it specifically describes player privacy.*"

  "*Nobody has ever discussed security, but one coach I worked for specified that all data was to be kept secret and only circulated among a few staff members. When he finished all data was removed from work computers before he left.*"

  "*I am aware of one specific example where a person with significant network access was terminated from employment and he literally pushed delete on all records as he left the building.*"



Top view of a signalling device that can be placed in a user's mouth, from "Apparatus, systems, and methods for gathering and processing biometric and biomechanical data," patent US 10675507 B2, Jun . 9 , 2020. Current Assignee: Nike Inc.

1710 - embodiment of signalling device
1715 - rear teeth
1718 - retainer
1720 - base
1722 - clips
1726 - RF antenna
1730 - microcontroller
1734 - internal power source
1738 - signal discriminator
1742 - modulator
1750 - embodiment of a circuit