Sports Science 3.0: Integrating Technology and AI with Foundational Knowledge

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Sports Science 3.0 | Evidence-Informed Practices | Technological Integration | Training Principles | Research-Practice Gap | Injury Surveillance | High-Speed Running | Practical Applications | Foundational Knowledge |Performance Metrics

The Current State of Sports Science

In the past 10 months, through my (MB) consulting, workshops, and mentoring, I've encountered a recurring issue in the sports science community. It has become apparent that the industry is lagging behind expectations. Many practitioners are taking shortcuts, relying on the latest papers or social media trends without a deep understanding of the underlying principles. For instance, isometric exercises have recently resurfaced with new names and terminology, along with courses and technology such as force plates to measure them, as if they were novel concepts. While it's commendable that these approaches have been made more accessible and easier to understand, we must ensure we're not confusing what has been repackaged with what has long existed. As highlighted by the recent work of Jos J. de Koning and Carl Foster (2024), 100 Essential Papers in Sport and Exercise Physiology, the most influential papers are often much older. These are foundational papers. For example, out of the 100 essential papers, 37 were published over 50 years ago and 63 since 1973, with only a few from after 2000. Notably, Paul's first paper on high-intensity interval training (HIIT) is cited among these 100 essentials (Laursen & Jenkins, 2002), and not our more popular reviews from a decade later (Buchheit & Laursen, 2013a, 2013b). This reality could suggest that today's practitioners risk merely scratching the surface and missing out on the deeper, more valuable insights found in foundational research and historical practices.

Another significant issue in sports science is that many practitioners aren't researching the right questions. "They build the spaceship for the moon, despite nobody asking them to go there". This is often due to constraints of publication requirements, limitations of available data, or simply not knowing what they don't know. This leads to research built around what can be measured or published rather than what is truly important. As I've (MB) repeatedly noted in my recurrent editorials (Buchheit 2016, 2017a, 2017b, 2019a, 2019b, 2020, 2022), this misalignment results in studies that fail to address the core issues practitioners face, ultimately hindering the advancement of the field.

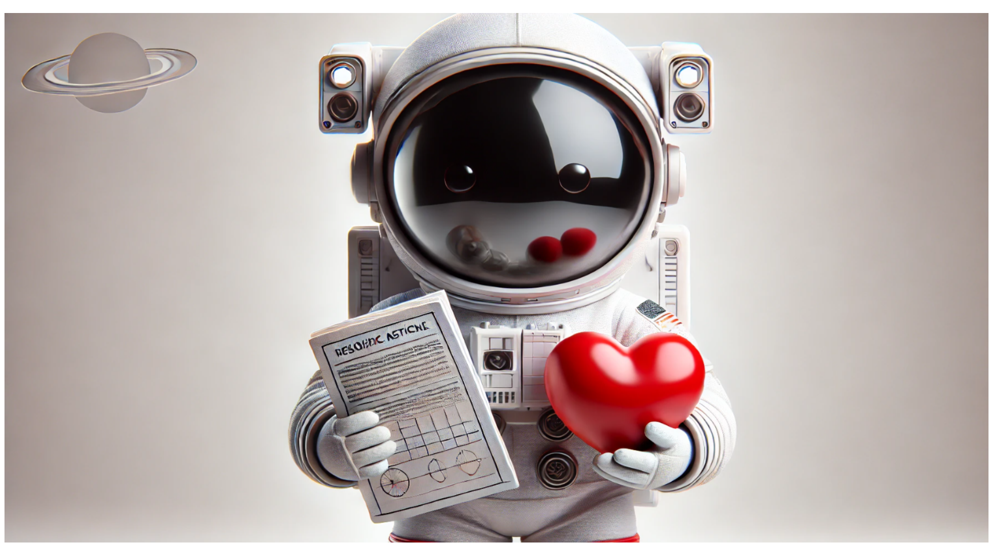

Fig. 1. This figure is a metaphor for researchers often being detached from practical applications ("in orbit," Buchheit 2017a). Please understand that my (MB) criticisms come from a place of genuine care and a desire to improve the practical relevance of scientific findings.

To illustrate some of the many publications that miss the point, I want to resurface a piece we wrote back in 2019 (Buchheit 2019a)—a topic I also recently commented on during the last Isokinetic Conference in Madrid (LinkedIn post). This commentary stems from a good place (Figure 1), as I respect the researchers both personally and professionally. However, it highlights how science can sometimes miss the mark. For instance, the injury surveillance led by the UEFA group involved a survey concluding that most top teams in Europe were not compliant with evidence-based research (Bahr 2015). This conclusion was drawn because these teams weren't exclusively using exercises that had received scientific attention (i.e., the Nordic hamstring curl). In practice, we employ a variety of strategies that may help mitigate injuries, often using exercises that haven't been scientifically validated but work well. Because we didn't report using only the most researched exercises, we were labeled as non-compliant, which understandably frustrated many practitioners.

Further illustrating this point is the research indicating that hamstring injuries have increased over the last 13 years (Ekstrand 2016) to 20 years (Ekstrand 2022). This study somewhat supports the findings of the previous study (Bahr 2015), suggesting that one reason for the increased injury rate, among many other factors, could be that practitioners weren't doing their jobs properly. However, if we measure injury rates against the distance covered at high speed—a metric that has increased substantially over the past years (Barnes 2014, Bush 2015, Taberner 2023) and is likely more associated with hamstring injuries than the time spent on the pitch (i.e., hours of exposure, Buchheit 2024b)—the relationship changes significantly. Our analysis (Buchheit 2019a) even suggests a decrease in injury rates, which could imply that practitioners are actually doing a better job despite not strictly adhering to evidence-based exercises.

This example underscores the potential divide between sports science research and practice. Despite their good intentions, some researchers often lack a deep understanding of the field, leading to questions, analyses, and interpretations that may seem odd or irrelevant to practitioners. Consequently, they risk losing the interest and trust of those working directly with athletes.

The Greatest Obstacle to Discovery Is Not Ignorance-It's the Illusion of Knowledge

The recent buzz created around the six-minute run to assess maximal aerobic speed (MAS), (re)popularized by social media coverage of Liverpool's 2024 pre-season training, highlights the illusion of novel knowledge on display by today's sport science practitioner. The engagement around this social media post was incredible and surprising since this is not a new concept; many AFL teams in Australia have been running 2-km time trials for years, and we discussed it extensively in our 2013 Sport Medicine reviews (Buchheit & Laursen 2013a & 2013b) based on V. Billat's work in the 1990s (Billat 1996). However, it seems many practitioners are treating it as a new discovery.

Another example I (MB) see is the frequent inquiries received about the 30-15 Intermittent Fitness Test (30-15IFT). Whether it's the protocol details, what measurements to take, or confusing VIFT (i.e., end-of-test running velocity) with MAS, there seems to be a fundamental misunderstanding of the physiology and determinants behind the test. Prescribing HIIT from VIFT as if it was MAS leads to inaccurate training demands due to these misunderstandings. VIFT is 15-25% faster than MAS, whose magnitude is related to the Anaerobic Speed Reserve and various physiological capacities like the ability to recover between efforts and change of direction ability (Buchheit 2010). It often appears that the freely accessible papers (Buchheit 2010, Buchheit 2020b, Buchheit 2021), the test App, and many more on the test webpage are overlooked or deemed too extensive to read. While I'm (MB) pleased that the test is being widely used, it's challenging to continually respond to emails and messages when comprehensive explanations are already available in the published literature.

This issue extends to specific training methods, such as Zone 2 and heat training in football. When we published the "Zone 2" article (Buchheit, Vesco F & Laursen 2024) and I shared the heat training LinkedIn post, they sparked considerable debate. Regarding Zone 2 training (i.e., long-duration, low-intensity runs traditionally valued for building aerobic capacity), many critics presented interesting arguments but often lacked substantial evidence to support their claims, highlighting a broader issue: the reliance on opinions rather than evidence-based practices. For example, one of our arguments was that Zone 2 training might not be well-suited for fast and explosive players, given the specific characteristics of their muscle fiber types. However, some critics argued that it could still be beneficial during the pre-season, raising the question: do fiber types change transiently over the summer? Many people seemed eager to continue with familiar methods without considering the existing evidence. While I am not dismissing the potential benefits of their approach, the debate I initiated was centered on presenting the existing evidence. Not surprisingly, I (MB) never received responses to their LinkedIn comments when I genuinely asked them to provide evidence supporting their views.

Regarding heat training, which we've advocated for over a decade ago using the real-life conditions of football players in Qatar (Buchheit 2011, Buchheit 2013, Racinais 2014) and Australia (Philp 2017 & 2022), the benefits are well-documented but are often overlooked or misunderstood. Many practitioners either don't want to hear about it or pretend to have forgotten our work. A common argument against heat training is that it's challenging to maintain training quality in hot conditions. While this concern is valid, it's entirely possible to adapt training sessions to accommodate these challenges. This can be achieved by incorporating more breaks, extending recovery periods, and using cooling strategies between sets, allowing athletes to train with intensity and quality while still benefiting from the powerful heat-specific physiological adaptations. However, this approach requires careful planning and adjustment, which some may find too complex. As a result, many prefer to avoid the complications and instead train at cooler times, like 7 or 8 PM, missing out on the potential advantages of heat training.

Additionally, in practical applications, there is a concerning trend of taking shortcuts. For example, some practitioners use High-Speed Running (HSR) measured by GPS as a key metric for assessing performance and injury risk without considering the context in which HSR is accumulated. This approach fails to recognize the significant differences between the distance accumulated during a 90-minute football match and the same distance covered in a 6-min straight-line run-based HIIT session in regular shoes (Buchheit 2019c & 2019d, 2024b). These contexts are not comparable, and the likely neuromuscular and metabolic stresses associated with each are vastly different. This illustrates a lack of deeper understanding and suggests a need to compute and monitor different types of HSR. Overall, there is a pressing need to improve how practitioners gather information and learn, as well as how they use data in practice. It is crucial to go beyond surface-level insights and develop a more comprehensive understanding of the factors that truly influence performance and injury prevention should GPS be selected as a key monitoring tool (Buchheit & Simpson 2016).

From Sports Science 1.0 to 3.0

To address these challenges, it's crucial to revisit the evolution of sports science. In the 20th century, Sports Science 1.0 focused on understanding training principles, planning, and physiological adaptations. This foundational knowledge was essential in shaping effective training strategies.

With the advent of technology >2010, Sports Science 2.0 emerged, characterized by the use of advanced tools to monitor training load and competitive demands. While technological advancements have provided valuable insights, they have also led to an over-reliance on data collection for the sake of it without addressing the root causes of performance issues and neglecting the need to plan and execute. For instance, using heart rate variability (HRV) as a standalone measure of training load is a mistake. As we've been saying for over a decade, HRV is a measure of the body's response to load, and without a proper framework, relying solely on HRV can complicate rather than clarify the understanding of an athlete's condition (Plews et al., 2013, Buchheit 2014).

Similarly, the trend of tracking every possible variable—such as sweat rate, blood lactate, or sleep quality—without contextualizing these metrics in relation to changes in load can be misleading. Often, it is the parallel evolution of these variables alongside training load that provides meaningful insights, rather than tracking them independently. Unfortunately, many in the Sports Science 2.0 era have neglected this comprehensive approach. This oversight highlights the need for more integrated and thoughtful strategies and frameworks in sports science practices.

There is also much to be said about the limitations of using GPS as a measure of external load in the team sport context. GPS data is often used as a proxy for various aspects of training load, including musculoskeletal stress (Kalkhoven 2021). However, this approach is flawed because GPS primarily measures external factors like distance covered or reached, rather than the internal stresses on muscles and tendons, such as the intensity or the type of muscle contractions. This results in a significant discrepancy between what GPS data suggests and the actual physiological demands placed on an athlete's body (Kalkoven 2021). Unfortunately, many practitioners still assume that these GPS-derived metrics are comprehensive indicators of all forms of load, which is a naive and simplistic view. This oversight underscores the need for a more nuanced understanding of the difference between external and internal load measurements.

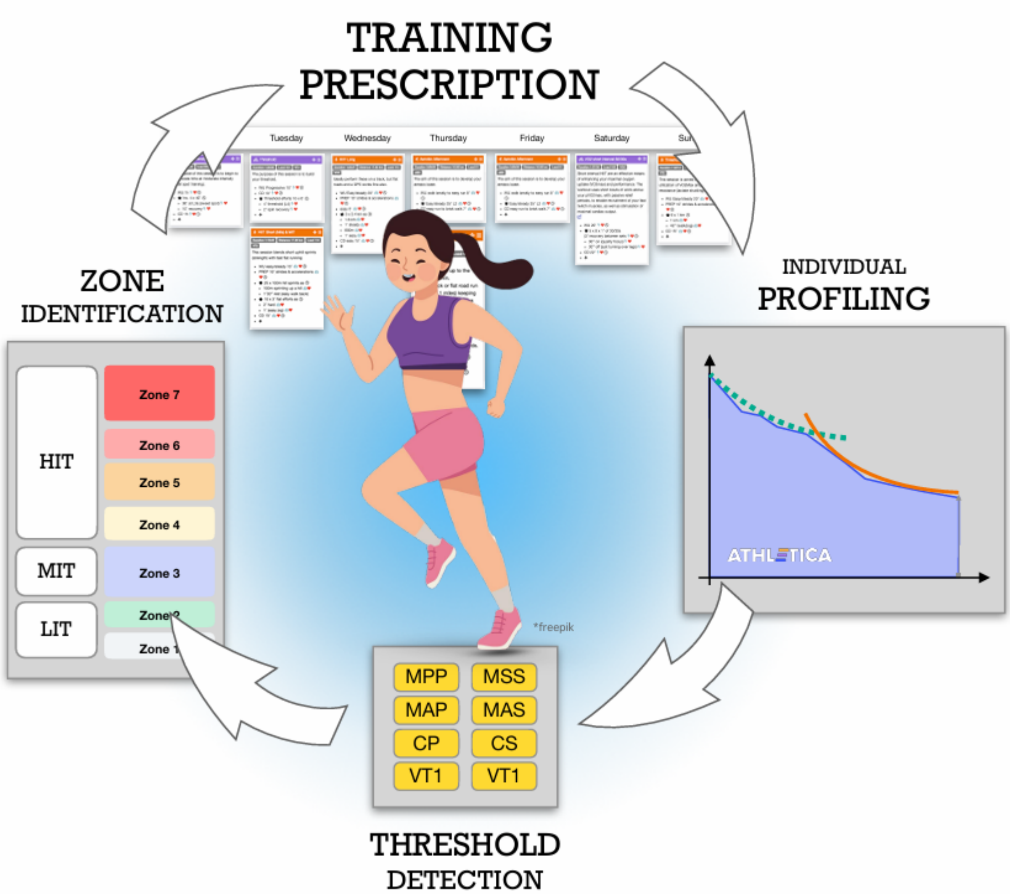

Fig. 2. An example of Sport Science 3.0 is the Athletica System that leverages AI alongside foundational sport science principles to build power and pace profiles from wearable data. Machine learning methods define thresholds and training zones, guiding personalized training prescriptions with an Athletica-modified load model (Banister et al., 1975), in parallel with an HRV load-response model (Zignoli & Laursen, 2024).

Towards an Evidence-Informed Approach

We are now at the cusp of Sports Science 3.0, a phase where we must integrate our technological understanding with a solid foundation of training and monitoring frameworks (Buchheit 2024c). This approach requires a shift from a naïve reliance on evidence-based practices to a more nuanced evidence-informed approach. In evidence-based practices, there's often a tendency to quickly apply research findings without fully considering the context upon which the findings were discovered or the context in which they are being applied. This can lead to misapplication or oversimplification of the research, resulting in ineffective or even counterproductive outcomes.

In contrast, evidence-informed practices take a more comprehensive approach. They not only incorporate the latest research and findings but also critically assess the relevance and applicability of this evidence to the specific context at hand. This means understanding the conditions under which the original research was conducted and carefully evaluating whether similar conditions exist in the current application (Buchheit 2016 & 2017a). By doing so, evidence-informed practices maintain a reservoir of knowledge that is readily available but used judiciously, ensuring that interventions are applied only when the context permits and is suitable.

For example, platforms like Athletica leverage foundational knowledge with AI to provide personalized training insights, which can be incredibly valuable (Zignoli & Laursen, 2024). However, it is crucial to use these tools within a structured framework or system developed by experienced coaches who respect traditional training principles. Such frameworks (Figure 2) help ensure that technology and AI enhance and inform coaching decisions rather than replace foundational knowledge and judgment. This balanced approach allows practitioners to draw on the strengths of both advanced technology and time-tested training methodologies, leading to more effective and contextually appropriate interventions.

Conclusion

In summary, Sports Science 3.0 should represent a crucial evolution in the field, integrating technological advancements with foundational training and monitoring frameworks (Buchheit 2024c). The shift from naive data and evidence-based practices of Sport Science 2.0 to more thoughtful evidence-informed approaches is essential for truly understanding and applying scientific insights to, in turn, have an impact on the world of sports performance (Buchheit 2016). It's important to seek information beyond the most recent publications or social media posts and revisit the core principles of sports science, akin to Sports Science 1.0, to understand the underlying fundamentals (Koning & Foster 2024).

Moreover, the distinction between strategy and tactics is crucial in sports science. Strategy involves long-term planning and setting overarching goals (i.e., having a defined microcycle periodization -Buchheit 2024a- or setting up a proper load and response monitoring system, which can take months to years, Buchheit 2014, Carling 2018, Buchheit 2024c), while tactics are the specific actions taken to achieve these goals (e.g., measuring urine specific gravity or jump height every day). In this context, it's akin to treating the cause of a problem rather than merely addressing the symptoms. In a rapidly evolving field, being proactive and innovative is key. This means not just reacting to new trends or data but thoughtfully integrating them into a well-established framework. As the saying goes, "One hour solving the right problem beats ten hours on the wrong one," highlighting the importance of focusing on the right issues and using the right tools to address them (Buchheit 2024c).

In conclusion, the future of sports science (i.e., Sport Science 3.0) lies in a balanced approach that respects traditional training principles (i.e., Sport Science 1.0) while leveraging modern technology and AI (i.e., Sport Science 2.0). By fostering an evidence-informed mindset and clearly distinguishing between strategic and tactical decisions, performance and medical practitioners should be able to better enhance their ability to support athletes in achieving their peak. This holistic approach would ensure that we are not just scratching the surface but delving into the true essence of athletic performance and development.

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