

24 - 26 MAY
2023

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World Congress on Science and Football 2023

Book of Abstracts

Groningen, The Netherlands

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Keynote Presentations

Injury Prevention in Football. Are we keeping up with the game?

Evert Verhagen

*Amsterdam Collaboration on Health & Safety in Sports, Department of Public and Occupational Health,
Amsterdam UMC, The Netherlands*

Amsterdam Institute of Sport Sciences, The Netherlands

Football is one of the most popular sports in the world, and it needs no introduction or explanation. It is played at all levels and by all age groups, and players participate for a variety of reasons. Football, like any other sport, has the risk of injury. These injuries detract from the enjoyment of participation, place a burden on individuals and society, may have long-term health repercussions, and diminish individual and team performance. Overall, there are numerous compelling reasons to prioritize injury prevention.

There is a lot of information in the scientific literature on effective strategies to minimize the number and direct and indirect burden of injuries. Evidence has been acquired for a variety of injuries, using diverse preventive methods and at several levels. Based on this research, the number of injuries should be reduced. While this may be true for some injuries, others have shown an increase in the last ten years or so. This demonstrates that our preventive measures have been less effective than we may imagine.

In this presentation, I will look at the available preventive evidence and emphasize the breadth and depth of what we know. I will connect this to current challenges in football injury prevention and outline potential future directions for having a substantial impact in football.

Advancements and Challenges in Monitoring Football Players: A Retrospective Analysis of Scientific Practices and Future Perspectives

Aaron J Coutts

School of Sport, Exercise and Rehabilitation, University of Technology Sydney, Australia

Over the past two decades, the support of scientific practices in football codes has significantly increased. One of the primary responsibilities of practitioners working in football is to monitor players' training and their responses to it. The advancements in technology and research have facilitated this increased scientific support on the field. This presentation aims to retrospectively analyse the progress made in monitoring football players and critically review current practices. Firstly, the conceptual basis and the importance of monitoring in contemporary football will be discussed. Secondly, the athlete monitoring systems used in the football codes will be explored, with a review of the evidence supporting each system. The discussion will focus on the current threats to successful athlete monitoring, including the inappropriate use of invalid metrics and measures, lack of player buy-in, and over-reliance on data in the absence of context and relationships. These threats will be used as lessons for future work. Finally, future perspectives will be discussed with recommendations for future research and practice.

Undesirable behavior in football

Marjan Olfers

Faculty of Law, VU Amsterdam, the Netherlands

In recent years, various forms of undesirable behavior have attracted attention in the media. Little by little, stories come out regarding sexual abuse in football. A brave former professional football player told his story. However, the retired football player and sports director, Mark Overmars has made headlines after allegations of sexual misconduct. Following these allegations, he left Ajax. There is talk of a toxic male culture. A culture that makes it unsafe for women and gay football players who do not dare to come forward. Another much-discussed topic is discrimination in football. Racist chants are not an uncommon phenomenon. Why are there so few black trainers and coaches? In this lecture I will briefly consider different forms of undesirable behavior and discuss how to best deal with it. How do we get a safe(r) sports climate in football? Football belongs to and is for everyone.

Football as Medicine – Prescribing Football for Global Health Promotion

Peter Krstrup

*Department of Sports Science and Clinical Biomechanics, University of Southern Denmark
Danish Institute for Advanced Study (DIAS), University of Southern Denmark.*

The scientific evidence supporting the use of recreational football as a fun, social and effective prevention and treatment of lifestyle diseases has gradually increased over the last decades. Firstly, numerous studies have shown that football training is an effective combination of strength, endurance and high-intensity interval (HIIT) training with marked positive effects on cardiovascular, metabolic and musculoskeletal fitness. Secondly, many efficacy and effectiveness studies have shown that football training improves health profile, fitness, wellbeing and learning for untrained adult across the lifespan as well as for several patient groups. For example, 3-6 months of twice-weekly 60-min football training sessions increases $VO_2\max$ by 3.5 ml/min/kg for untrained adults and lower the blood pressure by 11/7 mmHg for patients with mild-to-moderate hypertension, elevates leg, hip and lumbar spine BMD by 2-5% for untrained adults, elderly women with prediabetes, osteopenia or breast cancer, and for elderly men with prostate cancer. Moreover, 55-80-yr-old men with prostate cancer had stronger bones in a 5-yr follow-up, and a 40% reduction in the number of hospitals admissions comparing football with standard care. Thirdly, school-sport concepts can be used to enhance health, fitness, well-being, cognitive function and health knowledge for girls and boys aged 6-16 yrs, including ethnic minority children with no prior sporting experience. This research has been used to develop and implement several evidence-based sporting concepts for schools and sports clubs in 20 countries, such as FIT FIRST 10/20/Teen, 11 for Health, Football Fitness, Football Fitness ABC, FC Prostate and Football for the Heart.

Invited Sessions

Nutrition for recovery in football

Training load and competition frequency are steadily increasing and performance differences between race winners and “also-ran” are becoming more marginal. Consequently, athletes and coaches face the difficult task of maximizing training load and adaptation whilst avoiding insufficient recovery, which could lead to maladaptation, loss of performance and possibly to non-functional overreaching. In this situation, adequate recovery strategies are critical tasks in order to fine-tune training prescriptions.

Nutritional strategies play an important role in the recovery process. Appropriate nutrition can assist and accelerate post-training and -match recovery, and thus effective nutritional recovery strategies are important for football players, especially during periods of congested fixtures with two or more games per week. Specific strategies should be considered in tournaments, travel and to assist recovery from an injury. For example, evidence suggests that meals including a high amount of carbohydrates and protein within the hour following a match can enhance performance recovery. This is especially important during phases of congested scheduling.

In this invited session we will provide an overview of general and specific nutritional strategies together with practical recommendations to optimize performance recovery for male and female players as well as different football codes. Panel session to follow will discuss specific questions which will be of interest for practitioners and scientists within different football codes.

Presentations

Recovery in football - an overview

Sabrina Forster, *Institute of Sport and Preventive Medicine, Saarland University.*

The female soccer player: Nutritional challenges to health and performance

Sam Moss, *Department of Sport & Exercise Sciences, University of Chester.*

Nutrition strategies to optimise recovery in elite football

Julien Louis, *Research Institute for Sport and Exercise Sciences, Liverpool John Mores University.*

Translation of nutrition science into practice in team sport environments

Sarah Jenner, *Bath Rugby.*

Mental health symptoms in professional football and beyond: from epidemiology to treatment

Mental health symptoms refer to adverse or maladaptive thoughts and/or feelings that might impair activities either in daily life, work or sport. Examples of mental health symptoms are distress, burnout, anxiety, depression or sleep disturbance. Among professional footballers, the prevalence of mental health symptoms ranges from 9% for adverse alcohol use to 38% for anxiety/depression. Mental health symptoms are also common among Olympic/Paralympic and collegiate athletes, with prevalence rates (15%–35%) equivalent to or exceeding those of non-athletes. Mental health symptoms are generally multi-factorial, occurring as a consequence of the interaction between biological, psychological, social, sport-specific and career-related contributing factors. Especially, severe time-loss (28 days or more) injuries during a sport career can be considered as the most significant contributing factors. Most of the professional, Olympic/Paralympic and collegiate mention that mental health symptoms influence sports performance negatively, while support is lacking. This session will address the mental health symptoms occurring in professional football and beyond.

Presentations

Mental health symptoms in professional football and beyond: international perspectives

Vincent Goutteborge, *FIFPRO (Football Players Worldwide) Department of Orthopedic Surgery and Sports Medicine, Amsterdam University Medical Centers.*

Mental Health and Elite Female Footballers

Carly Perry, *University of Central Lancashire.*

Mental health symptoms and injury among elite athletes

Özgür Kilic, *Department of Orthopedic Surgery and Sports Medicine, Amsterdam University Medical Centers Academic Center for Evidence-based Sports Medicine (ACES), Amsterdam, The Netherlands. Amsterdam Collaboration on Health & Safety in Sports (ACHSS), AMC/VUmc IOC Research Center, Amsterdam, Netherlands.*

Government founded Clinical intervention for elite athletes in Sweden

Caroline Jönsson, *Triangelmottagningen Region Skåne Spelarförbundet FIFPRO (Football Players Worldwide).*

Management of head injuries in rugby vs. soccer

After a considerable number of prominent cases of concussions, more severe head injuries and even neurodegenerative diseases in several codes of football there is a public debate about its proper management and countermeasures to be taken by associations and clubs. However, the scientific basis is neither good for an adequate description of the status quo nor for an evidence-based advice for policy makers. Therefore, a detailed analysis of differences between rugby and soccer is intended to possibly help identifying areas of uncertainty and also possible knowledge transfer. It must be acknowledged that rugby has already initiated some institutionalized activities to reduce the number and severity of head injuries as well as their medical management. Differences in rules and match characteristics preclude a simple "copy-and-paste solution" for soccer where other measures have been considered and partly implemented among them the controversial "3-minutes-rule" (giving the team doctor 3 minutes to decide if a player is allowed to continue after a head injury). Comparisons between different injury mechanisms as well as different proneness of females vs. males for head injuries and more severe clinical courses of concussions within both codes of football may support further insights and stimulate research activities.

Presentations

Epidemiology of head injuries in football (soccer)

Giulia Gorgoni, *Institute of Sports and Preventive Medicine, Saarland University, Germany.*

Epidemiology of head injuries in rugby

James Brown, *Institute of Sport and Exercise Medicine, Division of Orthopaedic Surgery, Stellenbosch University, ZA.*

Gender differences in head injuries (rugby vs. soccer)

Rebecca Reeschke, *Institute of Sports Medicine, University of Paderborn, Germany.*

Differences in mechanisms of head injuries (rugby vs. soccer)

Tim Meyer, *Institute of Sports and Preventive Medicine, Saarland University, Germany.*

Resilience in football: Innovative approaches to measure and deal with psychological and physical stressors

Football players need to be “resilient”, which means that they should bounce back quickly from stressors, such as heavy training sessions, defeats, or issues outside football. The purpose of this invited session is to discuss innovative approaches to measure and improve resilience in football players. First, Ruud den Hartigh will demonstrate an infrastructure that is developed to measure the daily psychological and physical stressors and recovery of players. Collected data around training sessions are directly processed and translated into personalized visualizations for staff at professional football clubs. At the same time, university staff analyzes “warning signals” of resilience losses, which in turn can facilitate timely interventions at the football clubs. Second, Tynke Toering will discuss stressors that male and female football players need to overcome, particularly in the youth-to-senior phase. Based on her research, she will show which psychosocial factors can help to successfully overcome stressors during such transitions. Third, because encountering stressors is part of the game, Jolan Kegelaers will explain the relevance of structurally including stressors in training activities. His recent research has revealed that “pressure training” is an effective way to foster resilience. Fourth, Yannick Hill will go beyond resilience by outlining when stressors can lead to psychological and physical improvements in football players. He is implementing a novel framework in sports (i.e., hormesis), to determine the stress doses that can lead to growth. Altogether, this session connects novel theoretical and methodological insights to innovate the way we measure and improve psychological and physical performance under stress.

Presentations

A multidisciplinary, personalized approach to resilience: From theory to the pitch

Ruud J. R. Den Hartigh, *Department of Psychology, University of Groningen*

Psychosocial skills to make it through the stressful transition to senior football

Tynke Toering, *School of Sports Studies, Hanze University of Applied Sciences*

The use of pressure training to develop resilience in athletes

Jolan Kegelaers, *Vrije Universiteit Brussel*

When football players can grow from stress: A hormesis framework

Yannick Hill, *Department of Human Movement Sciences, VU University Amsterdam*

Improving resilience of FC Groningen players

Resilience can be conceptualized as a dynamic process of bouncing back to normal functioning following stressors. Professional football players are continuously exposed to physiological and psychological stressors like high training loads or losing streaks. A better understanding and improvement of football players' resilience is therefore crucial to maintain performance levels, and to prevent performance decrements and psychological or physical problems.

In football practice, data collection procedures are often put in place to support decision making alongside staff observations to optimize performance. Nevertheless, it remains a challenge for practitioners to combine and interpret all data sources appropriately and respect the individual and dynamic nature of interactions across physiological and psychological data sources. Close collaboration between scientists, staff and players is required.

During the site visit at the FC Groningen training facility, we offer a first-hand experience in the understanding and application of resilience science in professional football. This hands-on site visit showcases the collection, processing and personalized feedback procedures at FC Groningen. Moreover, we demonstrate the tailor-made monitoring tool and the impact of the workflow on individual and team training programmes.

Presentations

Improving resilience of FC Groningen players

Wouter Frencken, *Football Club Groningen, Groningen, The Netherlands.*

Improving resilience of FC Groningen players

Ruud den Hartigh, *Faculty of Behavioural and Social Sciences, Department of Psychology, University of Groningen.*

Improving resilience of FC Groningen players

Luca Leithuiser, *Football Club Groningen, Groningen, The Netherlands.*

Improving resilience of FC Groningen players

Mees van der Linde, *Football Club Groningen, Groningen, The Netherlands.*

Let's go to the football field: advancements in agility testing and training.

Still, many football players are dramatically affected by an ACL injury, both in their professional as well as their personal life. The outcome of ACL injury prevention programs is generally disappointing. Traditionally, research on ACL injury prevention often leans towards methods with limitations, such as a poor preservation of the athlete-environment relationship and the use of a biomechanical approach to injury causation. It has merit to include behaviour, cognition, motivation and the playing situation when determining ACL injury risk. Considering the profound burden of ACL injuries, it is necessary to continue to improve the content of current ACL injury risk screening and prevention programs. In our session we will provide an overview of factors and technological advancements that could be considered to optimise agility testing and training of football players and improve effectiveness.

Presentations

Where are we now with ACL injury risk screening? Context matters.

Eline Nijmeijer, *Department of Human Movement Sciences University Medical Center Groningen University of Groningen.*

Agility testing on the football field: smart technology requires smart thinking first.

Stefano Di Paolo, *Department for Life Quality Studies Department of Biomedical and Neuromotor Sciences Alma Mater Studiorum - Università di Bologna.*

Connecting the dots, what's next in agility training?

Anne Benjaminse, *Department of Human Movement Sciences University Medical Center Groningen University of Groningen.*

The complexity of training and competing in Football

The rise of technology has opened up a large number of possibilities to collect and process data from the matches and training sessions in Football. This symposium will address the usage of these quantities of data into the decision-making processes of coaching staffs and players. The presentations will cover topics like game complexity and the power of understanding organized and non-organized interactions, the representativity of small-sided games and machine learning and forecasting models.

Presentations

Team tactical behaviour in small-sided games.

Sigrid Olthof, *Liverpool John Moores University.*

Measuring Passing Creativity in Soccer.

Jesse Davis, *Department of Computer Science and Leuven.AI, KU Leuven, Belgium.*

Data-driven metrics for performance conditioning.

Paolo Cintia, *Kode Solutions Srl, Pisa, Italy.*

The Future of Refereeing: is technology all it takes?

In professional football, clubs and federations invest resources and manpower into new technologies to support in a more professional way both the match officials and the players to finally achieve better match performances and outcomes. These technologies include global and local positioning systems (GPS and LPS), accelerometers, heart rate measurements, cloud-based database and athlete management systems, video tracking and video match officials along with various biological/physiological measurements such as hormonal and immune parameters, hydration status, muscle damage, sleep tracking, etc. All these technologies have resulted in a 'data tsunami' for technical, medical and other staff in professional team sports. Why and how are such technologies implemented in refereeing in professional football? What are the pros and cons of the technologies that were recently implemented in match officials such as video assistant referees (VARs) and semi-automated offside detection? Are they useful to improve the overall refereeing performance, and if so, to what extent? What has changed since the VAR has been introduced? And finally, is technology all it takes to improve football? In this invited session, an international panel of renowned experts, researchers and one of the best referees worldwide will present valuable, practical and multidisciplinary insights in relation to the use of technology in refereeing in professional football.

Presentations

Timeline of technological changes in refereeing

Werner Helsen, *Department of movement control and neuroplasticity (KU Leuven, Belgium)* & *Sports scientist and performance coach UEFA.*

What is the impact of video match officials and semi-automated offside detection on the match performances and outcomes?

Daniel Memmert, *German Sports university, Köln, Germany.*

Sports nutrition and sleep tracking for optimal performance

Ian Rollo & Caroline Tarnowski, *Gatorade Sports Science Institute.*

Reflections from a top referee on how technology impacted

Danny Makkelie, *UEFA top referee.*

Methods Matter

A scientifically sound study starts with a precise and unambiguous research question, followed by the application of the best methods to answer the question. The use of inappropriate or sub-optimal methods in research has a huge impact on the study results. A substantial prevalence of so-called questionable research practices in various areas of research has been documented in the literature. Errors can be, and often are, involuntary; still, this can compromise the credibility of a scientific field, popularise wrong or unsupported practices, and create excessive expectations. Sports science and hence football research are clearly not immune from this problem. The underlying reasons are probably related to a combination of a publish and perish culture and inadequate education or training on research methods. The aim of this invited session is to explain the role of meta-research as the study of the research itself (methods, reporting, reproducibility, evaluation, and incentives; Ioannidis 2018), but also as a post-publication peer review contributing to the self-correcting process of science. Examples of errors (and solutions) in areas of particular interest in sport science and football research will be presented and discussed: machine learning, meta-analyses and individual responses (responder analysis). To avoid repeating the same mistakes over and over in (football) research, sports scientists should recognise, acknowledge and address previous errors. Luckily, the solutions are often already available in the methodological literature (we don't need to reinvent the wheel).

Presentations

Why we need meta-research in football, more than ever

Franco M. Impellizzeri, *Human Performance Research Centre, Faculty of Health, University of Technology Sydney, NSW, Australia.*

Assessing individual responses in sport: pitfalls and solutions

Anne Hecksteden, *University of Innsbruck, Department of Sport Science, & Medical University Innsbruck, Department of Physiology, Chair of Sports Medicine, Innsbruck, Austria.*

From meta-analysis to the pitch: critically translating research

Sophia Nimphius, *School of Medical and Health Sciences, Edith Cowan University, Joondalup, WA, Australia.*

Rage against the machine learning

Maarten van Smeden, *Julius Center for Health Sciences and Primary Care, University Medical Center Utrecht, University of Utrecht, Utrecht, the Netherlands.*

Football as Medicine and Activator

Football engages many active and passive participants all over the world. Its attraction unifies people from all layers of society ranging from young to old and high to lower socio-economic status. This makes football a unique option to reach, recruit and stimulate active and healthy lifestyles in the community in general but also in certain target groups. Football attracts people, is enjoyable to do, and training can accommodate specific aims and target groups, making it a feasible form of physical activity for many. In this symposium the potential of football as medicine and as an activator is put central. The presentations will cover the topics of: exercise is medicine, football as medicine for target groups and football as activator for an active and healthy lifestyle.

Presentations

Football for engagement and activator towards an Active and Healthy Life

Erja Portegijs and Johan de Jong, *University of Groningen, Department of Human Movement Sciences, & University of Applied Science Groningen, School of Sports studies, Groningen.*

Exercise is Medicine: prescription of football for a healthy score!

Hans Zwerver, *Gelderse Vallei Hospital, Sports & Exercise Medicine / SportsValley, Ede.*

Using the power of football to improve health behaviours in overweight fans: the EuroFIT trial

Hidde van der Ploeg, *Amsterdam University Medical Centres, Department of Public and Occupational Health | Amsterdam Public Health research Institute.*

Football as prevention and treatment of chronic diseases

Magni Mohr, *Department of Sports Science and Clinical Biomechanics, University of Southern Denmark*

Changing playing fields: transforming football marketing and CSR

The media environment of football has changed rapidly over the last decades. Changes in media consumption in general and sports consumption specific have increased the media value of football. (Cable) television has provided a platform where teams can reach out to a very large audience, well beyond the fans in a stadium. The digital revolution further transforms the way in which football is consumed. This has profound implications for football federations (both international and national), clubs and players. The changing playing field also comes with greater responsibilities for the actors involved: the increases in media attention and commercial possibilities implies that the actors are held accountable for their strategies. Integrating corporate social responsibility (CSR) strategies in these organizations is thus essential. The Dutch Football league (Eredivisie) has implemented their CSR strategy using the Theory of Change approach. In this approach, the league and clubs are encouraged to develop their overall impact goals and values and systematically integrate them in their overall strategy. In this symposium, the first two speakers will introduce trends in media consumption, both in televised football as well as digital football consumption. The implications of these trends for football's commercial opportunities both now and the future are then explored. In the final two presentations, the greater responsibility of football organizations will be presented. Finally, the speakers will debate the changing playing field of football marketing and CSR.

Presentations

Changing playing fields: value creation in football organizations

Jan-Willem van der Roest, *Utrecht University School of Governance*

Changing playing fields: how the digital revolution transforms sport marketing

Hans Westerbeek, *Victoria University Business School*

Changing playing fields: televised football as a platform for sport marketing

Ruud Koning, *University of Groningen*

Merel Walraven, *University of Amsterdam*

Changing playing fields: using the Theory of Change as a strategic tool in football clubs

Kaelin Staats & Simon Cageling, *FC Groningen*

Citius, altius, fortius.... electus?! A critical discussion on talent selection

In this symposium, we will reflect upon current procedures regarding talent selection in youth soccer players and the research methods that are being applied. First, a general overview on natural development in youth players through adolescence is provided. Thereafter, dr. Barbara Huijgen will give insight in how talent selection is organized nowadays in western society and its related consequences. This overview of decisions made in practice by stakeholders (i.e., club management, scouts, trainers, coaches) will be put in the perspective of youth players' natural development. To end, prof. dr. Matthieu Lenoir will present a study on talented soccer players who are monitored over a prolonged period of time with a focus on their soccer learning ability. This approach may open new venues for both science and practice when it comes to talent selection.

Presentations

Natural development in youth players

Marije Elferink-Gemser, *Department of Human Movement Sciences, University Medical Center Groningen, University of Groningen, The Netherlands.*

Talent selection in practice

Barbara Huijgen, *Faculty of Behavioral and Social Sciences, University of Groningen, The Netherlands.*

New venues for science and practice

Matthieu Lenoir, *Department of Movement and Sports Sciences, Faculty of Medicine and Health Sciences, Ghent University, Belgium.*

Technology in football: Insights from European Football

In football we find ourselves in an 'Age of Technology', with a tsunami of tech available for us to measure and intervene in many aspects of player health care and performance. From wearable sensors measuring objective and subjective training loads, to artificial intelligence and quantum computing to predict performance, injuries and even the next superstar player. Innovating through the use of technology is a key driver to enhance how we care for players and ultimately how the team performs on the pitch and effective use of technology can make our lives easier and decisions we make more accurate. However, there is a dark side of technology that we are in danger of falling into in professional football, where technology can replace critical thinking. In this symposium we will bring together global experts to discuss what technology is and what it is not as well as how to critically appraise and choose the right technologies that have the best chance at solving your questions or problems in practice. We will highlight examples of how technology can be used and how we can learn from it's mis-use in professional football. Expect insights from football experts but with lessons learned from other industries and ongoing collaborations with military intelligence and space agencies, and how we have learned and adapted processes to European football.

Presentations

Choosing technologies wisely: Introducing a sports innovation framework

Alan McCall, *Arsenal Football Club*

The influence of emotions on technology decision-making

Andreas Ivarsson, *Halmstad University*

The Rise (and fall?) of Technology in Women's Football

Kirsty Elliot-Sale, *Manchester Metropolitan University*

Using technology to enhance performance

Maurizio Fanchini, *AS Roma*

Athletic Skills Model

Optimizing talent development

The philosophy “Sports have more in common than they differ” is the central theme in the Athletic Skills Model® (ASM). The earlier version of this model was created in the early nineties at the soccer club Ajax in the Netherlands. ASM is evidence based and is a talent development model that advocates versatility and it embraces a holistic approach. It consists of 3 building blocks: 1. Basic Movement Skills, improving the development of versatile movers. 2. Coordinative abilities to enhance the quality of movement. 3 Conditions of movement to increase fitness levels. These building blocks are combined with 5 Transfers of Learning and is supported by recent motor learning theories. ASM provides practitioners (i.e. strength and conditioning coaches, youth coaches, physiotherapists) with a framework to design structural programs for recreational to elite athletes, for youngsters to the elderly, to achieve a healthy movement development across their lifespan.

In this workshop ‘Science meets practice’, the scientific theoretical foundation of the model (45 min) will be explained, followed by a practical session (45 min) in which videos will be shown. In addition, the participants are free to experience and take part in some of the exercises themselves.

Presentations

Athletic Skills Model for optimal talent development

Geert Savelsbergh, *VU Amsterdam*.

Athletic skills model, Practical session

Yordi Vermaat, *ASM Academy*.

Oral presentations

Use of isolated practice and small-sided games in the most productive European Football Academies

Nick Gearing¹,
Matt Bridge¹

¹ *University of Birmingham, UK*

Background/aim: Debate exists on the most appropriate practice environment to develop talented children into professional footballers, with academia largely supporting a small-sided games (SSG) approach whilst successful professional football academies often use of isolated practice (IP). IP defined by Pill (1) is isolating the skill in a drill format, progressing from basic to complex motor skill patterns, focusing on the 'correct' technique, implying a prescribed movement. This study bridges the gap between football and research, with coaches that have seen and helped to develop current players in the top 5 European Leagues (top division in England, France, Spain, Germany, and Italy) giving their view of what has contributed to the development of players. In this way it provides insight on "what works" in professional football grounded in the experience and viewpoints of highly successful academy coaches.

Methods: Coaches were interviewed from 13 of the top 20 most successful European football academies. The interview explored the coaches' views and use of different training session designs and structures over the past 20 years to understand how the current players of the top five European leagues were developed. Thematic analysis used the six steps of Braun and Clarke [2] to listen to the interviews, create themes based on session design, and use quotes from the interviews to explore the themes and details of how these sessions took place.

Results: Analysis of the interviews produced two key themes: (IP) and small-sided games. Within each of these sub themes were identified IP: ball mastery, individual & position specific coaching, doing 'extra's'; SSG: 1v1, 2v2, 3v3 (and variations of these), 4v4+. Coaches were found to use a range of these practices consistently, although some were unaware in which category (IP/SSG) their practices fell into, with some denying the use of IP but using it under a different name of ball mastery or simply 'extra sessions'.

Conclusions: From the evidence presented in this study, a mixed approach to practice design is recommended, containing ball mastery/football specific IP alongside SSG practices of 1v1, 2v2, 3v3 (and variations of these) as well as 4v4+. These approaches provide a range of learning design options to the coach, allowing them to select the right approach for the task, player(s), and context. The results of this research open the door for a new, football-specific, definition of IP to be created.

Analysis of match demands in footballers promoting from the Spanish 2nd division to the 1st division

Jordi Ferrandis Jorge^{1,2},

Juan Del Coso¹, Víctor Moreno-Pérez³, Roberto López-Del Campo⁴, Ricardo Resta⁴, Joaquín González-Rodenas¹

¹ Centre for Sport Studies, Rey Juan Carlos University, Fuenlabrada, Madrid, Spain.

² Department of Physical Activity and Sport Sciences, Catholic University of Valencia "San Vicente Mártir", Valencia, Spain.

³ Sports Research Center, Miguel Hernández University of Elche, Alicante, Spain.

⁴ Department of competitions and Mediacoach, LaLiga, Madrid, Spain.

Background/aim: Recent studies have revealed some physical and technical differences between football teams at different levels of competition in the same country (1). However, there is a lack of scientific evidence regarding the comparison of players' match performance when they promote from the 2nd division to the 1st division (2). The aim of this study was to compare the physical and technical performance variables of players who competed in the Spanish 2nd division and promoted to the 1st Division within the same team.

Methods: A total of 97 professional outfield football players that competed in the 2nd and 1st division of the Spanish professional football leagues following promotion were analyzed during five consecutive seasons. The data was analyzed using repeated measures ANOVA to compare the match performance of players in the Spanish 2nd vs 1st divisions.

Results: In the 1st division, players performed higher number of high-intensity running efforts (33.4 ± 10.1 vs 30.6 ± 9.2 ; $p < 0.001$) and covered more high-intensity running distance (555.6 ± 188.4 vs 526.4 ± 176.2 m; $p < 0.01$) than in the 2nd division. Additionally, players performed lower number of total passes (38.7 ± 9.1 vs 42.6 ± 9.9 ; $p < 0.001$), short passes (32.3 ± 7.9 vs 35.3 ± 8.5 ; $p < 0.001$), long passes (6.5 ± 3.4 vs 7.3 ± 3.7 ; $p < 0.001$), dribbles (1.7 ± 1.6 vs 2.0 ± 1.8 ; $p < 0.001$) and shots (0.97 ± 0.8 vs 1.1 ± 0.8 ; $p < 0.05$) in the 1st than in the 2nd division. No significant differences were found regarding the total distance covered, passing accuracy, forward passes, aerial duels, clearances, tackles and interceptions.

Conclusions: This study indicates that football players have to adapt to a more demanding game when they promote from the Spanish 2nd to the 1st division. This adaptation entails covering more distance at high intensity during the match with lower number of on-the-ball actions.

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Coach behaviours and practice structure in grassroots youth soccer

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Background/aim: Youth soccer players rely on coaches to design effective practice environments to help them acquire the skills necessary to perform successfully in competition. However, early observational analyses suggest that coaches structure practice and employ behaviours that may not promote effective skill acquisition. While a shift towards an approach more closely aligned with research evidence has been observed in performance soccer (e.g., (1)), there is little to no (recent) research investigating coaching behaviours and the microstructure of practice at the participation level of the sport (i.e., “grassroots”). The aim of this study was to examine the practice structures and instructional behaviours employed by youth soccer coaches working at the grassroots level in England.

Methods: Youth soccer coaches (i.e., U10 - U17; n = 12) working at the grassroots level of soccer at 10 different English clubs, were filmed during 36 regular training sessions. The practice structure and instructional behaviours observed within these sessions were then coded. The practice setting was split into two types of activities, “training form” and “playing form”, with the latter deemed more relevant to improve soccer match performance. Coaching behaviours were coded using a modified version of the Coach Analysis and Intervention System (2).

Results: Practice was structured such that players spent more time in playing-form activities (M = 59%, e.g., small-sided and conditioned games) than training-form activities (M = 23%, e.g., isolated skills practice), with the remaining time spent transitioning between activities (M = 18%). Coaches provided high levels of instruction (M = 42%), feedback (M = 25%), and management (M = 15%), irrespective of the activity in which players engaged. The use of questioning corresponded to 4% of total coach interactions, with only 0.8% of these being divergent questions.

Conclusions: Our findings show that there has been a shift towards an increased use of playing-form over training-from activities in youth (grassroots) soccer in England. Yet, the most frequently used coaching behaviour was instruction suggesting a direct and prescriptive approach is taken by grassroots youth coaches. Findings from this research highlight a partial divergence between research and practice in the coaching of young grassroots level soccer players.

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How to shoot a knuckle ball in soccer

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Background/aim: The knuckle shot remains one of the most difficult kick techniques to master (1). In this study, we used 3D motion capture to analyse the foot posture at the time of ball impact and the point of contact between the ball surface and the foot surface (impact point) for the knuckle shots of collegiate soccer players in order to demonstrate a model knuckle shot technique that can be mastered easily and effectively.

Methods: Using an optical 3D motion capture system (VICON, 2000 Hz), we recorded three types of kicking motions—instep kick, curve kick, and knuckle kick—by 15 male collegiate soccer players and measured the ball's velocity, spin rate, and foot impact point for each kick. The foot impact points were obtained by applying virtual modelling techniques using reflective markers affixed to the foot. We analysed the relationship between the ball's spin rate and the angle formed at impact by the normal vector of the impact surface in the horizontal plane and the foot swing vector (angle of attack).

Results: The average inward inclination angle (in the frontal plane) of the foot just before impact was greatest for the instep kick at ~50 degrees, followed by the knuckle kick at ~40 degrees and the curve kick at ~20 degrees. In other words, the knuckle kick tended to have a sharper inward inclination than the instep kick. This inward inclination of the foot was accompanied by outward rotation of the hip joint, which tended to move the foot impact point further inside. For all kick attempts, the relationship between the ball's spin rate and the angle formed at impact by the normal vector of the impact surface in the horizontal plane and the foot swing vector (angle of attack) was such that the smaller the angle of attack, the flatter the impact and the lower the spin rate ($R=0.84$, $P<0.01$).

Conclusions: It becomes relatively easy to achieve a flat ball impact with a reduced angle of attack by simply reducing the foot's angle of inward inclination to be closer to a curve kick than an instep kick. We believe this is an easy and effective way to master a model knuckle shot.

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A case study comparing training activities and coaching behaviors of Sino-Spain youth soccer coaches

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Background/aim: Youth soccer training should ensure proper player development. In fact, coaches worldwide behave differently during their coaching process. However, there are few studies comparing football coaches' behaviors between different cultures and countries so far, and there is currently a lack of research on the coaching behavior of Asian football coaches in this research area. Thus, the purpose of this study was to: a) compare the coaching behavior and training activities of the soccer coaches from Chinese and Spanish capitals, and b) explore the impact of cultural differences on coach's behavior and players' feelings and perceptions.

Methods: Based on a modified version of the Coach Analysis and Intervention System (Cushion et al. 2012), systematic observations and semi-structured interviews were developed for six youth coaches from Madrid (n=3) and Beijing (n=3). A total of 18 training sessions were recorded. Six coaches and 16 players who were randomly selected from each academy participated in the semi-structured interview. The rate per minute of all behavioral indicators was calculated to conduct the independent samples T-test for variables with parametric distributions, and the Mann-Whitney U test for variables with non-parametric distributions.

Results: The results showed significant differences in coaching behaviors and training activities between both groups. Coaches in Madrid used more "playing form" and they achieved greater times of activation (motor participation) during practices, compared to coaches from Beijing. "Concurrent instruction" was the most used behavior among coaches from Madrid and Beijing. Moreover, coaches from Madrid applied more "positive feedback" whereas Beijing coaches used more "negative feedback". The interview result showed that this phenomenon is related to different educational and cultural backgrounds.

Conclusions: Positive feedback is recommended to Beijing coaches and "silence" should also be properly used while "instruction" and "hustle" should be carefully used to help players learn to "think" (e.g., decision-making). Both Madrid and Beijing coaches should consider how to develop players' mental toughness in a more scientific and rational way with minimal side effects. This study offers a comparative analysis to develop proper strategies for a better player's development.

The manipulation of task constraints and the effect on creative performance of youth soccer players.

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Background/aim: Creativity is a popular topic that has been increasingly researched over the years. Recently, creativity is suggested as a relational concept. This conceptualization implies that creativity is not solely an individual ability. By contrast, creative actions emerge in the athlete's search to adapt to task and environmental constraints (Orth et al., 2017). Manipulating task constraints that serve to increase variability might, therefore, evoke creative actions. Such manipulations in soccer are often conducted in training situations with small sided games. This was recently shown with a numerical assessment of creative actions comparing small sided soccer games (SSGs) with 11v11 matches in elite adult soccer players (Caso & van der Kamp, 2020). They found that players performed more actions, a broader action repertoire and more creative actions in smaller formats (5v5, 6v6 and 7v7) than in an 11v11 format. The purely quantitative method of Caso & van der Kamp (2020), however, uses an arbitrarily 5% benchmark for originality. More importantly, although subjective, the coaches opinions are not meaningless and should not be neglected.

Methods: Our research examined whether the latter task manipulation also increased the action repertoire and creative performance of elite youth soccer players (O11-O13). A numerical method was introduced, assessing creative performances as a frequency of the action types emerging in an environment. A notational video-analysis identified all (not-) functional actions. Next, a threshold defined whether the action was original. This threshold has been determined with expert coaches ranking action types following the procedure of the consensual assessment technique (CAT). If the action was both original and functional, then it was defined a creative action. The data consisted of 293 minutes small sided game (4v4) and 263 minutes regular sided game (11v11).

Results: Results indicated that small sided games hold relatively more actions, more functional action and more creative actions compared with regular sided games.

Conclusions: This is in line with previous studies, that small sided games induce more action variability, which increase the possible emergence of creative actions (Orth et al., 2017).

A low dose running protocol can attenuate detraining effects

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Background/aim: Detraining, refers to the process of losing training-induced physiological adaptations due to a decrease or cessation of training. This can occur when athletes takes a break from training or significantly reduces the intensity or volume of their training. The aim of the current study was to evaluate the efficacy of a low dose running protocol during an off-season period.

Methods: Twenty-two footballers from one sub-elite team underwent anthropometric (body mass, sum of seven skinfold) and performance (countermovement jump (CMJ) height, static jump, right hand grip strength, 5-, 10- and 20 m sprint time, Yo-Yo Intermittent Recovery Test Level 2 (Yo-YoIRT2), repeated sprint ability (RSA) and 1 km time trial (TT)) assessments at two time points (November and January). A critical velocity intervention consisting of 12, 30 second efforts with 30 seconds recovery was implement twice a week and compared to a control group.

Results: There was a significant interaction for the multivariate main effect between time and group ($F(12, 8) = 6.849$; $p = 0.005$; $\eta^2 = 0.911$). Over time, the detraining group performed significantly poorer in Yo-YoIRT2, RSA average, RSA decrement and TT, while performing significantly better in 10 m sprint. At pre-intervention, the control group performed significantly poorer than the intervention group for 10 m sprint, but performed significantly better in TT at the same time point. At post-intervention, the control group performed significantly poorer in RSA average, RSA decrement and TT.

Discussion: The research is the first of its kind in Gaelic football to examine the impact of detraining on anthropometric and performance profiles. The data obtained highlights the negative impact detraining can have on physical performance. The findings may aid coaches in developing training regimes to better manage the off-season period, while preparing athletes for the upcoming pre-season. It is important for athletes to be mindful of the impact of detraining and to maintain some level of training, even during periods of rest or recovery, to avoid the negative effects of detraining.

Investigating scoring success in ladies Gaelic football

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Background/aim: Ladies Gaelic football (LGF) is one of the largest female sports in Europe with over 200,000 registered players. Despite this popularity, only one study has investigated the tactical factors which determine successful performance (1). Coaches, analysts, and players currently depend on this single investigation for benchmark data on attacking play, in particular the expected incidence of goals which are worth 3 points. This study aimed to address this knowledge gap by investigating scoring success in the 2022 Senior Championship.

Methods: 22 team performances in the LGF Senior Championship 2022, 7 knockout games and 4 from group stages, were analysed using NacSport. Definitions previously established for LGF were used to code 25 variables. Intraoperator reliability studies of 2 games coded 2 weeks apart demonstrated system accuracy within 5% error. Data for winning and losing teams were analysed in Jamovi using paired t-tests.

Results: While winning and losing teams had similar numbers of attacks (34/33) and shots (21/22) per game, winning teams had significantly higher shot conversion rates 57%, versus 45% for losing teams. The number of goals scored were significantly different, with winning teams averaging 2 goals and 10 points per game (2.10 or 16 points), while losing teams scored 1.09 (12 points). Results of the current sample (2022) vary considerably to benchmark data previously published from the 2019 and 2020 championship, where winning teams scored 3.14 and losing teams, 2.09 (1).

Conclusions: The discrepancy between data presented in this study and the only previously reported data may be explained by a more defensive approach from teams or by the nature of the sample composition. While the current sample is small, 64% of the games were played in the knock-out stages of the competition. In contrast, Kelly et al (1) used a sample where only 33% of the sample games (n=31) were knockout. It may be the case that in knockout games, teams are more evenly balanced, thus they are lower scoring overall. This study suggests that future studies should consider the nature of their match sample carefully and that the nature of games in knockout versus group stages of the competition is worthy of investigation.

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Isokinetic strength and balance performance in adolescent male football players

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Background/aim: Muscle strength is a crucial attribute of football players by its close relationship with game actions (1). Additionally, balance ability has been associated with sport-specific skills performance and injury prevention (2). The aims of this study are twofold: (a) to examine bilateral asymmetries according to the preferred leg (PL) and non-preferred leg (NPL) in muscular strength and balance, and (b) to evaluate the relationship between muscular strength and balance measures.

Methods: Eighty-eight male adolescent football players aged 15.7 years were assessed in body composition (InBody 770), isokinetic strength (Biodex System 4 Pro Dynamometer), and balance (Biodex Balance System). Isokinetic strength assessment included peak torque (PT), relative peak torque/bodyweight (PT/BW), and hamstring-to-quadriceps (H:Q) strength ratio for the knee flexors (KF) and knee extensors (KE). The Overall Stability Index (OSI), Anteroposterior Stability Index (APSI), and Lateromedial Stability Index (LMSI) were used as balance indicators. Paired samples t-tests were conducted to identify bilateral differences. Pearson correlations and multiple linear regression analyses were used to examine the relationships between isokinetic strength and balance tests according to the PL and NPL.

Results: No significant differences between the PL and NPL were observed for KF PT/BW ($p = 0.62$), KE PT/BW ($p = 0.34$), and H:Q strength ratio ($p = 0.08$). The LMSI score was significantly better while performing with the PL ($p < 0.01$, $d = -0.29$). KE PT/BW presented significant correlations with balance indicators (PL: $-0.40 > r < -0.59$, $p < 0.01$; NPL: $-0.34 > r < -0.51$, $p < 0.01$). Results of multiple linear regression indicate that KF PT/BW and KE PT/BW together could explain between 19 and 26% of the variance observed in the OSI performance. In both leg analyses, the KE PT/BW made the strongest unique contribution (PL: $\beta = -0.678$, $p < 0.01$, and NPL: $\beta = -0.582$, $p < 0.01$) for OSI scores.

Conclusions: Our findings underline the positive contribution of muscle strength to balance control. Lower-body strength contents should be included in the football training process to enhance balance ability, and, consequently, game performance.

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Exploring the technical actions associated within elite youth football training and match play

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Background/aim: Soccer match play is characterised by both physical and technical aspects, yet little is reported on the technical aspects of match play within youth football and how this compares to training. Therefore, this study aims to assess the differences between training and match play when monitoring different technical actions.

Methods: Seventy-four professional youth football players (mean \pm standard deviation: age = 17.7 ± 2.2 years, height = 174 ± 9.7 cm, mass, 69.8 ± 9.2 kg) had their training and match technical outputs (touches/min, releases/min, release index [number of releases multiplied by average release velocity (au)]) monitored using foot-mounted inertial measurements units (IMU) during the 2020/2021 and 2021/2022 seasons. Data was analysed using general linear mixed effects, with Hopkins effect sizes.

Results: Players completed more touches/min for average training sessions (Mean \pm SD: 2.2 ± 0.3 touches/min) compared to matches (1.0 ± 0.3 touches/min) (ES \pm 90%CL: 3.75 ± 0.41). Likewise, players completed more releases/min for training (1.1 ± 0.1 releases/min) compared to matches (0.4 ± 0.2 releases/min) (ES \pm 90%CL: 4.44 ± 0.42). In addition, release index was higher for training (140.1 ± 16.3 au) compared to matches (37.7 ± 20.4 au) (ES \pm 90%CL: 5.31 ± 0.39). Playing position differences showed, central defenders (ES \pm 90%CL: 1.25 ± 0.85) and strikers (1.50 ± 0.76) had large meaningful differences in touches/min for training compared to matches. Central defenders (1.41 ± 0.73), central midfielders (1.51 ± 1.07) and strikers (1.85 ± 0.93) showed large meaningful increases in releases/min for training compared to matches. Central defenders (1.58 ± 0.82), central midfielders (1.43 ± 0.93) and strikers (2.06 ± 0.87) also showed large meaningful increases in release index for training. Goalkeepers and wide defenders showed unclear differences between training and match technical outputs.

Conclusions: Technical outputs measured using foot mounted IMUs are greater during training sessions than matches. However, differences in playing position exist between training and match technical outputs. Understanding players technical exposure in training and match play, may help inform practitioners when planning or designing teams/players technical development plans.

Not all roads lead to Rome: the career patterns of Dutch elite youth soccer players

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Background/aim: Soccer clubs spent significant resources on the recruitment of talented youth soccer players for their developmental programmes (i.e., Academies). These Academies aim to increase the likelihood of those players becoming professional. As such, they typically recruit young players assuming that the performance development within Academies is superior compared to the other players (1). However, the effects of developmental programmes on attaining soccer success are ambiguous (1,2). Therefore, the aim of this study is to investigate the association between career patterns within Academies and professional soccer.

Methods: This study examined the career patterns of talented Dutch youth soccer players involved with an Academy (n = 3621). Therefore, players' under-age team (U-team) selection status (i.e., selected vs. not-selected) between 10 and 18 years of age was retrieved. The binary U-team status was aggregated into descriptive career 'patterns' indicating the duration, latest nomination, and in-between de-selection. In addition, (not) playing professionally before age 23 was retrieved as outcome measure. Logistic and linear regressions models were applied to test the effect of career patterns indicators on playing professionally.

Results: Descriptive statistics showed 193 unique career patterns. The logistic regression showed that late Academy involvement yielded a positive effect on senior professional appearance. In addition, linear regression showed that first team playing minutes was best predicted by duration in an Academy. The final analysis showed that late involvement was not associated with entry-age in an Academy.

Conclusions: While players' late involvement in an Academy did increase the likelihood of attaining professional soccer selection, early entry into an Academy was not related to this late involvement. This contrasts with the common assumption of professional Academies that players need to be recruited at a young age (1). There was, however, an effect for duration in an Academy on playing minutes, with longer careers yielding more playing time. In addition, it seems that de-selection is not detrimental if one can make a comeback in Academy soccer at older ages.

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Assessing player performance between professional and semi-professional Football leagues

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Background/aim: Professional sporting organisations in many team sports are required to compare player performance metrics across various competition standards. Whether it be the ability to forecast performances of a player being drafted into a professional league, translate performances between a senior league and a reserves league, or between two separate elite leagues, the capacity to comprehend how performance translates is inherently valuable. In order to appropriately make comparisons, decision makers must be able to account for the factors which make each league unique, including systematic differences in league qualities, as well as the effect of minor differences in rules. By modelling to account for these unique factors, this study looked to scale the difference in objective performance between various Australian Football (AF) leagues and create applications to help compare performance for practical use in an applied setting.

Methods: Champion Data ranking points were obtained across ten AF seasons, for all players competing within the Australian Football League (AFL) and the ten main second-tier AF leagues. Descriptive data pertaining to each player and the leagues in which they competed in were also collected. Various linear and non-linear methodologies were examined to investigate the difference between the AFL and senior second-tier leagues (leagues in which AFL affiliate reserves teams participate in), as well as the difference between the second-tier leagues from which players are traditionally drafted from by an AFL club.

Results: The results indicated a notable difference between the AFL as compared to each of the four senior second-tier leagues, as well as various differences between the second-tier leagues in which players are traditionally drafted from. By applying these findings, we were able to create an application which allows for player performance to be equitably standardised and visualised across multiple AF leagues both within the same season and across multiple seasons.

Conclusions: This study composed an approach to determine the extent to which player performance objectively differs between various AF leagues. The implementation of the methodologies used within this study may provide professional AF organisations valuable knowledge for practical use in supporting decisions regarding player recruitment, contracting, and team selection. Whilst the focus of this study is on AF, the ability to transfer player performance measures between leagues is a sports industry wide predicament, and similar methodologies and applications could be implemented within other team sports.

Talent self-orientation in youth soccer: disposition-based sampling strategies

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Background/aim: The development of expert-level performance in sports is discussed against the background of two different pathways: the early specialization approach with an early onset of sport-specific practice in a desired main sport, and the diversification approach with a diversified involvement in a range of other sports with later specialization. However, it is still unclear which of these two paths appears more beneficial for achieving later elite performance. This study examines the way in which children manage the conflict between specialization and diversification into their self-orientation strategies during the early stages of talent development in the domain of soccer.

Methods: To clarify the specific patterns of the early sports sampling strategies between the poles of early specialization and diversification of sports engagement the competition performances of 276 youth soccer players were systematically documented in the sports they played from the U6 to the U21 age group. Univariate ANOVAs and regression analyses were used to analyze whether later successful athletes differed from non-elite soccer players in their self-orientation strategies.

Results: Three different self-orientation strategies were identified in youth soccer athletes. ANOVA ($F_{2;273} = 5.55$; $p < 0.01$) showed that the three sampling strategies during childhood and adolescence lead to different performance outcomes at early adult age. The highest level of the final soccer performance at U21 age is seen at the less frequent strategy of participating in one or more other competitive sports before taking part in soccer competitions. Nevertheless, the highest performing soccer players, are those who had focused almost exclusively on playing soccer from the beginning. Their average age of entry into the sport was between U8 and U10.

Conclusions: Thus, the results of this evaluation are in line with the latest differentiated model of talent development in achievement domains verifying that the youth soccer athletes reaching the highest expertise at early adult age prefer an early and in-sport specialization approach starting with soccer competitions primarily at in the U8 to U10 age groups.

The Royal Dutch Football Association Relative Age Solutions Project—part two: a Delphi study

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Background/aim: Following the lack of widely implemented interventions to mitigate relative age effects (RAEs) in sports, the Royal Dutch Football Association (KNVB) called on stakeholders to propose relative age solutions in youth soccer (Study 1). This initial study yielded 13 possible solutions, many of which remain unclear or mainly hypothetical (1). Therefore, this study aimed to evaluate the effectiveness and feasibility of these proposed solutions to reach a consensus on their utility to moderate or overcome RAEs in Dutch youth soccer.

Methods: Twelve international experts, including researchers and practitioners with extensive knowledge and experience with RAEs in youth soccer, participated in this two-round adapted Delphi study. Participants rated the likelihood of statements being true for each solution on a 9-point Likert scale and were encouraged to provide a descriptive justification for their answer. The first round focused on how likely each solution was to mitigate direct and indirect RAEs, whereas the second round focused on how feasible each solution was to implement.

Results: Results showed that the expert panel perceived 'cut-off date modifications' as the most likely solution to mitigate direct and indirect RAEs (6.2 ± 1.2), however, it was not rated as particularly feasible (4.6 ± 2.5). In comparison, 'explicit cueing of differences in age' was perceived as the most feasible solution to implement (6.7 ± 2.1), and although it was deemed less useful for mitigating RAEs (5.2 ± 2.3), it was rated the highest based on aggregated results across both rounds (5.8 ± 1).

Conclusions: Taken together, 'explicit cueing of differences in age' was found to be most viable solution. Interestingly, to the researcher's knowledge, it is one of only two proposed solutions that has been empirically tested to date (2). Generally, highly rated solutions perceived to effectively moderate RAEs were expected to be more challenging to implement in practice. Moving forward, the highest rated solutions should be designed, implemented, and evaluated based on their effectiveness and feasibility in Dutch youth soccer.

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Reliability and validity of a ball-coordination test for talent diagnostics in soccer goalkeepers

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Background/aim: Talent identification and development (TID) can be supported by objective assessments of talent predictors, yet available diagnostics do not account for the specific demands of youth soccer goalkeepers (GKs). In early adolescence, attributes that are expected to provide relevant foundations for GK-specific learning processes are of particular interest, one of which are coordinative abilities (1). Accordingly, a test battery consisting of six ball-coordination tasks was developed, and its content validity was confirmed by GK experts. The current study aims to further evaluate the test battery's retest-reliability and criterion validity.

Methods: Goalkeepers from the U12 to U15 age groups (N=120), participating in the German football associations' TID program, conducted all tests in a test-retest design. GK-coaches then rated goalkeepers' talent with reference to the age groups' performance level in the German TID program as "above average" (A; n=13), "average" (B; n=60), or "below average" (C; n=47). Odd-even split-half reliability coefficients confirmed good internal consistencies at test and retest ($r=.72$; $r=.73$). Therefore, a score covering all z-transformed individual test performances was calculated to complement the analyses of single tests by global estimates. Test-retest reliabilities were estimated using Pearson's r . The criterion validity was evaluated by ANCOVAs controlled for age, followed by planned contrasts to compare performance groups.

Results: Retest reliabilities of individual tests were sufficient to good ($.65 \leq r \leq .80$, $p < .001$), and very good for the overall score ($r=.90$; $p < .001$). When controlling for age groups, lower coefficients were found ($.49 \leq r \leq .75$, $p < .001$), but the score's reliability remained good ($r=.80$, $p < .001$). On a global level, the criterion validity of the test battery can be confirmed, $F(2, 117)=11.932$, $p < .001$, $\eta^2=.171$. Higher-rated GKs significantly outperformed lower-rated individuals. The discriminative power of individual tests differed but could at least be confirmed on a descriptive level.

Conclusions: The results provide initial evidence that the diagnostic can support TID in GKs. Analyses of the factorial validity, sensitivity, and specificity are required to determine the test batteries' final composition. While some analyses could be conducted with the present data, further large-scale studies are mandatory to analyze the diagnostics' prognostic power and the incremental validity concerning assessments already applied within the German TID program.

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Exploring final third passing strategies in elite women's football.

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Background/aims: In elite women's football, team playing strategies have traditionally been developed by coaching staff using a qualitative approach, often informed by video analysis of matches and the coach's own experience and perceptions about which strategies lead to goal scoring opportunities. The process of manually viewing match footage to extract a team's playing strategy can be a laborious task and may be subject to bias. As such, it is recommended that quantitative techniques are used to complement existing video analysis approaches. The aim of this study was to build a clustering algorithm using spatiotemporal match event data to identify the common attacking passing strategies used in elite women's football. A second aim was to train a classification model to predict the outcome of attacking passes, based on key passing characteristics.

Methods: Spatiotemporal event data from all matches ($n = 108$) during the 2018-2019 FA Women's Super League were sourced from the StatsBomb Open Data repository (<https://github.com/statsbomb/open-data>). All passes made into the "final third" ($n = 13,593$) were subset for this study, and the variables used in the analysis consisted the pass start location (x,y), pass end location (x,y), pass height, pass type, and pass outcome. To achieve the first aim, a Density-Based Spatial Clustering on Applications with Noise (DBSCAN) clustering algorithm was used to identify the common attacking passing strategies for each team. To achieve the second aim, a suite of candidate classification algorithms (including random forest, AdaBoost, XGBoost, logistic regression, and decision tree) were trained and evaluated to predict the outcome of attacking passes into the final third.

Results: The DBSCAN identified distinct attacking passing patterns across the different teams, and highlighted the teams with a higher proportion of passes that were considered "noise" and indicated these passes did not conform to an attacking strategy (e.g., 5.2% of final third passes made by Chelsea FCW were considered noise, compared to 22.9% for Liverpool FCW). The random forest classification model achieved an overall out-of-sample prediction accuracy of 0.71, and Area Under the Receiver Operating Characteristic Curve (AUC) of 0.78.

Conclusions: The analytical methods and results from this study can be used to create a decision support system and inform the development of team playing strategies in women's football.

Solving the issue of dimension reduction for pattern recognition using kernel density estimation

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Background: In the last decade the use of tracking data helped improve the understanding of tactical behavior in football. It also enables the recognition of tactical patterns of individual players, teams, or subgroups. However, a major (technical) problem to create reliable models is the number of variables and that most approaches so far aggregate times series data of a possession to solve this, thereby missing out on possibly crucial information. We see the use of Kernel Density Estimation (KDE) of player positions as possible solution for this problem.

Aim: We aim to show that the use of KDE to aggregate the behavior of a player during yield to meaningful tactical patterns via clustering.

Methods: We focused on finding meaningful behavior patterns of football goalkeepers using tracking data of 170 matches, applying K-Means clustering to recognize different tactical patterns. Features for training the model were either based on expert-driven variables or based on KDE-derived variables. The KDE calculates probability scores for an entity in a certain position based on the full trajectory during a possession, standardizing spatiotemporal information. We create 3 different KDEs, one for the movement of the attacking team (via the team centroid), one for the ball, and one for the defending goalkeeper. To further reduce the information of the KDE, a principal component analysis was conducted for each KDE. Model performance of K-Means Models are evaluated using the silhouette score and usefulness of the clusters is evaluated by visual inspection.

Results: The model with the expert based variables had a silhouette score of 0.21 (23 clusters). The KDE based models have an average silhouette score of 0.58 +/- 0.24. Clusters in these models revealed the following distinct GK movement patterns: 1) standing around the edge of the box, 2) standing on the left side of the GK area, 3) standing on the right side of the GK area, 4) moving from the edge of the box to the right side of the GK area, 5) moving from the edge of the box to the left side of the GK area.

Conclusions: Using KDE for tactical pattern recognition reduced the number of features in the clustering models drastically while producing a good performance and meaningful patterns. This can be seen as a proof of concept for this approach. Using KDE also makes models easier to interpret, which benefits the practical application.

Successful pressing - Analyzing tactical behavior in top-level soccer using tracking data.

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Background/aim: The increasing availability of big amounts of data (e.g. tracking data in soccer) allows analysts to study the constraints of performance in various team sports in more detail. While offensive analyses have been conducted extensively in soccer, the evaluation of defensive performance is underrepresented. Hence, the aim of this study was to analyze successful defensive playing phases by investigating the space and time characteristics of defensive pressure.

Methods: Therefore, tracking and event data of 153 games of the German Bundesliga (second half of 2020/21 season) were assessed. Defensive pressure was measured in the last 10 seconds of a defensive playing sequence (time characteristic) and it was distinguished between pressure on the ball-carrier, pressure on the group (5 attackers closest to the ball), and pressure on the whole team (space characteristic). A linear mixed model was applied to evaluate the effect of success of a defensive play (ball gain), space characteristic, and time characteristic on defensive pressure. Defensive pressure is higher in successful defensive plays ($14.47 \pm 16.82[\%]$) compared to unsuccessful defensive plays ($12.87 \pm 15.31[\%]$). The characteristics show that defensive pressure is higher in areas closer to the ball (space characteristic) and the closer the measurement is to the end of a defensive play (time characteristic), which is especially true for successful defensive plays. Accordingly, defensive pressure is a valuable key performance indicator for defensive play. Further, this study shows that there is an association between the pressing of the ball-carrier and attacking players close to the ball with the success of defensive play.

Soccer is a game of inches: A study to the effects of off-ball run behavior on defensive formations

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Background: Soccer is a high-intensity game where two teams of eleven players compete at a physical, technical, and tactical level. One of the most occurring and most important high-intensity actions in soccer are off-ball movements. However, research on these actions remains scarce. One type off-ball movement, regularly used by players to create an advantage are high intensity runs called deep runs. Deeps can be further separated in Forward runs, Dummy runs, and Overlap runs (1) to create space for them self (Space Occupation Gain (SOG)) or create space for their teammates (Space Generation Gain (SGG)) to seize control of advantageous positions on the pitch.

Aim: Using a pitch-control model, we first aimed to find if off-ball actions can be used successfully to gain more advantageous positions for the attacking side. Secondly, we aimed to identify defensive formations that are more susceptible to successful off-ball behavior.

Methods: This study used a pitch-control model to calculate the SOG and SGG during off-ball movement. The off-ball actions were identified using notational analysis of video data from 39 Dutch Eredivisie games. To calculate SOG and SGG following the approach of Martens et al. (2), player position data was processed via python. Using various non-parametric tests, we derived if the SOG and SGG-increase led to significant differences between success and type of the run, as well as the dependency of the on the defensive formation.

Results: The results show that successful runs do create more space than unsuccessful runs (SGG: $p = .002$; SOG: $p = .314$). The analysis of run categories suggests the different types of runs create space in various manners ($p = .134$). Although the analysis of the defensive formation wasn't conclusive ($p = .050$), the results indicate some defensive formations might be more susceptible to successful off-ball movement than others.

Conclusions: The results show that off-ball actions create more space for the initiating player and his teammates. Moreover, successful deep runs create more space (SOG and SGG) than that are annotated as unsuccessful. Forward and overlap deep runs seem to create more space in general than dummy runs. The results indicate that the 5-3-2 formation is more susceptible to successful deep run actions than the other formations used in this study.

Shot-level xG at the 2022 men's FIFA World Cup

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Background: In association football, expected goals (xG) is the probability that a shot will result in a goal based on variables such as shooter location, body part, type of pass, and type of attack (2). When the xG of individual shots are aggregated for an entire match or multiple matches, comparing xG to actual goals can be used as an indicator of a team's or individual's finishing ability, but such inferences may be confounded by luck. When not aggregated (i.e., shot-level) xG can be useful for examining the quality of chances created across time in matches, and how the timing, distance, and xG (i.e., quality of) scoring opportunities vary under different circumstances.

Aim: The aims of this observational study were: (1) to examine differences in shot-level xG observed across time at each World Cup match, while accounting for half (first vs. second), stage (group vs. knockout), and match outcome (win vs. draw), using methods of intensive longitudinal data analysis; and (2) to demonstrate effective visualizations of shot-level xG.

Methods: We compiled Opta xG data from every shot taken at the 2022 men's FIFA World Cup, obtaining the following variables for each shot: minute, player, squad, xG, shot outcome, distance, and body part (1). For each match/shot, we additionally coded the following variables: half, stage, and match outcome. Using multilevel modeling, we examined relationships among xG, minute, and distance, and we compared these relationships by half, stage, and match outcome.

Results: The relationships among xG, minute, and distance are presented, comparing first vs. second halves, group vs. knockout stages, and wins vs. draws. Visualizations are used to aggregate the xG and distance of shots across time in matches under different conditions (e.g., group vs. knockout stages).

Conclusions: When compared with actual goals, aggregate xG is often used as an indicator of finishing ability, which may be confounded by luck. In this observational study, we demonstrated how shot-level xG can be useful for analyzing shots temporally on a more granular level, and how these data can be visualized effectively.

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Immediate effects of Ramadan on objective sleep outcomes in youth Middle Eastern soccer players

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Background/aim: Ramadan observance has the potential to disrupt sleep habits and physical performance, yet research in football remains inconclusive and based mainly on subjective assessments of sleep. We, therefore, adopted an interrupted time-series (quasi-experimental) design (1) to examine the immediate effects of Ramadan onset on objective sleep outcomes tracked using wrist-worn actigraphy in elite youth Qatari football players.

Methods: Twenty-two, full time, male elite youth football players took part in the study (age range: 12.6 to 16.2 years; 465 sleep observations). Primary outcomes were time asleep, total sleep duration, and wake-after-sleep-onset in minutes. Secondary outcomes were 10-m sprinting, 40-m sprinting, countermovement jump height (CMJ), and maximal aerobic speed (MAS) plus proxy measures of external (high-speed running distance; >19.9 km/h) and internal (session ratings of perceived exertion [s-RPE]) training load. Separate segmented generalized mixed-effects models quantified pre-post effects of Ramadan onset on primary outcomes considering the first block of night sleep only. Each model included time, period, and time-by-period interaction term specified as fixed effects, with individual specified as random effect plus a random intercept. The Akaike Information Criterion (AIC) assessed the relative quality of each candidate model.

Results: The AIC criteria revealed the model with time asleep (AIC = 1768.7) as primary outcome was the best in the pool of candidates. We observed an immediate mean reduction of 88 min (95% confidence interval [CI], 54 to 123 min) of time asleep per night in the first block with Ramadan onset. Model-adjusted estimated marginal means for time asleep were 5.7 h (95%CI, 5.1 to 6.2 h) and 4.2 h (95%CI, 3.6 to 4.7 h) pre and post Ramadan onset, respectively.

Conclusions: Effects of Ramadan on performance assessment and proxy measures of external and internal load were trivial. Despite our study subjects not meeting age-specific recommendations throughout other periods of the Gregorian calendar, Ramadan onset resulted in further curtailments of ~1 to 2 hours in the first block of night sleep. While these reductions did not impair physical performance meaningfully, delaying or postponing in-week morning activities can represent a plausible alternative to promote optimal sleep intake with Ramadan onset.

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An investigation into the relationship between dRPE and external load in elite football.

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Background/aim: Differential RPE (dRPE) extends RPE by differentiating perceptual scores by their specific mediators (e.g. local, central, cognitive). Previous research on dRPE (1) found limited differences between dRPE in football training, questioning the usefulness of such measures. For example, if scores are not distinct from one another, they provide similar information and dRPE may not enhance load monitoring procedures. Our aim was to evaluate the degree of separation between dRPE during football training sessions, and the relationship of dRPE with objective measures of training load.

Methods: Twenty-four male Scottish Premiership players provided dRPE scores (Borg CR100) for Leg Muscle Exertion, Breathlessness and Cognitive Exertion immediately following each training session and match during a 4 week preseason period (median observations per player: 19.5 (range: 10-24)). External load data were collected using 10Hz Catapult GPS devices. A factor analysis identified latent constructs in the external load data. Weightings from this analysis were used to combine metrics to create measures of distinct external demands. Five constructs were identified (Volume, Sprint, Density, High Intensity and Acceleration) which were rescaled for comparison with dRPE. Linear mixed models evaluated the relationship between separation of external load and dRPE, and between dRPE with external load. Separation was measured by the standard deviation of each set of scores.

Results: Players differentiated scores in 70% of observations but this varied significantly by player (range: 40-100%). Only 3% (within-player range: 0-9%) of scores showed any separation between the three dRPE measures and total separation between dRPE scores was <20 arbitrary units (AU) on 66% of sessions. All dRPE measures demonstrated a strong relationship with external load (conditional $R^2 = 0.67$) but demonstrated less separation (mean \pm standard deviation: 5.4 ± 5.7 AU) than the external load measures (19.7 ± 7.7 AU). There was a weak relationship between the degree of separation of external load and the degree of separation of dRPE scores (conditional $R^2 = 0.2$).

Conclusions: There is a clear relationship between dRPE and external load during football training activities although players vary significantly in how they rate sessions; however, dRPE separate less than the external load.

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A data reduction approach for youth soccer training load variables guided by a conceptual framework

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Background/aim: Data reduction techniques have become increasingly prevalent in team sports for the identification of variables that provide insights into the training load performed by each individual player (1). The aim of this study was to apply a conceptual framework to guide the reduction of load variables assessed within an elite youth soccer player monitoring program and verify the consistency of metrics retained, and variance described, across four different age groups.

Methods: A Principal Component Analysis (PCA) with Varimax rotation was conducted to reduce the dimensionality of training and match data (including preseason and inseason periods) recorded by 145 players from U15 to U19 squads across two competitive seasons. The selection of variables was guided by expert opinion and previous literature, including both internal and external training load measures (n=16) (2). A sub-analysis compared absolute metrics to relative metrics (i.e., total load vs. intensity, dividing volume of load by duration). Factors were extracted when Eigen values were greater than 1.

Results: Four PCs were extracted for U15, U16 and U19 age groups, describing 67.2–72.7% of the variability, with only three PCs extracted for U17. The absolute PCA consistently retained 14 of the 16 variables included, however, there were inconsistencies in the order and weighting of variables between the different age groups. General themes did emerge, identifying components relating to training volume, high-speed running, high acceleration load, and high intensity heart rate. The order of variables also differed slightly between the absolute and relative PCA, despite similar constructs of load emerging.

Conclusions:

The variance of load described by each component was similar across the PCs identified in each age group, indicating that a myriad of factors is required to explain training and match loads experienced by elite youth players. Collectively, these findings demonstrate that data reduction methods applied to training load variables do not identify a one-size fits all approach for an elite soccer academy, even when variable selection is guided by a conceptual framework.

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Influence of tactical formation on physical demands by playing position in World Cup Qatar 2022

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Background/aim: In football, the physical demands vary between positions and also within tactical roles, as noted by Wonwoo et al. (2022). The study aims to analyze these differences between positions and how they are affected by formation in the FIFA World Cup 2022.

Methods: The physical data of the latest World Cup were collected, with 64 matches and 1222 players, excluding goalkeepers and players who participated less than 60minutes. General positions were classified by formation: Wide defensive (WD) (n=244), central defensive (CD) (n=285), wide offensive (WO) (n=208), midfield (MF)(n=331) and central offensive (CO) (n=154). During World Cup, 8 formations were used by teams (1-3-4-3; 1-3-5-2; 1-4-1-4-1; 1-4-3-3; 1-4-4-1-1; 1-4-4-2; 1-5-3-2; 1-5-4-1). The physical variables analyzed were: Relative total distance (RTD, m/min); Relative high-speed running distance (RHSR; m/min >20 km/h); Relative sprint distance (RS, m/min > 25 km/h); Percentage-HSR (PHSR; HSR%); Percentage-Sprint (PS; Sprint%). The first analysis aimed to study the differences in the physical variables between general positions. A second analysis was performed to study the differences between formation structures for each position, dividing each line based on the number of players that form it: N°defenders; N°midfielders; N°forwards. For example, 1-3-4-3 will be classified as: 3 defenders; 4 midfielders; 3 forwards. One-way ANOVA was developed with a Bonferroni post-hoc test with a 95% CI.

Results: For all physical variables, significance differences ($p < 0.05$) were found when compared between positions except between WO-CO and WD-CO. The highest total distance (m/min) was covered by MF (MF-CD: 17.24) (MF-WD: 9.29) (MF-WO: 6.98) (MF-CO: 7.60). Wide players (WO and WD) showed significance highest values for RSD, RHSR, PS and PHSR when compared to the other positions. On the other hand, CD and WD covered less RTD and RHSR when playing with 5 defenders in comparison of playing with 4 or 3.

Conclusions: The formation and the number of players per line had a notable effect on the distance covered by players of the same and different positions. The most demanding scenario for defenders is when playing with 3 on the back line.

External match-play loads in elite female field soccer referees

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Background/aim: In soccer, little research (1) exists on competitive physical performance in contemporary elite female field referees (FR) and the occurrence of temporal changes in performance across match-play (2). This study described the overall external match loads in elite female FR during official matches and analysed performance across halves and during the final 15-minute intervals of each half.

Methods: Altogether, 6 elite French FR (age 28.1±2.0) participated. Data were collected in 159 competitive matches (domestic and international) over 3 seasons (2020/21-2022/23) using Global Positioning Systems (Catapult One, Catapult, Australia). External load variables analysed for the match overall included: total distance covered (TD), distance >13km/h (D>13km/h) and >19km/h (D>19km/h), frequency of accelerations & decelerations (>3m/s/s) and maximal speed attained (MS, km/h). Percentage changes in TD & D>13km/h and D>19km/h were analysed across match halves & for the first 15-minute match interval versus the final 15-minute interval in each half. Effect sizes (ES, small [0.2], moderate [0.6], large [1.2], very large [2.0] and extremely large [4.0]) are reported for differences in mean values.

Results: Overall match data were TD=9571.3±961.9m, D>13km/h1=2287.4±584.6m, D>19km/h=400.2±153.3m, accelerations=38.0±25.3m, decelerations=46.9±22.7m and MS: 24.8±1.4km/h. 1st versus 2nd half changes for TD, D>13km/h1 and D>19km/h respectively were: -7.0%, -10.3% and -14.0% (ES: 0.8 [moderate], 0.5 [small] and 0.5 [small]). Changes in TD, D>13km/h and D>19km/h for the first 15-minute match interval compared to both the final 15-minute interval in the 1st half and 2nd half respectively were -7.4%, -15.8% and -18.9 (ES for all analyses=0.8, [all moderate]) and -10.2%, -17.5% and -19.2% (ES: 1.1, 0.8 and 0.8 [all moderate]).

Conclusions: This study has established the general physical match demands for French female field referees in elite soccer match-play. It also shows that they experienced temporal declines in running performance across competition. While this result suggests a need for specific physical conditioning practices to counter fatigue, further research is necessary to account for the potential effects of contextual factors.

Development of a technology quality framework for football

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Background/aim: The use of technology in sport, including football, has grown enormously in recent decades and shows no sign of abating. Despite this, sport technology is largely unregulated with a patchwork of standards depending on the sport governing body and regional authorities. This makes it challenging and expensive for manufacturers to be compliant across sports and localities, while consumers fail to fully understand what features of a device have or have not received third-party scrutiny, leading to poor decision-making. An evidence-based decision-making framework for organizations, manufacturers, investors, and athletes to guide the evaluation, development, and adoption of sport technology would help to address some of these challenges.

Methods: A Delphi-style survey was conducted with 54 participants, all of which whom were recruited based on their substantial expertise in sport and technology. A draft framework was proposed based on a review of the literature, including similar frameworks available in other fields and disciplines. This resulted in an initial identification of 25 features relating to the quality of a sports technology.

Consensus on the inclusion of a feature in the final framework was set at 75%.

Results: Consensus on the final framework was achieved after two rounds of survey. The final framework included 5 Pillars including 23 Features: Pillar 1: Quality Assurance & Measurement – Accuracy, Repeatability, Reproducibility, Specifications Pillar 2: Established Benefit – Construct validity, Concurrent validity, Predictive validity, Functionality Pillar 3: Ethics & Security – Compliance, Privacy, Ownership, Safety, Transparency, Environmental Sustainability Pillar 4: User Experience – Usability, Robustness, Data Representation, Customer Support & Training, Accessibility Pillar 5: Data Management – Data Standardisation, Interoperability, Maintainability, Scalability

Conclusions: The Sports Tech Quality Framework can be used by organisations to improve their decision making relating to sports technology. Future work will look to determine the validity of the framework. Specific opportunities in football include: testing its ability to improve tech acquisition decisions by teams, helping governing bodies to maintain a high standard of technology, as well as guide new companies throughout the start-up phase.

Team tactical behaviour varies across phases of professional football match

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Background/aim: In football matches, attacking, defending and transition phases alternate constantly due to repeatedly switching of ball possession between opposing teams. Team's specific objectives within each phase lead to different strategies and, resultingly, team tactical performance varies across offensive and defensive phases (1). Transition phases also occur frequently in a match. However, team tactical behaviour during those phases is sparsely researched. Therefore, this study aims to investigate team tactical behaviour in different match phases.

Methods: Positional data from one team during a professional football match were collected using player tracking technology (Catapult, Australia). Match phases were annotated using a video notation software (Hudl Sportcode, USA) and differentiated for in possession (IP), out of possession (OOP), attack-to-defence transition (ADT), and defence-to-attack transition (DAT). Positional data and match phase data were synchronised by visual inspection. Team tactical measures were calculated from positional data in the respective match phases, i.e., centroid, length, width, length per width (LpW) ratio, surface area, stretch indices, and interpersonal distance. A one-way ANOVA and pairwise comparisons were conducted to compare team tactical behaviour between match phases. Cohen's d was calculated as effect size.

Results: The four match phases occurred frequently with different time proportions of the total effective match-playing (IP: $n=73$, 39.6%; OOP: $n=75$, 29.7%; ADT: $n=83$, 15.0%; DAT: $n=86$, 15.6%). The team played with a significantly longer and wider formation, greater stretch indices and interpersonal distances, and lower LpW ratio within IP than OOP, DAT, and ADT ($p<0.001$, $d\geq 1.23$). Teams had a greater surface area ($p<0.001$, $d=0.65$) within ADT than OOP. No significant difference for tactical measures was detected either between DAT and ADT, or between DAT and OOP.

Conclusions: A longer and wider team formation was observed within IP, which corresponds with the offensive principle of exploiting space to disorganise opponent defence. The team formation in OOP was more contracted than ADT, but showed similarity to DAT. This indicates how team tactical organisation varies in the transition to defence and to attack.

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The characteristics of football styles of play according to elite coaches

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Background/aim: Previous research has analysed styles of play using different variables to describe them (1). However, there does not seem to be a consensus regarding how many styles of play exist in football and their characteristics. Therefore, experts such as elite coaches could provide insight into the styles of play and what characterises them. The aim of this study was to explore the different football styles of play and their characteristics according to elite football coaches.

Methods: Ten elite football coaches were interviewed for this study. Only coaches from the top five European leagues and with any experience on the top domestic league or national team were considered. A semi-structured interview was used to collect data about the coaches' thoughts on football styles of play and their characteristics. Purposeful sampling was employed to get the participants for this study, and interviews were voice recorded and transcribed verbatim. We used the qualitative data analysis software Nvivo 11 and conducted thematic content analysis to identify and analyse the data.

Results: Elite football coaches in the sample identified a total of 14 styles of play in football. All coaches identified the direct and possession styles of play, and each coach identified additional styles according to their opinion. The other styles identified by coaches were: counterattack, crossing, inner play, playing in the wings, vertical, fast attack after regain, high pressure, middle block, retreat, individual marking, pressure after losing the ball and set pieces. Elite coaches also determined the characteristics of those styles after identifying them. For example, speed and fast attacking players that exploit the space behind the defenders are characteristics of the counterattack style of play.

Conclusions: The findings of this study showed the different styles of play that exist in football and their characteristics according to experts such as elite coaches. This information could be used by practitioners in order to design metrics to analyse styles of play in football. In addition, these findings could help to improve the understanding of these tactical behaviours and how to evaluate them.

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Real-time prediction of match outcomes for decision support in Australian Football

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Background/aim: In-match performance analysis can play a critical role in supporting the decision-making of Australian football (AF) coaches. Limitations in human cognition under time pressure can sometimes result in this analysis being slow or suboptimal, at no fault of the coach or performance analyst. During matches, coaches could benefit from access to quick, objective analyses of match data to support or supplement perspectives put forward by performance analysts and other support staff. Leveraging machine learning (ML) is one possible pathway to achieving this type of support. This study aimed to determine whether ML models based on technical performance alone, with no information on score, could be used to predict end-of-match outcome of Australian football matches in real-time. If efficacious, these models could be used to generate insights about team performance and support the decision making of coaches during matches.

Methods: A database of 168 team technical performance indicators from 829 Australian Football League matches played between 2017-2021 was acquired from the league's official statistic provider. Two feature sets (data-driven and data-informed) were used to train and evaluate six models (generalised linear model, random forest, and adaboost) on end-of-match outcome prediction (Win/Loss) over 120 epochs (a representation of normalised time during each match). Models were evaluated using classification accuracy (CA), area under the receiver operator characteristic curve (AUC), and Brier score.

Results: All models performed well (mean CA = 73.5-75.8%, mean AUC = 0.81-0.85, mean Brier score = 0.16-0.18) in comparison with a benchmark score-based model (mean CA = 77.4%, mean AUC = 0.83, mean Brier score = 0.16). Data-informed feature sets performed better than data-driven in most cases. Classification accuracy was low at the start of a match (45.7-48.8%) but increased to a peak near the end of a match (87.2-92.7%).

Conclusions: These findings suggest any of the employed models can be used to formulate in-match decision support on technical performance in AF. Using a feature permutation process, suggestions about the optimal magnitude and direction of changes in technical performance indicators could be provided to coaches to support their decision-making during matches. The model which is best in practice will depend on factors such as time-cost trade-off, feasibility, and the perceived value of its suggestions.

Examination of data-driven rule-based baseline models for the problem of xGoals

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It is common knowledge in soccer that certain shots can be converted with ease (so-called sitters) while others are more difficult to score from. However, a quantification of these descriptions into quantifiable scoring probability was only achieved recently by expected goals (xG) models. This concept is likely the most popular metric that has emerged from soccer analytics yet, making its way even up to a regularly used statistic in TV broadcast of games.

Nevertheless, training of xG models is non-trivial due to the low-scoring nature of soccer and the, thus, highly imbalanced ratio of goals to non-goals. Moreover, there is a lack of standards for evaluation of xG models (1) which also includes missing intuitive perspectives on why errors were made and how complex architectures improve naïve judgement.

With respect to this, it is common convention in the computer science community to compare machine learning model performance with manual-expert, rule-based and/or statistical baselines. In the field of xG, however, this has barely been approached. If manual baselines are provided (1) they are not evaluated with respect to a fine-grained prediction, while rule-based and or statistical approaches are lacking altogether.

To fill this gap, we develop a naïve rule-based baseline for xG by iteratively increasing the number of variables and function complexity. For each step, we evaluate the impact on the performance on a dataset of more than 300.000 shots and derive interpretable and relevant knowledge for the application in the real world. In the end, we derive a formula for xG with the findings of this work. Our results show a predominant influence of goal-distance, however, interesting relations between goal angle, goalmouth, body-part, and the last action before the shot. In this respect, we show that symmetric xG models are outperformed by models that favor shots from the left side, however, this relation decreases when balancing the dataset with respect to right and left foot shots. Similarly, shots from the center are generally more dangerous than from the sides, however, there is a slight increase of xG for very high angles where goalkeepers might expect a cross over a shot. Overall, our baseline achieves fair results compared to state-of-the-art models.

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Who is in control of anti-doping in football? A systems thinking approach for doping prevention.

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Background/aim: Doping remains an intractable issue in elite sport. Doping occurs in a complex and dynamic environment comprising interactions between individual, situational, environmental factors. Anti-doping efforts have previously predominantly focused on athlete behaviors and sophisticated detection methods, however, doping issues remain. As such, an alternative approach may be necessary. The aim of this study was to apply a systems thinking approach to model the current anti-doping system for four football codes in Australia (soccer, rugby league, rugby union, and AFL), using the Systems Theoretic Accident Model and Processes (STAMP).

Methods: STAMP is grounded on the observation that single component failures in isolation are rarely the cause of incidents. Systems theory and control theory forms the theoretical basis for STAMP and promotes the view that incidents or adverse behaviors result from inadequate control structures and deficiencies surrounding the enforcement of safety-related constraints. The STAMP control structure was developed and validated by 18 subject matter experts (SMEs) across a multi-phase validation process. SMEs had a mean age of (40.1 ± 8.8) years and held positions at the World Anti-Doping Agency, Sport Integrity Australia, National Sporting Organizations, professional football clubs, Universities, and sports academies.

Results: The findings demonstrate that the current anti-doping system is a complex sociotechnical system whereby doping activities are emergent properties of the broader sports system. The anti-doping control structure model highlights the complexity of the anti-doping system through the specification of numerous actors that share the responsibility for anti-doping. Further, education was identified as a prominent approach anti-doping authorities use to combat doping. However, the effectiveness and reach of the education is unknown. Analysis of the model suggests that a majority of existing controls are reactive, and hence that there is potential to employ proactive interventions to prevent doping, and that new feedback mechanisms may be required to capture such information.

Conclusions: It is our contention that anti-doping research and practice should undergo a paradigm shift to move away from the current reactive and reductionist approach of detection and enforcement to a proactive and systemic approach focused on proactive indicators. This will provide anti-doping agencies a new lens to look at doping in sport.

Finding a Superior Defending Approach in One Versus One Actions in Male Elite Soccer

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Background: The upcoming of tracking data has made it possible to analyze tactical team patterns and decision making in soccer. A proven tactical principle to increase the chance of scoring is by outplaying opponents (Rein et al., 2017), for instance during a one versus one action. Consequently, it is important for defenders to know if a specific approach might decrease the chance of being outplayed. For instance, the defender could choose a passive approach by moving in a similar direction as the attacker, or a more proactive one by moving in the opposite direction, thus towards the attacker.

Aim: Therefore, the aim of the current study is to test if there is a approach for defenders to decrease the chance of getting outplayed in a one versus one action by an attacker in male elite soccer.

Methods: Using a rule-based preselector, 372 one versus one actions were manually obtained from 25 Eredivisie matches and labeled either successful (n=215) or unsuccessful (n=157) using video data of the match. Two defending approaches were analyzed: (1) passive defending; the defender moves in the same direction as the attacker during the action, and (2) proactive defending; the defender moves in the opposite direction as the attacker during the action. On top of that, the voronoi area of the attacker at the start of the action, as a measure of space, and the x- and y-position of where on the pitch the duel took place were collected from the tracking data. A logistic regression was used to investigate successfulness of the action using the defending strategy, controlling for pitch location and space.

Results: The type of defending and the y-position of the duel statistically contributed to the model ($p < 0.05$). The position in the x-direction of the pitch and the area the attacker had at the start of the one versus one action did not significantly contribute to the model. On top of that, the model also significantly predicted the successfulness of the actions ($p < 0.05$).

Conclusions: The superior approach for defenders in one versus one actions is to move toward the opponent during the duel. On top of that, the closer the action is to the sideline, the lower the likelihood that the one versus one action is successful.

Validated risk and reward measures for the analysis of football passing

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Background/aim: Passing is a foundational action in football that reveals key aspects of attack building. The prediction of pass outcomes can help analyse team tactics and individual decision making by providing an estimate of the risk and reward associated with different passes. The goal of this study was to validate the predictive quality of ground pass simulation in order to determine its usefulness as a reliable foundation for football analysis. To further test the utility of our pass simulation model, we evaluated whether it could successfully identify key passes using measures of risk and reward.

Methods: We implemented a modified version of the ground pass simulation model by Spearman et al. (1) and used it as a probabilistic classifier to predict the success of passes from their initial conditions and positional data. The model was fitted and evaluated using Brier scores on data from 6 consecutive games of a male professional national team in 2022, which were collected and processed by Subsequent via optical tracking. As a baseline, we used the average success rate of passes in the training data to predict each pass outcome. Finally, we compared regular passes with key passes using t-tests on risk and reward metrics derived from the model: Expected Completion (measuring pass difficulty) and DAS Gained (Dangerous Accessible Space, additional dangerous space that has become available through successful passes).

Results: With a Brier score of 0.077, the pass simulation model outperformed the baseline (0.088). On average, key passes were slightly more challenging for the model to predict (Brier score 0.089) than regular passes (0.077). Key passes were less likely to be completed than regular passes ($t = -9.49$, $p < 0.001$) and associated with higher amounts of gained DAS ($t = 5.46$, $p < 0.001$).

Conclusions: Our pass simulation model outperforms the baseline at predicting the outcome of ground passes, using situation-specific details to account for the complex dynamics of team passing. The studied model was able to identify key passes as particularly risky and valuable. Its ability to determine the risk and reward of passes has significant implications for practical applications, such as the evaluation of player decision making and the improvement of game strategies.

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Exciting times or: How to best schedule for a last round showdown.

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During the FIFA 2022 World Cup, the neutral viewer could not have been happier with the outcome of Group C. Both group matches that were played simultaneously on the third match day, were between teams that could still make it to the knock-out phase given the right results – in the end, Saudi-Arabia and Mexico failed to do so, while Poland and Argentina did. In this instance, tension was maximum until the dying seconds on both pitches: an organizer's dream.

In many leagues and competitions however, towards the end of the season, only few teams are fighting for the title or against relegation, while most other teams have little to play for. Matches between two teams where one has something to play for and the other does not, are skewed and said to be prone to match-fixing. Besides skewed matches, there is also the possibility of dead rubbers, matches where, for each of the teams, there is nothing on the line. While skewed matches may influence the competition outcome in an unfair way, dead rubbers do a bad job in entertaining the fans. It is not difficult to see that the schedule of the competition has a great impact on which matches have the potential to be skewed or dead rubbers and which do not.

From a fan's and a fairness perspective, it is important to know which schedules are more prone to these unwelcome effects. To answer this question, we model the possible outcomes for a variety of round robin competitions, given that we know in advance that some teams are expected to be better than other teams. Using a combination of theoretical analysis and computer simulations, we gain insights in how to schedule competitions to maximize the expected number of meaningful matches, and how to minimize the number of skewed matches and dead rubbers that may occur during the season. Considering these results while scheduling competitions is vital in countering match-fixing, while simultaneously increasing the odds for last-round turnarounds that make sports ever so exciting.

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Decision-making accuracy of soccer referees in relation to markers of internal and external load

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Background/aim Soccer refereeing represents a highly demanding activity, requiring referees to make potentially match-changing decisions under challenging physiological conditions (1). As referees must contend with the physical and decision-making demands of their role simultaneously, the relationship between these facets of performance warrants investigation (2). The current study therefore examined the decision-making performances of soccer referees in relation to the internal and external loads present at the time of each decision.

Methods: Following the collection of baseline measures and habituation procedures, 13 national male referees completed the Soccer Referee Simulation (SRS). At various stages throughout the SRS, a video clip depicting a potential foul play situation was presented, with referees making a technical and disciplinary decision. The correctness of each decision was ascertained by an expert panel comprising two former FIFA-listed referees and was subsequently assessed in relation to the mean heart rate (HR), respiratory rate (RR), minute ventilation ($\dot{V}E$), perceptions of central (RPE-B) and muscular (RPE-M) exertion, and running speeds recorded in the 10-s and 60-s preceding decisions.

Results: A significant association was observed between decision-making accuracy and the mean HR ($P=0.042$) and RR ($P=0.024$) recorded in the 10-s preceding the decision, with significantly more incorrect decisions observed when $HR \geq 90\%$ of HR_{max} (OR, 5.39) and $RR \geq 80\%$ of RR_{peak} (OR, 3.34). Decision-making accuracy was also significantly associated with the mean running speeds performed in the 10-s ($P=0.003$) and 60-s ($P=0.016$) prior to the decision, with workloads of ≥ 250 $m \cdot min^{-1}$ increasing the likelihood of a decisional error (OR, 3.84). Finally, a significant association was found between decision-making accuracy and RPE-B ($P=0.021$), with a disproportionate number of incorrect decisions occurring when RPE-B was rated as “very strong” to “maximal” (OR, 7.19).

Conclusions: Collectively, the current data offer novel insights into the detrimental effects that high internal and external loads have upon the decision-making performances of soccer referees.

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Match to match variability in peak intensity periods in elite youth soccer.

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Background/aim: Time motion analysis is a commonly used technique to analyse elite soccer performance, however to date there is limited data exploring the locomotor characteristics of elite youth female soccer. Furthermore, it is important to consider the large natural match to-match variability in performance within and between players when interpreting data (1). Therefore, the purpose of this study was to examine the match-to-match variation and between player analysis of peak intensity periods in elite youth female soccer.

Methods: Locomotor data measured by a 10Hz foot-mounted inertial measurement unit (Playermaker) were collected from 257 players across 171 FA Women's Super League Academy matches from 11 teams during the 2021-22 season. The raw instantaneous velocity data were exported from the manufacturer software and analysed in R. A custom-built script was used to compute moving averages of speed ($m \times min^{-1}$), high speed running (HSR; $5.29-6.26 m \times s^{-1}$; $m \times min^{-1}$), sprinting ($>6.26 m \times s^{-1}$; $m \times min^{-1}$), acceleration ($m \times min^{-1}$) and deceleration ($m \times min^{-1}$) over 1-, 3- and 5-minute durations. Between match and between player variation was examined using co-efficient of variation.

Results: There was large variability in average speed, HSR and sprinting between peak periods. Average speed exhibited the smallest variation (10-11%), while HSR (13-16%) and sprinting (11-18%) demonstrated the largest match the match variation. There was very large between player variation in peak demands for all locomotor variables. Between player variation was lowest for average speed (17-19%) and greatest for sprinting (44-74%).

Conclusions: There is large between match variability in peak locomotor demands of elite youth female soccer and very large between player variation. Findings are consistent with previous findings in senior elite female soccer. Practitioners and researchers should account for within player variability when examining match performances. Understanding of the peak intensity periods in match play can help practitioners prepare players for the worst-case scenarios in match play.

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Comparing intensity and volume markers to describe training intensity distribution in soccer

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Background/Aim: To maximize player fitness and availability, intensity and volume parameters are monitored during outdoor training. Total training volume, expressed in time or distance, is often subdivided based on intensity thresholds, usually heart rate (HR) or speed zones. This allows insight into the training intensity distribution (TID), which is traditionally a conceptual 3-zone intensity distribution model, demarking the training intensity into a low, moderate and high intensity zone. The aim of this study are to compare the TID using the different combinations of intensity and volume parameters.

Methods: Twenty professional male soccer players performed an incremental running tests on a treadmill to determine HR and speed at the first and second lactate threshold. All team-based outdoor activities were undertaken with players wearing a sensor with a portable HR-monitor and GPS-unit. TID was described using the following combinations between respectively intensity and volume parameters: HR distribution over time (HR-Time), HR distribution over distance (HR-Distance), speed distribution over time (Speed-Time), and speed distribution over distance (Speed-Distance).

Results: The proportion of volume spent at low intensity was higher for Speed-Time than for HR-Time ($p<0.001$), HR-Distance ($p<0.001$) and Speed-Distance ($p<0.001$). The proportion of volume spent at low intensity was higher for HR-Time than for HR-Distance ($p=0.014$) and Speed-Distance ($p=0.002$). At moderate intensity, the proportion of volume spent was higher for HR-Distance than for HR-Time ($p=0.024$), Speed-Time ($p<0.001$) and Speed-Distance ($p=0.002$), and for Speed-Time lower than for HR-Time ($p<0.001$) and Speed-Distance ($p<0.001$). At high intensity, the proportion of volume spent was higher for Speed-Distance than for HR-Time ($p<0.001$), HR-Distance ($p<0.001$) and Speed-Time ($p<0.001$).

Conclusions: A large proportion of the total TID is spent at low intensity, regardless of the combination of intensity and volume parameters. Speed as a marker of intensity may better reflect the stochastic nature of soccer in comparison to HR. Time as a marker of volume may overestimate the proportion of volume spent at low intensities. Speed and distance can be used as markers of respectively intensity and volume and may be in the context of soccer be the most relevant and practically feasible method to describe TID.

Positional differences in whole and peak match characteristics of elite female academy footballers

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Background/aim: This study aims to quantify positional differences in match volume and peak intensity of locomotor characteristics among female academy football players, an age group key to preparing players for elite senior football, yet omitted from prior exploration.

Methods: Instantaneous speed and time measured by a 10Hz foot-mounted inertial measurement unit (Playermaker) was collected from 257 players across 171 2021-2022 FA Women's Super League Academy matches from 11 teams (n=4005 observations). Players were categorised (CD; n=42, WD; n=52, CDM; n=18, CAM; n=71, WM; n=32, F; n=41) and peak moving averages for average speed, HSR (5.29-6.26 m×s⁻¹), sprinting (>6.26 m×s⁻¹), acceleration (>3 m×s⁻²) and deceleration (<-3 m×s⁻²) (m×min⁻¹) across 1, 3 and 5 mins and whole match (distance, m×min⁻¹) were calculated. Partial least squares correlation analysis identified relative variable importance and linear mixed effects models identified magnitude of effects.

Results: Across the whole match, CDM cover less volume (HSR; CDM: 2017±111 vs WM: 385±189; F: 338±166 m, effect size (ES) -1.11 to -1.01) and intensity than other outfield positions. Peak sprinting distances were lower in CDM than other positions during 1 (CDM: 6±8 vs WD: 9±1, WM: 12±12 m×min⁻¹, ES -0.74 to -0.77), 3 (CDM: 2±3 vs WD: 3±4, WM: 6±8 m×min⁻¹, ES -0.75) and 5 minutes (CDM: 1±2 vs WD: 2±2, WM: 3±3, F: 2±3 m×min⁻¹, ES -0.81 to -0.82). This was similar for peak HSR across 3 (CDM: 9±7 vs WD: 12±7, WM: 13±8, CD: 10±6, F: 12±8 m×min⁻¹, ES -0.74 to -0.79) and 5 (CDM: 6±5 vs WD: 9±6, CD: 7±4, WM: 10±6 m×min⁻¹, ES -0.72 to -0.76) minute durations. All other positional peak locomotor differences were trivial to small.

Conclusions: Elite female academy football players' whole and peak match volume and intensity are similar across all outfield positions, except CDM which covers moderately less. Thus, practitioners should not prescribe pitch-based training volume and intensity based on position. From a physical perspective, players could have positional versatility which can be used to inform tactical decisions by coaches.

External load, internal load, and well-being on a top-level national male futsal team-a case study

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Background/aim: Futsal is an intermittent high-intensity indoor team sport that requires frequent bouts of high-intensity efforts interspersed with short-durations of recovery. A greater understanding of the physical demands experienced by players during match-play is critical to informing appropriate training prescription and player management strategies during competition. Such information can also be used to establish benchmark data for monitoring players' wellbeing during competition. Therefore, the aim of this study was to characterize the relationship between external load ((Player Load (PL)), internal load ((Rated Perceived Exertion (RPE)/ session (s_RPE)), and well-being metrics (Hooper Index) based on tactical positions, in a top-level national male futsal team during the 2021 World Championship and 2022 European Championship competitions.

Methods: Player locomotor activities were assessed using LPS with ultra-wideband (UWB) tracking system technology (WIMU PROTM) during 13 official matches. Players were grouped by their tactical positions. A two-way mixed design analysis of variance (ANOVA) was conducted to compare differences in the performance variables between positions. The Bonferroni post-hoc analysis was used for multiple pairwise comparisons and Cohen's d effect size was used to determine the magnitude of the effect. Additionally, a Spearman Rho correlation was performed to analyse the relationship between the metrics in the study.

Results: Although wingers and pivots presented similar PL, results revealed significant higher values of RPE ($p \leq 0.05$) for pivots ($8,69 \pm 1,10$), than wingers ($7,15 \pm 1,54$) while higher PL ($p \leq 0.05$) were observed for universals ($94,81 \pm 17,34$) than defenders ($70,04 \pm 20,04$). Correlation analysis revealed that playing time positively impacts the s_RPE ($p \leq 0.001$, $r=0.94$) and PL ($p \leq 0.001$, $r=0.74$). Higher s_RPE also promoted greater values of Hooper's fatigue Index ($p \leq 0.001$, $r=0.21$). Interestingly, the interval of days between matches negatively influenced athlete's PL ($p \leq 0.05$, $r=0.19$).

Conclusions: Our results demonstrate that PL varied according to tactical position. Additionally, a positive relationship was observed for players between playing time and s-RPE and PL. Within international competitions, a lower PL was observed with lower number of days between matches. Therefore, a lower PL may indicate the implementation of strategic player rotation which promotes greater fatigue management and, as a consequence, higher player performance.

Influence of environmental temperature on running and gameplay performance in professional soccer

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Background/aim: As hotter environmental conditions become more frequent, football teams are competing in high temperatures more regularly. Although hotter temperatures reduce exercise performance, reports of their influence on running and gameplay performance during competitive matches remain scarce.

Methods: One Major League Soccer team was observed over two seasons (64 matches), to investigate relationships between temperature and performance. Running performance was recorded via GPS and reported as total distance, distance in (individual) speed zones, total player load, acceleration load/ -density, and maximum velocity. Game actions were recorded from the official competition website. Dry-bulb temperatures were collated from Meteostat.net and aligned with each match retrospectively. Four games played in stadiums with closed roofs were excluded. Linear regressions were used to identify relationships between temperature and performance.

Results: The temperature ranged between 5 and 33°C (mean±SD: 21.4±7.3°C). On average, the team (goalkeeper included) covered 104±4.7 km per match, divided into five speed zones: 0-2 m/s (SZ1), 2-3.92 m/s (SZ2), 3.92-5.5 m/s (SZ3), 5.5-7 m/s (SZ4) and >7 m/s (SZ5). There was a significantly lower total distance (R²=0.15) and distance covered in SZ3 (R²=0.13) in higher temperatures. In individual speed zones, the distance was significantly lower at 0-20% (R²=0.14), 40-55% (R²=0.08), and 55-70% (R²=0.07) of individual maximum velocities, but higher at 20-40% (R²=0.10). Other load measurements (total player load: R²=0.22, acceleration load: R²=0.40, acceleration density: R²=0.18) were all significantly lower in higher temperatures, while maximum velocity was higher (R²=0.14). Finally, passing was more successful under hot conditions (R²=0.07), but not in the attacking half, nor the final third, and there were fewer yellow cards (R²=0.15).

Conclusions: A small to medium relationship exists between hotter temperatures and reduced match running performance. More specifically, less distance was covered in lower SZs, whilst higher SZs remained unchanged. These findings support previous observations in simulated matches, showing pacing exists reducing distances at lower speeds (and therefore thermoregulatory strain) to maintain high-speed running and sprint performance. The higher passing percentages, but not in attacking zones, and the lower number of yellow cards, could also support more ball and less player movement due to the hotter conditions.

Prevention of injuries in young football (soccer) players: a cluster-randomized controlled trial

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Background/aim: We created a new multi-component exercise-based injury prevention programme based on scientific evidence with the intention to contain as many football-specific elements as possible. We aimed to evaluate its effectiveness in reducing injuries in 13 to 19-year-old male football players.

Methods: 55 football teams from Kosovo of the Under 15, Under 17, and Under 19 age groups were randomly assigned to the intervention (INT) or the control group (CON). The INT group performed the 'FUNBALL' programme after their usual warm-up at least twice per week, while the CON group followed their usual training routine. Teams were followed for one football season (August 2021 - May 2022). The primary outcome was the overall number of injuries. The secondary outcomes were region-specific injuries (hip/groin, thigh, knee, and ankle), and injury severity.

Results: The final analysis contained 45 football teams (INT 23, CON 22) and 1027 players (INT 524, CON 503). 108,972 hrs of football exposure were recorded. In total, 319 injuries occurred (INT 132, CON 187). The incidence rate in the INT group was significantly lower for the overall number of injuries (incidence rate ratio (IRR) 0.66; 95% CI 0.52–0.82; $p < 0.001$), for thigh injuries (IRR 0.59 [0.37–0.92]; $p = 0.022$), for moderate injuries (time loss between 7 and 28 days) (IRR 0.63 [0.42–0.93]; $p = 0.020$), and for severe injuries (time loss > 28 days) (IRR 0.45 [0.24–0.82]; $p = 0.009$).

Conclusions: The 'FUNBALL' programme was effective in reducing the overall number of injuries (by 33%), as well as some injury subcategories in young football players: severe ones (by 55%), moderate ones (by 37%) and injuries of the thigh (by 41%). Although more football-specific elements were included, overall efficacy did not exceed the one documented in other intervention studies. Thus, its use is recommended in this age group. It should be performed at least twice per week.

Effect of neuromuscular neck exercises on the incidence of football-related head and neck injuries

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Background: There is growing concern among football players, coaches and parents regarding head and neck injuries, including concussion, particularly from heading a ball. Thus, creating a need to explore soccer-specific head injury risk reduction initiatives. One such initiative is to condition the neck musculature of young players by adding neck exercises to existing injury reduction exercise programs.

Aim: To investigate the effect of neuromuscular neck exercises completed as part of an injury risk reduction exercise program on the incidence of soccer-related head and neck injuries in adolescent (12-18 years) soccer players.

Methods: Prospective cohort study involving n=364 male and female soccer players, aged 12-18 years

Intervention: We targeted one sports high school and two football clubs who completed neuromuscular neck exercises contained within an injury reduction program during training (Neck Training Group) as well as another sports high school and four football clubs who completed an injury reduction program but without neck exercise (Comparison Group) during the 2021 football season.

Main Outcome Measures: Self-reported injury data were collected from each player at the end of the season and used to calculate incidence rate ratios (IRR) with 95% confidence intervals (95%CI).

Results: In total, 364 players completed the study, including 146 players in the Neck Training Group and 218 players in the Comparison Group. Despite players in the Neck Training Group being less likely to self-report concussions (incidence rate ratio (IRR): 0.23 (95%CI 0.03-1.04) and pain on heading a ball (IRR:0.62 (95%CI 0.34-1.07), only lower incidence of potential concussive events (IRR:0.38 (95%CI 0.14-0.89); $p<0.05$) was significant.

Conclusions: Integrating neuromuscular neck exercises into injury reduction exercise programs has the potential to reduce the risk of sustaining a concussion, potential concussive event and pain on heading a ball in adolescent soccer players.

Effect of two eccentric hamstring exercises on 3D muscle architectural characteristics with DT-MRI

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Background: There is strong evidence that a 12-week Nordic hamstring exercise (NHE) intervention can reduce hamstring injury rate up to 51%. Although this non-functional exercise is effective in daily practice, the underlying preventive mechanism is yet not fully unraveled. Current literature suggests a change in muscle fibre architecture on two-dimensional ultrasonography; lengthening of the biceps femoris long head fascicles and a change in pennation angle of the biceps femoris long head. Limitations of two-dimensional ultrasound studies are that findings are predominantly limited to biceps femoris long head, based on a single fascicle and the measurements. Furthermore, it is discussed whether the NHE is the most appropriate preventive exercise, where hip-orientated exercises are suggested as alternatives. They are executed at a longer muscle length, when the majority of injuries occur in the biceps femoris long head.

Aim: The aim of this study was to evaluate the effect of NHE or Diver hamstring exercise (DHE) on muscle fascicle length and orientation in biceps femoris long head, semitendinosus and semimembranosus through three-dimensional diffusion tensor imaging (DTI).

Methods: Injury-free male basketball players were randomly assigned to the NHE-group, DHE- group, or a Control-group. Participants in the intervention group performed NHE or DHE for 12-weeks. DTI datasets of the upper-legs were acquired with magnetic resonance imaging at baseline and follow-up. Muscle fascicle length and orientation of the hamstring muscles were extracted from the DTI data with custom-built scripts and tractography software. Changes in the primary outcome measures muscle fascicle length and orientation per muscle over 12-weeks were compared between groups.

Results: Datasets of fifty-three participants were used for data analysis. The average age was 22±7yrs, mass; 87±11kg, height; 191±9cm. Fascicle length in the semitendinosus over 12-weeks significantly increased in the NHE-group compared to the Control-group, mean between-groups difference: 19.9mm, 95%CI: 1.9/37.9, p=0.026. Fascicle orientation in the biceps femoris long head over 12-weeks significantly decreased in the DHE-group compared to the Control-group, mean between-groups difference: -2.4°, 95%CI: -4.7/0.1, p=0.039.

Conclusions: The NHE increases fascicle length of the semitendinosus muscle. The DHE intervention decreases muscle fascicle orientation in the biceps femoris long head. A combination of these commentary exercises might be relevant for preventing hamstring injuries.

Developing and implementing VoetbalFit: an exercise-based injury prevention program in football

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Background/aim: Many effective injury prevention programs have been developed, as 11+ (kids) (1,2). Nevertheless, lower extremity injuries remain a problem in football (3). Unsuccessful implementation might be a reason. The project's aim was to implement an injury prevention warm-up program in amateur football suiting the Dutch context.

Methods: Interviews with trainers and expert meetings were organized to optimize 11+ (kids) for the national context. An implementation plan was developed with stakeholders' input. A pilot implementation was evaluated among trainers via questionnaires and interviews using the Reach Effectiveness Adoption Implementation Maintenance (RE-AIM) model and national promotion was initiated.

Results: Due to a lack of ball- and game-like exercises trainers would generally not use 11+ (kids). Based on 11+ (kids), experts developed VoetbalFit: 94 age-specific exercises focused on injury prevention and motor development (4). Actions in the implementation plan were integrating VoetbalFit exercises with videos in an online trainers platform (Rinus), the football association developing a vision on injury prevention / motor development for youth and promoting VoetbalFit. Pilot implementation in fall 2020 among 63 trainers (reach) showed trainers evaluated VoetbalFit averagely with a 7.8 (effectiveness), 80% at least regularly used VoetbalFit (adoption) and 57% would keep using VoetbalFit (maintenance). Lack of time hindered using the pre-scribed two exercises per training (implementation). Videos at www.knvb.nl providing background information were used for promotion.

Conclusions: Trainers appreciated VoetbalFit, but structural use could be improved by shortening the duration and linking exercises in Rinus to training sessions. Implementing VoetbalFit in Rinus, an already existing platform for the target group, and collaborating with partners seemed valuable during implementation. When implementing injury prevention programs, other sports associations could also consider this approach.

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Player characteristics and perceptions are associated with adherence to injury prevention programs

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Background/aim: A multifactorial problem as football injuries asks for a multifactorial solution. One of the factors to reduce football injuries are injury prevention exercise programs. Adherence to injury prevention programs in football remains low which is thought to drastically reduce the effects of injury prevention programs. To increase adherence, adequate implementation strategies need to be developed (1). These strategies start with understanding the context. Reasons why (medical) staff and players implement injury programs, have been investigated, but player characteristics and perceptions about these programs are largely unknown (2). Therefore, this study investigated the relationships between player characteristics and adherence and between player perceptions and adherence following an implemented injury prevention program.

Methods: Amateur football players, competing in the first class, were eligible for participating in a large nationwide cluster-RCT investigating a Bounding Exercise Program. At baseline, football players were asked to fill out a questionnaire consisting of questions about player characteristics including previous injuries. During the large cluster-RCT, football players who were randomized to the intervention group were asked to register compliance with the intervention weekly and to complete an evaluation questionnaire after the competition.

Results: Data from 98 of 221 male football players from the intervention group of a cluster-RCT concerning hamstring injury prevention were analyzed. Significant correlations were found between adherence and player characteristics, being older age and more years of football experience. In contrast, there were no significant correlations between adherence and the number of previous hamstring injuries, hamstring injuries during competition, and educational level. Difficulty of the program and intention to continue the exercises were not significantly related to adherence.

Conclusions: Implementation of injury preventive measures is challenging. This study shows that these players and especially these specific characteristics and perceptions should be considered when designing and implementing injury prevention programs.

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Recreational football training increases leg-extensor force production at high velocities

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Background/aim: Ageing is accompanied by a progressively blunted ability to produce force at moderate to high velocities. Therefore, improving muscle power, especially at moderate to high velocities, is a crucial target for exercise interventions in middle-aged and older adults. This study investigated the effects of 10 weeks of recreational football training on the leg-extensor force-velocity (F-V) profile in 55- to 70-year-old adults. Simultaneous effects on functional capacity, body composition and endurance exercise capacity were examined. In addition, feasibility and the physical demands (internal and external load indicators) of the training program were tracked throughout the intervention period.

Methods: Forty participants (age 63.5 ± 3.9 years) were randomized in a football training (FOOT, $n = 20$) and a control (CON, $n = 20$) group. FOOT performed 45-min to 1-h of football training sessions with small-sided games (SSG's) twice a week. Pre and post intervention, the following outcomes were measured: leg-extensor F-V profile (maximal power (Pmax), maximal force (F0), maximal velocity (V0), the slope divided by F0 (SFV/F0)), functional capacity, body composition and endurance exercise capacity.

Results: The results revealed an increase over time for Pmax ($p_{\text{time}} = 0.009$), but no interaction effect ($p_{\text{int}} = 0.221$). A greater increase in V0 and in SFV/F0 was apparent in FOOT compared to CON ($p_{\text{int}} = 0.043$ and $p_{\text{int}} = 0.065$). No interaction effect was found for F0 ($p_{\text{int}} = 0.922$). Three-step stair ascent power, 10m fast walk, body fat percentage and running speed at 2mM lactate improved significantly more in FOOT than in CON (all $p_{\text{int}} < 0.1$). The training sessions, in particular the SSG's, elicited intense muscular actions and high average heart rates of 85.7% of maximal heart rate. Despite the high training load, participants perceived the training sessions as very enjoyable and feasible.

Conclusions: The present study emphasized that recreational football can be used as a feasible, enjoyable and effective training tool in middle-aged to older adults for improving force production at high velocities. This improvement is translated into a better performance on functional capacity tests that rely on high execution velocity. In addition, broad-spectrum health benefits can be realized with only 2 hours of training per week.

FIFA Sudden Death Registry (FIFA- SDR): an update from 2019 to 2022

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Background/aim: The aim of the study is to investigate the underlying causes of sudden death in football players worldwide and - based on that - to provide information on prevention measures.

Methods: From 2019 to 2022 cases of football-related sudden death and their circumstances of cardiopulmonary resuscitation (CPR) were collected through media search, a web-based reporting platform in 11 languages, and data matching with existing national sudden death registries (n=21). Inclusion criteria were met if sudden death occurred during a football-specific activity or within one hour thereafter. Death during other activities was excluded. This study represents continuation of FIFA- SDR: a prospective, observational study of sudden death in worldwide football from 2014 to 2018 (1).

Results: A total of 498 football players (age: 31±14 years; 99% male; playing level: 93% amateur and 7% elite) with sudden death were reported from 83 countries; 101 players (20%) survived. A diagnosis was confirmed by autopsy or medical report in 104 cases (21%), suspected in 73 cases (15%) and remained unclear in 321 cases (64%). In young players (≤ 35 years) the most common cause (confirmed and suspected combined, n=98) was sudden unexplained death (SUD, n=25, 26%) followed by coronary artery disease (CAD, n=8, 8%) and coronary artery anomaly (n=6, 6%). In the old players (> 35 years) CAD predominated by far (n=68, 86%). Among all age groups intracranial cerebral hemorrhage (n=16, 9%) was the most common traumatic cause, commotio cordis occurred infrequently (n=6, 3%). Prompt CPR resulted in a survival rate of 64% when an automated external defibrillator (AED) was used compared to 46% without AED. The most frequent first responders were players themselves (30%).

Conclusions: Primary prevention measures for sudden death in young football players remain challenging, with the primary suspected diagnosis being SUD. Of note, CAD is not only to be expected in older players. Nevertheless, more national registries are needed to reduce underreporting. Usage of an AED and regular CPR training of players appears paramount for optimized survival.

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Football increase well-being and health-related quality of life in middle-aged and older men

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Background/aim: Regular physical activity throughout the life course is essential for healthy longevity, and the guidelines from the World Health Organization have provided recommended minimum levels of physical activity. Football, one of the most popular team sports worldwide, is a form of physical activity that benefits physical health. Participation in team sports makes people engage in physical activity and mutual communication with others; therefore, it is effective in contributing to both physical and mental aspects of health. However, the contribution of football to health has not been examined in middle-aged and older men who have decreased physical activity due to a change in their social roles and decline in physical functioning. Thus, the aim of this study was to investigate whether participation in football increases well-being and health-related quality of life (HRQOL) in middle-aged and older men in Japan.

Methods: Middle-aged and older men who were registered members of the Japan Football Association as a player were recruited in this study (Football group). Well-being was measured using the Satisfaction with Life Scale (SWLS) and HRQOL was assessed using the Short Form-36 (SF-36). The physical component summary (PCS) score and mental component summary (MCS) score were calculated based on data from the SF-36. We also collected data through an online survey of middle-aged and older men for comparison groups and categorized them into three groups according to daily exercise habits (No-exercise group, Individual-sports group, and Team-sports group).

Results: The Football group included 2011 participants. A total of 1998 participants comprised the No-exercise group, 1787 comprised the Individual-sports group, and 206 participants comprised the Team-sports group. The Football group had significantly higher SWLS scores (Football = 23.3 ± 5.2 ; No-exercise = 18.2 ± 6.7 ; Individual-sports = 20.6 ± 6.5 ; Team-sports = 20.5 ± 6.9 .) and MCS scores (Football = 56.2 ± 7.5 ; No-exercise = 48.4 ± 10.5 ; Individual-sports = 52.1 ± 9.9 ; Team-sports = 51.3 ± 10.2) than all other groups. The Football group also had significantly higher PCS scores than the No-exercise group (Football = 52.1 ± 6.3 ; No-exercise = 49.4 ± 9.6). These differences remained significant after adjusting for covariates.

Conclusions: Participation in football could contribute to improvement in well-being and the mental health aspects of HRQOL in middle-aged and older men.

The effects of football experience on BMD and 25-OH-VD levels in middle-aged pre-menopausal women

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Background/aim: Osteoporosis is a serious disease in the female life stage. Exercise reportedly had positive effect on bone strength and bone mass (1). Sunlight exposure results in vitamin D production, which is involved in bone formation (2). Football, which promotes the mechanical stimulation of bones via exercise and vitamin D production from sun exposure, provides benefits in terms of osteoporosis prevention among women. This study aimed to investigate the effects of playing football on bone mineral density (BMD) and 25-OH-VD levels in middle-aged Japanese women.

Methods: The study included pre-menopausal women, aged 40-49 years. The participants were divided into three groups: football players (n=27), volleyball players (n=70), and participants without a sport (control group; n=25). The BMD of the second to fourth lumbar vertebrae and femoral neck were evaluated using dual-energy X-ray absorptiometry. The body composition and serum 25-OH-VD were measured in October 2022.

Results: The lumbar BMD of the volleyball group was higher than that of the control group. Meanwhile, the femur BMD and skeletal muscle mass of the football and volleyball groups were higher than those of the control group. The football group had higher 25-OH-VD levels and a lower waist-hip ratio than the volleyball and control groups.

Conclusions: Among middle-aged pre-menopausal women, the BMD and skeletal muscle mass were higher in the football and volleyball groups than in the control group. Moreover, the football group had more elevated serum 25-OH-VD levels than the volleyball and control groups. These results of this study suggest that playing football may be effective to prevent osteoporosis for middle-aged pre-menopausal women.

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Effect of carbohydrate intake before and during a football match on immune response.

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Background: The "open window theory" states that strenuous physical activity may lead to a temporary impairment of the immune function, enabling entry and proliferation of pathogens. Carbohydrate consumption during exercise has been suggested as a strategy to mitigate such response.

Aim: To investigate the effect of carbohydrate consumption on leukocyte, lymphocyte, and neutrophil counts after a football match.

Methods: Thirteen semiprofessional football players participated in this RCT. Participants performed two trials (competitive matches): carbohydrate (CHO) and placebo (PLA). During CHO, subjects ingested 500ml of a 6% maltodextrin drink and a 147g gelatin (30g maltodextrin) before kick-off and during halftime (total 120g maltodextrin). During PLA, participants ingested a placebo drink and gelatin of similar taste at the same timepoints. Venous blood samples were drawn before kick-off (baseline) and 15 minutes (15MP), one hour (1HP), and 24 hours after. Samples were analyzed for differential blood count. Total distance covered (TDC), average heart rate (AHR), maximal HR (MHR), and sprint distance (SP) data were collected with GPS and HR monitors.

Results (mean \pm SD): An increase in leukocytes (all cells $\times 10^3/\mu\text{L}$) was seen from baseline (CHO 5.96 ± 1.63 ; PLA 5.78 ± 1.38) to 15MP (CHO 11.2 ± 2.76 ; PLA 11.3 ± 1.74) and to 1HP (CHO 12.9 ± 3.75 ; PLA 12.8 ± 1.91). The same pattern was observed in neutrophils. No significant differences were found when comparing both conditions ($p > 0.05$). A decrease in lymphocytes was observed in both CHO (baseline 1.63 ± 0.42 ; 15MP 1.12 ± 0.39 ; 1HP 1.27 ± 0.46) and PLA (baseline 1.79 ± 0.56 ; 15MP 1.23 ± 0.47 ; 1HP 1.27 ± 0.46) after the match. No significant differences were found between conditions ($p > 0.05$). No differences were found when comparing CHO and PLA in TDC ($9469.7\text{m} \pm 1451.1$; $8979.9\text{m} \pm 1432.7$, respectively; $p = 0.3$), AHR (165.3 ± 9.4 ; 163.1 ± 9.3 , respectively; $p = 0.5$), MHR (193 ± 9.4 ; 190.8 ± 7.9 , respectively; $p = 0.5$) or SP ($651.06\text{m} \pm 288.8$; $594.6\text{m} \pm 182.7$, respectively; $p = 0.5$).

Conclusions: We found evidence for an "open window" after a competitive football match. However, our findings suggest that CHO does not mitigate the decrease in lymphocyte count. Possibly the CHO dose was too low, which might be indicated by the lacking effect on physiological variables.

Training loads and micro-cycle periodization in Italian Serie A youth soccer players

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Background/aim: Training micro-cycles are key building blocks for training load management, helping to optimize training effects and players' performance (1). During periods of growth and maturation, a detailed understanding of training load patterns across different age groups is fundamental for supporting youth players' development (2). The aim of this study was to quantify external and internal training load accrued by elite youth soccer players across a competitive week and its periodization within a micro-cycle.

Methods: Data were collected from 90 Italian Serie A youth players across a full competitive season. External and internal training loads were quantified using a global positioning system (total distance, distance above 20 km/h, accelerations above 3 m/s²) and a heart rate (HR) sensor (time spent above 85% HR_{max}). Mixed models were used to detect daily and weekly variations in training load measures between age groups (under-19, under-17, under-16, under-15) and training days, categorized based on their proximity to match day (MD) (i.e., MD-5, MD-4, MD-3, MD-2, MD-1). Estimated marginal means and 95% confidence intervals were calculated and Bonferroni correction was applied to adjust for pairwise comparisons.

Results: A significant effect of age group and training day was observed on all external and internal training load measures ($p < 0.05$). Weekly external training loads increased progressively across age groups. No differences in weekly training loads were observed between under-15 and under-16 players for external training loads, while internal load was higher in under-15. MD had the highest daily load of the micro-cycle, with significant differences between each age group. MD-5 displayed greater loads than other training sessions for all age groups, with a reduction in load the two days before a match.

Conclusions: External and internal loads increase progressively throughout the academy pathway, with MD presenting the greatest training load of the competitive micro-cycle for all age groups. Daily training loads tend to decrease as the match approaches, with MD-5 being the most demanding training session. Differences in micro-cycle periodization suggest variations in the distribution of the load across age groups.

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Match-play data-driven player positions within the Australian Football League Women's competition

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Background/aim: Currently, no analysis of competition technical skill data exists by player position in the Australian Football League Women's (AFLW) competition. Understanding player positional performance roles are important for match-play tactics, player recruitment, talent identification and development. Our primary aim was, to observe what positions and roles characterise AFLW match-play using detailed technical skill action data of players. We also provide a commentary on the application of clustering methods to achieve more interpretable, reflective positional clustering results.

Methods: A two-stage, unsupervised clustering approach was applied to match-play data from five seasons of the AFLW, totalling 1465 players. Applying clustering algorithms in an effective manner takes careful consideration with the use of principal components analysis for data reduction, and random forests for interpretation of important variables key to producing actionable results.

Results: First-stage clustering found four positions, following common Australian Football convention of forwards, midfielders, defenders, and rucks. Key performance indicators of interest included the field location of actions across all positions, contested possessions and clearances for midfielders, interceptions and rebound 50s for defenders, hitouts for rucks, and statistics inside attacking zones for forwards. Second-stage clustering revealed 13 roles within these positions (forwards, midfielders, and rucks: three each, defenders: four). Forward clusters were nominated as a high scoring or general forward, with the third cluster representing those that also spend time in midfield. Defensive clustering had similar clusters, with high-disposal instead of high-scoring and an around-the-ground defender who performed more actions outside defence in addition to the general defender. Midfield clusters were determined by those who primarily do attacking work, defensive work, and those that perform both. Rucks clusters included general rucks, those who kick goals, and those that perform actions all around the ground.

Conclusions: Positional roles within AFLW match-play may not be constrained to existing positional classification seen in previous men's literature. This finding, coupled with key game actions players need to perform by position, can assist training practices, while defining new roles with suggestions of how to best use available data, producing more holistic player performance profiles. Data analysts derive benefit from the application of clustering in this environment with key data and methodological clustering and data considerations to make while producing interpretable, reproducible, comparable results assisting improved match-play performance and future research. These results will also be considered with physical performance in mind.

Intra-match variability of match high-intensity activity characteristics in professional football

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Background: Match running performance plays an important role in the success of the match. Although numerous investigations have demonstrated match running performance, such as the total distance covered and number of sprints, few studies have focused on changes in running performance over time during a match.

Aim: This study aimed to reveal the variability of high-intensity activity characteristics during official football matches in the Japanese men's football league.

Methods: Match activity data were collected from 199 matches from the Japanese soccer league second division over three seasons between 2018 and 2022. The selected data were limited to information on outfield players. A total of 2,859 observations were obtained. All players, including the substitute players, were included in the analysis. Match activity was assessed by the validating global navigation satellite system (OptimEye X4; Catapult Sports). This system sampled XY coordinates at a frequency of 10 frames per second. The distance for high-speed running (>19.8 km/h; HSR), high deceleration (<-3.0 m/s²: DCC), high acceleration (>3.0 m/s²: ACC), larger metabolic power (>35 w/kg: MET) were observed. These variables were recorded every 15 min during the match (0–15, 15–30, 30–45, 45–60, 60–75, 75–90), and additional time was included in the final tertial, respectively.

Results: The distances of HSR, DCC, and ACC were significantly different according to the time of the match ($p < 0.05$). The longest distances of HSR, DCC, and ACC were obtained in the first period (0–15 min) of the match, and the shortest at 60–75 min of the match ($p < 0.05$). Furthermore, the distance of HSR, DCC, and ACC were significantly longer at 75–90 min compared with that at 60–75 min ($p < 0.05$). In contrast, there was no significant difference in the distance of MET.

Conclusions: The results of the present investigation demonstrated that the total team value for high intensity running activity declined from the beginning of the match to the middle of the second half. The effects of high intensity running activity intra-match variability on match success remains unclear.

Muscle stiffness assessed by shear wave elastography is decreased following elite academy match-play

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Background/aim: Muscle stiffness is an important factor in musculoskeletal performance and injury prevention. The purpose of this research is to provide information on the change in muscle stiffness using shear wave elastography (USWE) following a 90-minute elite academy football match.

Methods: Twelve elite academy footballers (aged 16-18) were scanned with the USWE ~75mins pre- and ~75 mins post- an elite academy football match. The participants were scanned in two different conditions, relaxed and passively stretched. Scans were collected at the centre of the rectus femoris between the tibial tuberosity and anterior inferior iliac spine. For the relaxed scans, the participants were seated on a medical bench, with their hip angle at 90° and lower body laid completely straight. For the passively stretched position, the participants were laid flat on a medical bench, with their knee angle at 90°, with their feet hanging beneath the bed. The ultrasound probe was placed on the marked position, with minimal pressure. Three different scans were taken for each measurement, and the average was used for the statistical analysis. During the match-play, each player wore a micro-electromechanical systems (MEMS) unit to measure external physical output. The MEMS measures time motion parameters represented by the distance covered and number of efforts at different running velocities. The muscle stiffness response from the USWE was then correlated against the external output to examine the influence of the match-play on the change in muscle stiffness.

Results: No significant difference was found between the pre-scan and post-scan for muscle stiffness ($p = 0.118$) though a mean decrease of -0.17m/s decrease was observed for the players who played 90-mins (~ 7.1 decrease). A moderate negative correlation between the difference in muscle stiffness and meters per minute ($r = -0.514$), and a moderate positive correlation with number of sprints performed ($r = 0.508$) though these were not significant ($p = > 0.05$).

Conclusions: Despite no significant changes in muscle stiffness following match-play, the decrease was consistent at an individual level ($\sim 81\%$ participants) and could have been deemed significant if the sample size was larger. To our knowledge, there has been no known research conducted to assess muscle stiffness following football match-play. While the exact physiological mechanisms are still debated within the literature, current hypotheses suggest the immediate decrease in muscle stiffness may be a result of cross-bridge attachment release induced by endurance activity.

What to expect from player performance during the FIFA World Cup 2022: the scheduling challenges

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Background/aim: For the first time in history, the FIFA World Cup will take place in a country in the Middle East and contextual factors (e.g., weather conditions) force the competition to be held in the months of November and December. Indeed, this change may pose an additional challenge for coaches (i.e., clubs and national teams) in managing training and match loads, as the tournament takes place during the competitive season. The change of the date of the competition, resulted in an increase of the physical and mental demands imposed on the players due to the increase of matches played since the beginning of the season (1). Thus, the main objective of this study was to critically analyze the potential impact that changing the usual date of the FIFA World Cup can have on the performance of players who play in the main European leagues and who will participate in the tournament.

Methods: For the research, the Web of Science, Pubmed and SPORTDiscus databases were accessed using the primary keywords FIFA World Cup and Soccer World Cup associated with the secondary keywords: match performance, fixture congestion, fatigue and weather conditions. After evaluation, 52 articles were considered for analysis.

Results: The results seem to indicate that periods of fixture congestion are common in elite soccer, however the accumulated external load can increase fatigue indices, condition performance and increase the risk of injuries and therefore the impact of these changes needs to be clarified. On the other hand, changing the usual FIFA World Cup date can have a positive impact on players' performance, given that recent data reported the existence of positive differences in external load responses during the 1st competitive period compared to the 2nd period competitive of the season (2).

Conclusions: There are many uncertainties about the potential impact that changing the date of the FIFA World Cup 2022 will have on player performance and future studies are essential to clarify these doubts.

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The motivational approach adopted by youth-elite football coaches during pre-match talks

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Background/aim: Coaches typically gather their players to recall the game strategy and provide the final 'psychological' messages before competition. Whilst literature has systematically observed what behaviours coaches use (1), 'the how' (i.e., style and tone) these are transmitted has been neglected. Indeed, various instruments grounded on self-determination and achievement goal theories have been validated for examining the style and tone of coaches' behaviours. These aspects are particularly relevant during pre-match because of the motivational effects that these talks can have on players (2). Therefore, a mixed-method approach was employed to explore the pre-match motivational approach adopted by youth-elite coaches.

Methods: Three youth Spanish coaches (Ramiro, Rodrigo, and Manuel) working with U19, U18, and U16 players, consented to participate. Six pre-match talks per age-group were filmed and coded using an adapted version of the Coach Interpersonal Style Observational System, and coaches were interviewed to explore their behaviour rationales. Mean frequency (%) of dimensions and specific behaviours were calculated for each coach and interviews were analysed utilising thematic analysis procedures.

Results/discussion: Coaches were mostly engaged in game strategy (70.60-74.39 %). This involved 'neutral' (31.44-39.44 %), 'support' (15.03-18.70 %), 'description' (13.19-17.08 %), and 'control' (2.07-7.17 %). The most employed specific behaviours were 'autonomy neutral A' (i.e., player-role clarification), which was typically complemented with considerable 'competence neutral A' (i.e., game-objective specification) or 'description B' (i.e., comments about opposition). Moreover, contextual and social climate 'control' statements (0.00-1.30 %) were minimal compared to 'support' (0.78-8.90 %). Only Manuel presented higher 'task' (5.60 %) than 'ego' (3.12 %) motivational orientation. Qualitative data suggest that higher autonomy provision was required for attacking contents compared to defending and games against lower-ranked opponents required higher 'competence control' and 'ego-involving' messages.

Conclusions: Results suggest similarities and differences in behaviour ascribed to coaches' individual beliefs and age-groups coached. Contextual factors played a crucial role for adjusting autonomy and competence behaviours.

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Investigating the origin of scores for winning and losing teams in elite Gaelic Football

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Background/aim: In the last 10 years, an evolving body of literature has supported a better understanding of the nature and characteristics of the game of Gaelic Football (GF). However, few of these studies have reported data beyond isolated variable counts. This study aimed to connect variables by investigating the origin of scores in elite GF and how that differs between winners and losers. Possession in GF can be secured in 4 ways; throw ins, own kickout, opposition kickout or turnovers won. In goal-posts similar to rugby posts, teams can score a goal (3 pointer) or kick the ball over the bar between the uprights for a one pointer (point).

Methods: All-Ireland Championship games (2021 - 2022), were analysed using NACSport. Definitions previously established for GF (1) were used to code possession and scoring variables. Intra-operator reliability studies of 2 games coded 3 weeks apart demonstrated the system accuracy within 5% error. Paired sample t-tests and Wilcoxon signed rank testing were used to interrogate differences in winners and losers in SPSS.

Results: Differences were identified in scoring from own kickouts, with winning teams having significantly more success, scoring more goals ($t = 3.217$, $p = 0.002$) and points ($Z = -2.761$, $p = 0.006$). Points scored from turnovers won significantly differed between winning and losing teams ($t = 3.387$, $p = 0.001$). Winning teams scored nearly 3 times more goals from their own kickout than losing teams (23 to 8), and twice as many from turnovers (16 to 7). Own kickout was the primary origin of scores (45%), followed by turnovers (40%), Opposition Kickouts (12%) and throw-ins (3%).

Conclusions: The findings concur with previous work, which linked the source of possession to success in GF (1). They are the first to specifically suggest the importance of own kickout to goal creation and document the primacy of own kickout to score generation. Data potentially reflect the increasing emphasis placed by coaches on securing possession from their own kickouts and working it patiently into scoring positions. These results may be of interest to GF coaches and analysts to provide a better understanding of the likelihood of scoring after winning different types of possession.

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An analysis of the effectiveness of kickouts in sub-elite Gaelic football

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Background/aim: Kickouts in Gaelic football have not been researched in detail at elite or sub-elite level even though it's an extremely important element of the game (1). There is only one paper that has focused solely on kickouts in elite level and the Ulster championship (2). The research concluded that short kickouts were most effective however, the research was carried out prior to rule changes that were implemented in each level.

Methods: A total of 45 competitive sub-elite games from 2 seasons (2020 and 2021) were analysed. Video analysis software was used to code game videos to analyse performance indicators.

Results: It was found that 65% of kickouts were won by the kickout team. Short kickouts inside the 45m line were the most successful. Kickouts lasting less than 0-5s and 6-10s were found to give teams a better opportunity to win their kickout and build an attack following the kickout. The most common attack outcome following winning a kickout was a turnover, followed by a score for the team. It was found the highest win percentage was with 5 and 7 opposition players inside the 65m, the lowest win percentage was with 6 and 10 opposition players inside the 65m line.

Discussion: Similar to the findings of Daly and Donnelly, (2018), it was observed that short kickouts were most successful. Overall, short (inside the 45m line) kickouts that are taken quickly give the kickout team a better opportunity to regain possession from the kickout and then build a successful attack following the kickout.

Conclusions: The findings of the present study provide insights for coaches to build effective kickout strategies and the importance of creating tactics to build attacks following winning a kickout due to the high number of turnovers observed after winning a kickout.

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Characterization of counterattack and its impact on the performance of futsal teams

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Background/aim: In Futsal, the efficacy of counterattack characterizes winning teams. However, any knowledge exists regarding the frequency of the use of counterattacks and teams' success. Thus, this study aimed to characterize the teams' counterattack frequency and understand its impact on the performance of the teams.

Methods: The teams' performance from 190 matches, from different seasons, of Portuguese Futsal League was analysed considering match outcome, number of counterattacks and some notational analysis such as ball possession, goals, shots, %shots at goal, positional attack, % of positional attack with shot, set pieces, % of set pieces with shot, passes, % successful passes, duel, dribbles, % successful dribbles, tackles, % successful tackles, faults, which was retrieved from the InStat Scout® website. A two-step cluster was performed to classify teams according to the number of counterattacks performed per match. Further, a discriminant analysis was performed to understand which notational variables better discriminated the counterattack according to its classification.

Results: Through the two-step cluster analysis, three clusters were obtained according to the number of counterattacks (lower counterattack, LCA; medium counterattack, MCA; higher counterattack, HCA). The LCA presented the largest number of teams (43.9%) and the HCA the smallest number of teams (16.2%). Most of the teams from the MCA and HCA win the game (51.0% and 57.4% respectively), while most of teams from LCA lose the game (57.2%). The discriminant analysis revealed that HCA was explained by high number of tackles, % shots at goal and goals, while LCA was explained by high ball possession and % successful passes.

Conclusions: Results show that it was possible to characterize the teams according to the number of counterattacks in competition. In opposition to coaches' general perspective, the teams that performed more counterattacks revealed better performance. Such result can be explained by the positive relationship between the number of counterattacks, tackles, % shots at goal, and goals. That is, it is expected that being able to tackle more often would create more chances to create goal-scoring opportunities. In turn, teams with low number of counterattacks revealed a negative relationship with ball possession and % successful passes. Thus, the number of counterattacks and the success of the teams are not only related with attacking capacities, but also with the defensive capacity of team to recover ball possession and start a quick progression in the field that may lead to attack with numerical and spatial advantage.

Cognitive-motor interference in visual tracking of soccer players during ball interception

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Background/aim: Prospective decision-making in soccer requires taking information about teammates and opponents while ensuring effective reception and control of the ball. However, these two tasks are concurrent and require similar visual attention resources. An off-field assessment tool would be relevant if it detects inter-individual differences in actual play. However, the effect of expertise in traditional visual tracking tests might be underestimated by not considering the constraints of the field. The multitasking aspect of team sports is barely considered in the study of the relationship between sport and visual tracking expertise (1). This research explored the ability of soccer players to pay attention to their surroundings while intercepting a ball, in Virtual Reality simulations.

Methods: Backward passing situations were extracted from real games and simulated from the perspective of the ball receiver in Virtual Reality. Twelve national and 12 regional soccer players faced 3 conditions, a single-task one and 2 double-tasks. In the single-task condition (ST), in which the virtual ball was removed, participants were required to track 3 players for 10 seconds. In the dual-task conditions, participants had to track the players but also to anticipate a potential pass coming from one of the virtual teammates. In the DT_Pass condition, a pass was performed before the end of the simulation and the participants had to intercept the ball while tracking the players. In the DT_NoPass condition, no pass is performed before the end of the trial. The DT_Pass condition is thus compared to the ST condition to study the impact of the tracking of both players and ball without performing the ball interception. The DT_NoPass condition is compared to the DT_NoPass condition to assess the additional interference caused by the interception.

Results: Compared to ST condition, visual tracking performance decreased in DT_NoPass condition by additionally tracking the ball but did not decrease further in DT_Pass condition by intercepting it. No significant difference was found between national and regional soccer players.

Conclusions: Remaining aware of a possible upcoming pass is challenging enough to impair visual tracking. Additional adaptations of traditional visual tracking tasks may be considered for examining how soccer expertise may be related to expert visual tracking.

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Intermittent training prescribed by Yo-Yo Recovery's speed produces only moderate metabolic stress

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Background/aim: The Yo-Yo intermittent recovery level I test (Yo-Yo IR1) is considered a valid measure of fitness performance in Soccer¹. In agreement, some physical trainers prescribe Maximal Aerobic Velocity (MAV) trainings applying this methodology. However, own results² and other studies³ indicate that short intermittent endurance training (Int ET) [<30 -s] produces an attenuated metabolic response compared with longer intervals. The purpose of this study was to measure the metabolic response of Int ET prescribed from end speed reached in the Yo-Yo IR1, adding additional intensity.

Methods: 186 male professional Soccer players (24.5 ± 1.6 yr) performed Yo-Yo IR1 to determine MAV. Subsequently, performed an Int ET consisted of 2 x (8 x 20/30-s work/passive-rest ratio) and 2 x (8 x 20/20-s work/passive-rest ratio) interspersed, with 1-min passive-rest between sets. Yo-Yo IR1 speed was 4,21 m/s; we add additional 20% (mean value: 5,05 m/s. Range: 4.86-5.22 m/s). Blood Lactate (BLa) and Heart Rate (HR) were measured post each set.

Results: BLa were 2.25 ± 0.53 , 3.29 ± 0.49 , 3.12 ± 0.83 and 3.46 ± 0.54 mMol/Lt., after 1-2-3-4 sets, respectively. In addition, we found a low correlation between BLa and HR ($r = 0.34$), comparing 744 values.

Conclusions: The main findings suggest that, despite using a speed above the end value reached in the Yo-Yo IR1, an attenuated metabolic response is maintained when Int ET prescribed. We also found that HR is not a good indicator of metabolic stress during Int ET.

Keyword: Soccer; Intermittent Endurance Training; Yo-Yo test; blood Lactate

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Lower limbs strength variations between injured and non-injured professional soccer players

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Background/aim: Due to professional football being correlated to high-intensity physical demands as jumping, running, and direction change, muscle strength is one of the most crucial characteristics for players (1). In addition, lower limb injuries have showed high frequency in elite football (2). The aims of this study are: (a) describe the differences between injured and non-injured players according to their performance in vertical jumps, and (b) analyze the impact of the injury profile on football players' variations in lower limbs' maximum isokinetic strength.

Methods: Twenty-one male professional football players (age: 26.0 ± 4.1 years, height: 181.0 ± 6.9 cm, body mass: 73.7 ± 6.9 kg) were assessed in isokinetic strength (Biodex System 4 Pro Dynamometer), and Optojump Next (Microgate, Bolzano, Italy). Isokinetic strength analyses considered the knee flexors (KF) and knee extensors (KE) peak torque (PT) scores, according to the player's preferred leg (PL) and non-preferred leg (NPL) at two different time moments. The countermovement jump (CMJ) and squat jump (SJ) maximum height were used as lower-body explosive strength indicators assessed throughout the season in eight-time moments. A mixed ANOVA (between groups within subjects) was conducted to assess the effects of injury profile on lower-body strength.

Results: There was a substantial main effect of time at performance with the PL (Wilks' Lambda = 0.46, $F(1,19) = 22.38$, $p < 0.01$, $\eta^2 = 0.54$) and NPL (Wilks' Lambda = 0.45, $F(1,19) = 23.34$, $p < 0.01$, $\eta^2 = 0.55$) with both groups increasing in performance across the two moments. The same trend was observed concerning the time at KE PT (PL: Wilks' Lambda = 0.46, $F(1,19) = 22.38$, $p < 0.01$, $\eta^2 = 0.54$; and NPL: Wilks' Lambda = 0.56, $F(1,19) = 15.07$, $p < 0.01$, $\eta^2 = 0.44$). In contrast, no significant interaction was found between the injury profile and time for lower-body explosive strength (CMJ: Wilks' Lambda = 0.60, $F(7,13) = 1.25$, $p = 0.35$, $\eta^2 = 0.40$; SJ: Wilks' Lambda = 0.62, $F(7,13) = 1.15$, $p = 0.39$, $\eta^2 = 0.38$).

Conclusions: Our findings indicate performance in muscular strength assessments increases throughout the season, independently of the injury profile. In this study, the overall lower-body strength performance was not discriminant between groups. Due to its multifactorial causes, future research should integrate other factors related to sports injuries.

Force-velocity profiling of elite wheelchair rugby players over multiple wheelchair sprints

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Background: Wheelchair sprinting leads to high hand velocities and there is little time for the upper-body muscles to contract, to couple the hand with the rotating rim-wheel interface and to transfer the power to the wheelchair.

Aim: This study investigated the effect of increased rolling resistance on wheelchair sprint performance and the concomitant force-velocity characteristics.

Methods: Thirteen wheelchair rugby athletes completed five 15 s wheelchair sprints in their own rugby wheelchair on an instrumented dual-roller wheelchair ergometer. The first sprint was performed against a close to overground resistance and in each of the following sprints, the resistance increased with 80% of that resistance. A repeated-measures ANOVA examined differences between sprints. Subsequently, linear regression analyses examined the individual force-velocity relations and then, individual parabolic power output curves were modelled.

Results: Increased rolling resistance led to significantly lower velocities (-36%), higher propulsion forces (+150%) and higher power outputs (+83%). These differences were accompanied by a lower push frequency, higher push time, yet a constant recovery time and contact angle. The modelled linear regressions ($R^2 = 0.71 \pm 0.10$) between force and velocity differed a lot in slope and intercept among individual athletes. The peak of the power output parabola (i.e., the optimal velocity) occurred on average at 3.1 ± 0.6 ms⁻¹.

Conclusions: These individual force-velocity profiles can be used for training recommendations or technological changes to better exploit power generation capabilities of the wheelchair rugby athletes' musculoskeletal system.

Evaluating the behavioural effects of pitch obstacles during women's football small-sided games

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Background/aim: Since the structural traits of training tasks constrain young football players' motor behaviour, coaches manipulate them habitually to elicit players' functionality in challenging training scenarios such as SSGs with pitch obstacles. However, research examining the effects of task constraints on players' motor behaviour in women's football is lacking. Thus, this study aimed to assess the behavioural response (i.e., tactical and physical responses) of adding different pitch obstacles during several SSG exercise bouts.

Methods: Twelve recreational female players played three four-minute bouts of a novel 6-a-side SSG (i.e., Gk + 5 vs 5 + Gk) with obstacles like cones, mini-goals, and saucer cones scattered across the 33 m length × 25 m width artificial turf pitch symmetrically. All the official game rules applied except for the offside rule. Positional data was gathered using a GPS to measure tactical (distance between players, stretch-index [SI], spatial exploration index [SEI] and their normalized approximate entropy measures [ApEn], and longitudinal and lateral synchronizations) and physical performance (total distance and walking, jogging, running, and high-speed running distances).

Results: SEI decreased from the first to the consecutive bouts (first [7.39 ± 1.54m] vs second [5.57 ± 1.34m]: Cohen's d with 95% of confidence intervals: -2.33 [-3.54; -1.09], $p < .001$; first vs third [6.20 ± 1.23m]: -1.62 [-2.57; -0.64], $p = .009$), while the ApEn of the distance between players increased from the first (0.12 ± 0.03 AU) to the third (0.14 ± 0.03 AU) (0.86 [0.34; 1.37], $p = .016$). Players covered less distance from the first to the second bout overall (first: 405 ± 75.8m, second: 358 ± 64.6m; -1.67 [-2.63; -0.67], $p = .008$), while jogging (first: 155 ± 50.7m, second: 132 ± 40.8m; -1.25 [-2.07; -0.39], $p = .049$), and while high-speed running (first: 26.8 ± 20.0m, second: 13.9 ± 14.0m; -1.34 [-2.19; -0.45], $p = .033$). No significant differences ($p > .05$) were apparent in the rest of the variables.

Conclusions: The reduction of the SEI and the physical effort could be due to a coping mechanism to deal with a new training scenario with pitch obstacles. It seems that young female players may adapt immediately to a novel SSG, exploring less and deploying a lower effort from the first to the consecutive bouts.

Rondo a case for over-constraining in football practice – Analyzing the representativeness of rondo

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Background/aim: Rondo can be understood as a sociocultural artifact of practice in football that is attributed to its potential to promote cooperative patterns of play to maintain and dominate space by fluent ball possession (1). While most sports scientists just like coaches underpin the effectivity of rondo to simulate sub-tasks of football, there is a lack of studies investigating to what extent rondos do represent the interpersonal layout of the performance environment in football (2). Consequently, the present study investigates how different rondo tasks in soccer represent the kinematic properties of football.

Methods: 22 male soccer players of a 6th division club in Germany participated in one formal game condition (FG11VS11), one 6 versus 6 on-goal condition (GO6VS6), and three rondo conditions: 6 versus 6 (RO6VS6), 8 versus 4 large (RO8VS4L) and 8 versus 4 small (RO8VS4S). The teams performed 73 trials in a crossover study design. Players' positional data were computed using a local positioning system and processed to calculate measures of inter-team distance, team spread (offensive, defensive), dyadic distance (offensive, defensive), distance to the nearest opponent (offensive, defensive), mean pressure received, mean pressure exerted and mean ball direction.

Results/conclusions: The major findings indicate, that the more task constraints are used in the practice design, the less the interpersonal characteristics resemble the formal football game. On the other hand, the playing direction seems to be a crucial constraint to facilitate representative kinematic properties in training. Further investigation is needed to discuss to what extent the extensive engagement in rondo tasks plays the role of a lock-in operational method and thereby is a case for over-constraining in football training tasks (3).

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Exploring the effects of training repetition on women footballers' motor behaviour: the free play

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Background/aim: Women's football academy players spent the greatest proportion of their training time, almost 40%, performing SSGs (1). Coaches use to implement non-constrained SSGs known as free play at the end of the sessions to enhance players' decision-making and confront them with competitive physical demands. Although being a daily-employed training task from worldwide academy coaches, research examining the effects of repeating the same SSG in women's football is lacking. Thus, this study aimed to assess the effects of repeating the same SSG playing freely on young women footballers' motor behaviour.

Methods: Twelve recreational footballers played three four-minute bouts of a 6-a-side SSG (i.e., Gk + 5 vs 5 + Gk). The SSG was performed on a 33 m length × 25 m width artificial turf pitch. Both teams used a 1-1-3-1 formation, and all the official game rules except for the offside rule were applied. Positional data was gathered using a GPS to measure footballers' motor behaviour, that is, tactical (distance between players, stretch-index, spatial exploration index and their normalized approximate entropy measures, and longitudinal and lateral synchronizations) and physical (total distance and walking, jogging, running, and high-speed running distances) performances.

Results: No significant differences ($p > .05$) between bouts were apparent in any variable, except for the spatial exploration index (first [$6.97 \pm 0.61\text{m}$] vs second [$6.28 \pm 0.71\text{m}$]: Cohen's d with 95% of confidence intervals: -1.91 [-2.96 ; -0.83], $p = .003$; second vs third [$7.44 \pm 0.62\text{m}$]: 2.12 [0.96 ; 3.24], $p < .001$) and the overall distance covered (first [$368 \pm 13.4\text{m}$] vs second [$334 \pm 34.2\text{m}$]: -1.47 [-2.36 ; -0.54], $p = .018$) and while jogging (first [$154 \pm 33.5\text{m}$] vs third [$130 \pm 40.0\text{m}$]: -1.60 [-2.54 ; -0.63], $p = .010$).

Conclusions: The stable response displayed by the women footballers during free play may result from the adaptability developed to a training task performed almost daily from season to season, being harder to influence unwavering motor behaviour. It seems that free play barely modified well-familiarized footballers' performance between bouts, ensuring a stable and similar response during the training.

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Dynamics of submaximal effort of instep and side-foot kicks

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Background/aim: Among numerous types of kicks used in soccer, the instep and the side-foot kicks are the most frequently used techniques. During a soccer match, players are often required to kick the ball with a wide range of velocities. Although there have been a few attempts to illustrate kinematic aspects or muscle recruitment patterns of selected lower limb muscles of soccer kicks in accuracy enhanced submaximal effort conditions, the information of the dynamics of the submaximal kicking motion has been limited. We aimed to illustrate kicking leg dynamics during submaximal effort soccer instep and the side-foot kicks.

Methods: Kicks with three effort levels (50, 75, and 100% effort levels based on maximal effort) of eight male university soccer players were captured (500 Hz) while initial ball velocities were monitored simultaneously.

Results: For both kicking techniques, a systematic regulation in joint kinetics was demonstrated for hip flexion and knee extension moments thereby supporting the interpretation that the final foot velocity is precisely controlled in a context of a planar, sequential segmental system within thigh–shank plane. For the side-foot kick, out of thigh–shank plane motion (hip external rotation moment) was also found to be systematically adjusted. After systematic, precise control of the final foot CG velocity, there are still differences in ball velocity that are not explained by foot velocity alone. In the instep kick, players tended to hit an off-center part of ball using a more medial side of the foot and with a less upright foot posture in submaximal effort kicks, suggesting they tend to add some fine-tuning of the resultant ball velocity by changing the apparent manner of foot-ball impact. In contrast, although foot–ball velocity ratios in the two submaximal levels reduced significantly in the side-foot kick, the players kept a similar ball impact manner.

Conclusions: This finding suggests inapparent fine-tunings of ball impact are possibly made in the side-foot kick by changing ankle joint fixation or stiffness of the foot itself. Additionally, in the side-foot kick, several kinematic changes associated with increasing effort level were observed. From the kinematic procedure of Sprigings et al (1994), the contribution of knee extension angular velocity to the final foot velocity was found to be increased significantly in the maximal effort while that of hip external rotation reduced significantly, coinciding with a more straightforward approach-run.

How do video instruction and feedback change sidestep cutting execution in female soccer players?

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Background/aim: Despite intensive efforts put forward on prevention programs, the rate of injuries remains unchanged in the Netherlands. Current prevention programs mainly address what should be trained. Less focus is placed on how athletes should train these skills. Previous research showed beneficial effects of implicit learning on improving motor skill performance and learning. No research so far has investigated the effects of video instruction and feedback (i.e. implicit learning) on sidestep cutting in soccer players, a task that is highly related with ACL injury risk. Therefore, the aim of this study was to investigate the effects of observational learning on sidestep cutting movement execution.

Methods: Thirty talented healthy soccer girls (age 14.7 ± 1.0 y, height 167.8 ± 5.3 cm, mass 55.8 ± 7.4 kg) participated in this study. The girls were randomly assigned to the control (CTRL, n=10), video instruction (VIDEO, n=10) or video instruction and feedback (VIDEO+FB, n=10) group. All subjects practiced three sport-specific tasks (each 10 trials) for four weeks in the laboratory. The video groups received video instruction before the first and sixth trial. When the VIDEO+FB players asked for feedback, they received videos of their last performed trial. Furthermore, baseline, immediate post and one-week retention tests were performed. Primary outcome variables were knee kine(ma)tics and vertical ground reaction force of unanticipated sidestep cutting. After non-linear registration, the data were analyzed with SPM1d ANOVAs (1).

Results: The two-way repeated measures ANOVA did not reveal any significant main effect of time or group, neither interaction effects. Separate one way ANOVAs showed smaller internal rotation angles in (0-100% stance phase (SP), $p < .001$) abduction moments (0-39% SP, $p < .001$) and internal rotation moments (0-12% SP, $p = .014$) in VIDEO+FB compared to CTRL during immediate post. Regarding retention, the adduction moment of VIDEO+FB was greater compared to CTRL in retention (1-18% SP, $p = .003$).

Conclusions: Although preliminary, the results may indicate beneficial effects of video instruction combined with video feedback on sidestep cutting movement execution during initial contact. Even though the beneficial effects of video instruction and feedback disappeared during retention, the VIDEO+FB group showed smaller knee abduction moments after initial contact till the end of absorption phase. More research is necessary to examine the full lower-body changes after receiving video instruction and feedback.

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Injury Characteristics of Teams at the 2022 Women's U17 and U20 World Cups.

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Background/aim: Injuries are common in football, with a higher frequency in matches versus training. Injury rates in the men's World Cup have been reported, but fewer studies have reported on injuries during women's or youth football tournaments (1,2). This information is important to understand factors contributing to injuries. The purpose of this abstract was to report injury incidence for one team each at the 2022 women's U17 and U20 World Cups.

Methods: 21 athletes were on each World Cup roster. The U17 and U20 athletes participated in pre-World Cup training (precamp) for 15 days and 12 days respectively. The U17 and U20 athletes played in 4 and 3 World Cup matches respectively. For the U17 team, one time-loss injury was evaluated following the final match. Two time-loss injuries were recorded during training before the World Cup; all were non-contact injuries.

Results: The overall and non-contact injury rate per match for the U20 team was 0.33 and the non-contact injury rate per 1000 match hours was 10.6. Including injuries from precamp, the injury rate per athletic exposure was 0.31. Injuries included: two hamstring strains, one gastroc strain, one concussion, and one [contact] ACL rupture.

Conclusions: Elite women's tournaments have reported 62.5 injuries per 1000 player hours. Although the athletes did not play the maximum 6 possible matches in either youth World Cup, their injury rates were lower than those reported in elite tournaments. This retrospective analysis of injuries is among the first to report injury rates during women's youth soccer tournaments and will allow future investigations to identify strategies to lower injury risk.

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Effects of digital filtering on peak acceleration and calculated efforts during football sports

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Background/aim: In football acceleration data is mainly used to calculate acceleration and deceleration (negative acceleration) efforts as they may have a critical impact on players' performance. Acceleration data is obtained from athlete tracking systems, which fundamentally adds noise to the signal. Noise is any unwanted portion of a signal that typically has a frequency different from those in the true signal. Whilst noise may not be obvious in the signal, it can cause large inaccuracies on differentiating acceleration and some form of data filtering must be adopted to decrease the noise. Filtering smooths the acceleration data but could also lower the peak acceleration values. As acceleration and deceleration efforts are calculated based on set thresholds, filtering could change the calculated efforts and impact related decisions made by practitioners. Investigating the effect of filtering on peak acceleration would help in determining which filter to apply to get the most valid acceleration data and calculated efforts. The aim of this study was to investigate the effect of filtering on peak acceleration and calculated efforts derived from a Global Positioning System (GPS) device during accelerating and decelerating movements commonly performed in football.

Methods: Nine team sport athletes performed four different accelerating/decelerating movements at different intensities for a total of 35 trails each. The movements were collected concurrently at 10Hz using a GPS (Catapult Sports) and 100Hz using a motion analysis system (VICON). Acceleration data was filtered using a fourth-order Butterworth filter. The GPS cut-off frequencies ranged from raw to 5Hz, whilst the VICON cut-off was based on residual analysis. The peak acceleration was calculated for each movement and participant for each cut-off frequency. Linear mixed models were performed to determine the difference between the filtered GPS and VICON peak acceleration.

Results: The fourth-order Butterworth filter with a cut-off frequency $\geq 1.5\text{Hz}$ resulted in no difference ($p > .05$) in GPS peak acceleration values compared to the VICON. Lower cut-off frequencies caused a greater smoothing effect on the peaks, which resulted in decreased peak acceleration values.

Conclusions: When using peak acceleration derived from GPS during accelerating/decelerating movements commonly performed in football, data can be filtered with a fourth order Butterworth filter with a cut-off frequency $\geq 1.5\text{Hz}$. Applying the suggested filter resulted in no reduction of the peak acceleration values, which will result in unchanged calculated efforts or metrics where peak acceleration is of interest.

What do lab measurements tell? Defining high-risk ACL injury - motion patterns of female footballers.

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Background/aim: Anterior cruciate ligament (ACL) injury risk has traditionally been established in relatively standardized laboratory environments. Measuring movement in an ecological valid environment may potentially reshape the current definition of high-risk biomechanics. The aim of the present study was to investigate football-specific biomechanical field data in female footballers starting from the current definitions of ACL injury risk based on laboratory data.

Methods: Twenty-four healthy female highly-talented female football players (14.9 ± 0.9 y) performed cutting manoeuvres in three conditions: (1) laboratory setting during unanticipated side step cutting at 40-50°; on the football pitch (2) football-specific exercises and (3) football games at 30-60°. In condition 1, knee kinetics (external joint moments) was collected (Vicon Nexus). The discrete wavelet transform with the Haar wavelet was used to decompose signals. Hierarchical agglomerative clustering based on Ward's linkage method was used to group together the trials with the most similar features. The clusters were then used to investigate the kinematic data collected on the field (condition 2 and 3) through wearable sensors (Xsens Link).

Results: Three clusters emerged: Cluster 1 presented the lowest knee moments in all three planes ("Low Risk"); Cluster 2 presented high knee extension but low knee abduction and rotation moments ("Mid Risk"); Cluster 3 presented the highest knee abduction, extension, and external rotation moments ("High Risk"). In exercise field data, greater knee abduction angles were found at initial contact ($p=0.007$) in Cluster 2 and 3 compared to Cluster 1. Greatest knee external rotation angles were also found in Cluster 3 ($p<0.001$). Cluster 2 presented the lowest knee flexion angles ($p<0.001$). For the field game data, greatest knee external rotation ($p=0.003$) and lowest knee flexion angles ($p<0.05$) were found in Cluster 3.

Conclusions: Clinically relevant differences towards ACL injury identified when cutting in the laboratory reflected at-risk movement patterns only partly when cutting on the field. The high knee external rotation moments found in the 'high-risk' players in the lab were reflected in the field exercise and game with high knee external rotation angles. Also, these players showed the lowest knee flexion angles in the field game. The 'low-risk' players in the lab showed the lowest knee abduction angles in the field exercise, while these differences disappeared during the field game. A field-based paradigm should be included to identify at-risk players.

Curved sprinting in soccer: the influence of radius

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Background/aim: The aims of this study were i) to compare the sprint times between linear-sprint (LS) and curved-sprints (CS) tests of different radii, and ii) to examine the relationships between sprint times in these tests in soccer players.

Methods: Nineteen elite youth male soccer players (age, 18.6 ± 0.6 years) completed a LS test and three CS tests with different radii (11.15-m radius = CSwide, 9.15-m radius = CSmedium, and 7.15-m radius = CSnarrow).

Results: Significantly lower sprint times were evident for LS compared to all three CS tests ($p < 0.01$, MD = 0.08-0.16 s, ES = 0.83-1.49), for CSwide compared to CSnarrow ($p < 0.01$, MD = 0.04 s, ES = 0.47), and for CSmedium compared to CSnarrow ($p < 0.01$, MD = 0.07 s, ES = 0.82). Very large correlations ($p < 0.01$, $r = 0.75-0.80$) were found between sprint times in LS and the three CS tests. Very large to nearly perfect correlations ($p < 0.01$, $r = 0.79-0.91$) were found within the three CS tests.

Conclusions: Practitioners should be aware that sprint times are lower in LS compared to CS of different radii and that CS times are higher at narrower angles compared to wider angles. Given the high correlations within the three CS tests, the application of only one CS (e.g., CSmedium) during a test battery may be sufficient if using different CS is not possible (Filter et al., 2020). Results of the correlation analysis also suggest that LS contributes to CS performance, however, to slightly different extents depending on the radius of the CS. Consequently, both LS and CS drills might be incorporated into sprint training practices of elite youth soccer players.

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Air pollution negatively affects elite adolescent soccer players' performance and well-being

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Background/aim: Exercising outdoors may inadvertently lead to individuals inhaling levels of air pollution that may be detrimental to their health and activity-related performance. Endurance athletes are a particularly susceptible subgroup due to their high ventilation rates sustained over prolonged periods of time coupled with high training loads that often occur outdoors. In this study, we estimate the athletic performance effects related to air pollution in an elite adolescent soccer team.

Methods: External, internal, and subjective loads and wellness questionnaires were recorded for the 26 matches and 197 training sessions carried out during the 2018-19 season for a U19 team competing in Germany. Each session was combined with hourly information on the concentration of three primary pollutants in spatial proximity to each playing field for the duration of training or playing.

Results: Increases in PM₁₀ and O₃ had significant ($p < .001$) associations with decreasing total distance (m) ran per session. Furthermore, increases in O₃ and NO₂ concentrations were related to an increase in average heart rate ($p < .05$). Furthermore, increases in PM₁₀ concentration was associated with increased rating of perceived exertion ($p < .001$). Last, the total inhaled dose of air pollution over one session was linked to significant decreases in athletes' wellness scores on the following morning.

Discussion: We find supporting evidence of the negative effects of air pollution in elite adolescent soccer players in both matches and training. The negative impacts observed on several aspects of performance are present within an elite team that regularly trained in pollution levels well within the normal ranges of what the World Health Organisation (WHO) reports to be suitable air quality. Therefore, mitigation strategies are recommended to reduce athlete exposure to air pollution even when exercising in moderate air quality.

Sprint performance relative to chronological and skeletal age in high-level youth soccer players

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Background: Early maturing players show, on average, better sprint performance than their on-time and late maturing counterparts within the same chronological age group. Thus, biological maturity needs to be considered to provide more nuanced evaluations within the talent identification and selection process.

Aim: The primary aim of the current study was to compute performance curves for the 5m and 30m sprint relative to chronological and skeletal age in elite youth soccer players. A secondary aim was to evaluate the impact of maturity status on sprint performance by comparing the individual's sprint performance scores relative to the chronological and biological performance curves

Methods: The study sample included sprint performance assessments data available for a sample of $n=1767$ male academy soccer players over a six year period. Skeletal age data were available for a sub-sample of $n=522$ over a three year period. Sprint performance was measured using a 30m linear sprint test and biological maturity was determined by measuring skeletal age. Chronological and skeletal age percentile curves for 5m and 30m were fitted. Subsequently, individual z-scores relative to chronological and skeletal age percentile curves were computed and compared for 5m and 30m for the entire sample and each maturity group (i.e., late, on-time, early, very early) by calculating standardized mean differences (SMD). Additionally, separate linear regression models for chronological and skeletal age reference curves were computed between maturity status and z-scores.

Results: For the entire sample, differences in individual chronological and skeletal age z-scores for 5m (SMD: -0.03 (95%CI -0.15 to 0.09)) and 30m (SMD: 0.01 (95%CI -0.11 to 0.03)) were trivial. For very early (SMD: -1.00 to -0.69) and late maturing players (SMD: 0.67 to 1.23) differences were moderate to large for both 5m and 30m, while for early (SMD: -0.41 to -0.27) and on-time players (SMD: 0.18 to 0.36) there were small differences. Slopes between the chronological and biological regression models were significant for both 5m and 30m ($p < 5e-10$).

Conclusions: Our results suggest that sprint performance varied substantially for very early and late maturing players relative to chronological and skeletal age reference curves whereby very early maturing players have poorer and late maturing players have better performances when sprint performance was evaluated relative to skeletal age.

In-Season Internal Load and Wellness Variations in Professional Women Soccer Players

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Background/aim: The internal intensity monitoring in soccer has been used more in recent years in men's football; however, in women's soccer, the existing literature is still scarce. The aims of this study were threefold: (a) to describe the weekly variations of training monotony, training strain and acute:chronic workload ratio through session Rated Perceived Exertion (s-RPE); (b) to describe weekly variations of Hooper Index [stress, fatigue, Delayed Onset Muscle Soreness (DOMS) and sleep]; and (c) to compare those variations between playing positions and player status.

Methods: Nineteen women players (24.1 ± 2.7 years) from a Portuguese BPI League professional team participated in this study. Based on player status, they were divided into two groups: starters (n = 11) and non-starters (n = 8). Additionally, the playing positions were divided into five defenders, five central midfielders, four wide midfielders and five strikers. All variables were collected in a 10-week in-season period with three training sessions and one match per week during the 2019/20 season.

Results: Considering the overall team, the results showed that there were some associations between Hooper Index categories and s-RPE such as stress and fatigue (0.693, p < 0.01), stress and DOMS (0.593, p < 0.01), stress and s-RPE (-0.516, p < 0.05), fatigue and DOMS (0.688, p < 0.01). There were no differences between all parameters when comparing playing positions or player status.

Conclusions: In conclusion, the study revealed that higher levels of fatigue and DOMS occur concurrently with better nights of sleep. Moreover, any in-season variations concerning internal load and perceived wellness seems independent of position or status in outfield players. The data also showed that the higher the players' reported stress, the lower the observed s-RPE, thus possibly indicating a mutual interference of experienced stress levels on the assimilation of training intensity by elite women soccer players.

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Sleep patterns of elite female football match officials during WEuro 2022.

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Background/aim: Sleep has numerous physiological and cognitive restorative functions important to elite athletes and, therefore, to elite match officials. Athletes reportedly have poorer sleep compared to the general population. However, there is no research into the sleep habits of elite football match officials, who experience similar demands. Therefore, the aim of this study was to examine the impact of proximity to match day (MD), kick-off (KO) time and role on MD on sleep patterns of elite female match officials during the 2022 European Women's Football Championship (WEURO2022)..

Methods: Sleep was measured over 18 ± 5 days in nine elite female football match officials (age: 39 ± 4 y) during WEURO2022. Night-time sleep variables were measured using wrist-worn actigraphy (Biostrap EVO). Data was analysed by proximity to MD: Training Day (TD), MD-1, MD and MD+1; KO time: 17:00PM or 20:00PM; and, Role on MD: Referee or Fourth Official. Data are shown as mean \pm SD (range), with statistical significance set at $p < 0.05$.

Results: Sleep duration was $7:20 \pm 1:20$ (6:20 – 8:04), with no difference between type of day ($p > 0.05$). Time in bed was lower on MD ($7:22 \pm 1:29$) compared to MD-1 ($8:25 \pm 1:19$) and TD ($8:15 \pm 1:07$, $p < 0.05$). Sleep onset time was later on MD ($00:54 \pm 1:22$) compared to MD-1 ($23:39 \pm 1:07$), MD+1 ($23:58 \pm 0:52$) and TD ($23:27 \pm 0:52$, $p < 0.01$) and sleep wake time was later on MD ($8:06 \pm 0:58$) compared to TD ($7:42 \pm 0:48$, $p < 0.05$). An 20:00PM KO resulted in later sleep onset time ($01:29 \pm 01:04$) compared to 17:00PM ($00:00 \pm 1:21$, $p < 0.01$), with no difference in sleep wake time ($p > 0.05$). Accordingly, sleep duration was shorter after 20:00PM KO ($6:00 \pm 1:05$) compared to 17:00PM ($8:06 \pm 1:38$, $p < 0.01$). No differences were observed between Referee and Fourth Official performance ($p > 0.05$).

Conclusions: Elite female football match officials, on average, achieved the recommended sleep duration and quality during WEURO2022, however there was large interindividual variation. Sleep duration was < 7 h on MD and after 20:00PM KO, likely due to later sleep initiation and non-compensatory wake time. Individualized sleep hygiene strategies considering match scheduling are recommended.

Co-Creation of a football analysis system integrating spatial-temporal and network analysis metrics

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Background/Aim: An array of innovative metrics have been applied in recent years to investigate football using both tempo-spatial and network analyses. These complex approaches have gained traction within some professional teams, however, metrics employed are rarely created on the basis of, or clearly link to, domain expertise in football (1). Consequently, coaches may be hesitant to feature collective behaviour metrics as a method of performance analysis. Therefore, the aim of this study was to implement and evaluate a method of co-creation between coaches and performance analysts to obtain more relevant collective behaviour metrics.

Methods: The co-creation approach was iterative and comprised interviews with coaches that centred around selected metrics and adapted these based on discussions and feedback. Semi-structured interviews were conducted with three international-level coaches with a focus on identifying philosophies and principles of play. Interviews were recorded and transcribed verbatim. A reflexive thematic analysis (2) was conducted to analyse the data. Subthemes were identified from quotes and were connected into themes to create a branched matrix. This process formed the basis for identifying calculatable metrics that aligned with the themes and measured concepts that coaches highlighted as relevant. A second interview was conducted that comprised a presentation of adapted metrics and feedback from coaches focusing on their value and further adjustments.

Results: The themes identified aligned with principles of play in football reinforcing their validity. Across the ten principles identified, nine metrics were presented to the coaches. These were categorised as resonant (metrics that accurately identified a principle of play), relevant (metrics that largely identified a principle of play, but required further refinement), or hesitant (metrics that were inaccurate in representing their conceptual understanding of principles or lacked practical value). From coach responses, the resonant metrics that related closely to coaching concepts and philosophies along with evoking a positive reaction included: network intensity (mobility), distance between defenders (discipline), triangles (support), team length (depth).

Conclusions: An approach to co-creation with elite football coaches and analysts can lead to tailored and more informative collective behaviour metrics.

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Developing players' collective tactical knowledge and understanding using video analysis.

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Background: In recent years, video analysis has provided opportunities for coaches to create innovative systems of play alongside developing football players strategic and tactical understanding during matches (1,2). Despite its potential, there has been limited research into the pedagogy of using video analysis to support the development of football team performance (3). Studies have highlighted that coaching and player learning is not a linear and straightforward process (4). This challenges the dominant view that coaches simply sharing video analysis of team performance leads unequivocally to developing a team's collective intelligence and tactical flexibility during games (5).

Aim: The aim of this study was to develop players' collective tactical knowledge and understanding using video analysis. The study took place at a semi-professional football club over a five-month period, where data was collected using a combination of focus groups and semi-structured interviews. Applying action research design, Galperin's (6) teaching and learning framework was used to support the players collaborative analysis and understanding of game situations during video analysis sessions.

Results/conclusions: The findings offer evidence for developing team tactical understanding through collaborative discussions. Specifically, players emphasised how the approach supported tactical understanding in off the ball attacking situations. The importance of creating a supportive and enabling environment was also highlighted, with players valuing the opportunity to critically discuss decisions with each other and the coaches. During these interactions the benefit of using technological tools to support collaborative learning was also emphasised.

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The impact of shot variables and shot location on shot outcome in elite Gaelic football

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Background/aim: The aims of the current study were to establish what factors impact the success of a shot and to find where most successful scores are taken from. Gaelic football is one of Ireland's national sports and is governed by the Gaelic Athletic Association (GAA). At the elite inter-county level teams participate in two major competitions; the National Football League (NFL) and the All-Ireland football championship (Mangan & Collins, 2016; Timmons et al., 2022). The National Football League commences in early February and concludes with finals across all four divisions in April. The All-Ireland football championship begins in May and the final is played in September. In the last number of years, there have been specific rule changes within Gaelic football.

Methods: Data were collected over a two year period (2019-2020), which included games from both the league and championship. A total of 1,500 shots were coded over 28 competitive elite Gaelic football matches. Operational definitions for shot actions and outcomes were based upon those previously used for Gaelic football (McDermott et al., 2021, Mangan et al., 2017b). The shot location co-ordinates were based on the measurements of a GAA pitch, which is 145m long and 88m wide (Mangan et al., 2019). For the analysis of shot location, one half of a pitch was divided into 40 zones, dissecting the pitch vertically and horizontally. It was dissected with 5 zones from touchline to touchline, and 8 zones progressing approximately every 7 meters (Gaelic Stats., 2016).

A backwards conditional logistic regression was run to investigate what factors impact the success of a shot. The variables used in the regression were categorical and included number of plays, origin type, origin zone, defensive pressure, shot method, and shot type. Statistical significance was accepted when $\alpha = 0.05$.

Results: The key findings found in the current study were both shot method ($p = 0.001$) and defensive pressure ($P \leq 0.001$) were found to be predictors of shot outcome. The odds of scoring significantly decrease from no pressure to any pressure, but do not decline further in pressure 2 and 3 compared to pressure 1. The hand pass significantly increases odds of scoring compared to the right foot.

Conclusions: The results give coaches an insight into what areas of the field produce the most successful shots and as a result can create game plans and an attacking style to utilise their attacks.

Coaches' perspective on a mastery motivational climate in competitive elite youth soccer

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Background/aim: A mastery climate created by the coach has received extensive support as beneficial for youth athletes, in terms of motivation, development and positive experiences. This has led to extensive recommendations for creating this type of climate in the developmental context of youth soccer. However, to date, there is a lack of research investigating the provision of a mastery climate from the coach's perspective.

Methods: The present study adopted a qualitative, inductive approach, to study the experiences of coaches responsible for developing youth footballers in elite clubs in Norway.

Results: Preliminary results show that the coaches to a large degree attempt to create a mastery climate, but that this is in certain ways challenging in regard to the elite context. Furthermore, many coaches present a fairly limited understanding of what a mastery climate is, often reducing it to a strategy for maintaining motivation in lesser skilled athletes, rather than a pedagogical perspective on how best to learn and develop.

Conclusions: In conclusion the study shows that although a mastery climate seems to be a focus for the coaches, coach education, and research, should aim to create a deeper understanding for what this is. Furthermore, we need to know more about how this should be implemented in an elite youth context.

Practitioners' perspectives on decision-making: The application of technology in football academies

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Background/aim: Decision-making (DM) training is a key component of skill acquisition in football, but despite the use of technologies that support this process evidence of best practice in real-world settings is limited. It is proposed that by understanding the perceptions of key stakeholders, interventions may be more optimally designed. This exploratory investigation aimed to identify current trends in this domain and examine the potential of innovative technologies such as virtual reality (VR).

Methods: A purposive sampling method invited 424 football academy practitioners to take part in an online survey. Of the 62 respondents 51 were considered suitable, including technical directors (n=8), academy leads (n=10), and development phase coaches (n=33). From these, 12 agreed to be interviewed. Through a mixed-methods design, survey data were analysed and cross-tabulated to evaluate relationships between multiple variables. Descriptive statistics were calculated to identify proportional trends and rankings. Interviews were transcribed verbatim and analysed using a six-step inductive thematic analysis process.

Results: Results confirmed that DM forms a significant part of youth development programs (98% strongly agreed or agreed) and interventions are designed based on theoretical models, formal education, and experiential knowledge. However, 64.7% of respondents rely solely on subjective observations to assess their efficacy, and the design of technological interventions are diverse. Although the use of video is ubiquitous, with 100% confirming that it is used in some form, methodologies vary in volume, timing, and delivery. 11.8% of respondents reported using additional technologies and whilst acknowledging the limitations of video, particularly in terms of viewing perspective, solutions aren't readily accessible. 9.8% use or have used VR and an additional 45.1% would consider it, but of these 13.7% stated they needed to do more research. Interviews revealed that opportunities to increase 'reps' or contact time is desirable and VR is regarded as a potential solution. However, several barriers exist (e.g., financial, evidence of efficacy, time constraints).

Conclusions: The significance of DM training is clear, and elements of its design are grounded in theory; however, the use of technology is less so. It is evident that, amongst other barriers, greater access to research that provides practitioners with practical guidance is required. It is suggested that key theoretical frameworks should also be consulted when adopting technologies that support the learning process, namely, Representative Learning Design and the Modified Perceptual Training Framework.

How long does it take to physically and psychologically recover after an injury in soccer?

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Background/aim: When soccer players sustain an injury, they generally have to recover, both physically and psychologically. The process of recovery after an adversity such as an injury can be defined as resilience (1). Despite its importance, individual resilience after a time-loss injury has never been quantified before. Therefore, this study aimed to quantify resilience in terms of both physical and psychological variables after time-loss injury in individual soccer players.

Methods: We included 21 soccer players who sustained time-loss injuries during the 2021/2022 season. For each individual, we monitored the training load, perceived recovery, motivation, self-efficacy, mood, and enjoyment for every training and match day. We quantified resilience using these variables following injury by fitting multiple growth models. Next, we identified the best one using the Bayesian information criterion (2). Then we used the predicted values from the selected model to identify the time point at which the physical and psychological variables should return to baseline levels.

Results: Eight of the 21 soccer players experienced a significant drop in physical or psychological variables following an injury. For three soccer players, the psychological variables self-efficacy and mood did not return to baseline levels even though these players resumed training. Accordingly, the average duration between the day of the injury and the predicted day of return to baseline was lower for the physical variables (training load = 20.5 days and recovery = 73.5 days) than for the psychological variables (motivation = 358 days, self-efficacy = 114.8 days, mood = 104.4, and enjoyment = 70.25 days). However, these trajectories were highly individual-specific.

Conclusions: Injuries often lead to a significant decrease in the physical and psychological variables of soccer players. Although the recovery trajectory after an injury is highly individual-specific, the recovery of psychological variables often requires more time than the recovery of physical variables. Practitioners can use these findings during the multidisciplinary and personalized rehabilitation of injured players.

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Football-specific cutting biomechanics through wearable sensors: are on-field measures reliable?

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Background/aim: Movement biomechanics is becoming crucial in injury prevention programs for anterior cruciate ligament (ACL) injury in football. Data collected in ecological environments has been advocated to improve injury risk patterns detection (1). However, no studies reported the reliability of biomechanical measurements in football-specific tasks. The aim of the present study was to present normative and reliability data of two different change of direction tasks collected on the field in young footballers.

Methods: 48 competitive academy footballers (age 15.9 \pm 2.4, 28 males) were enrolled. The players performed a planned 90° changes of direction within the Agility T-test (pCOD) and unplanned football changes of direction (uCOD). The uCOD consisted of a cut with an opponent holding the ball, to simulate a football-specific pressing pattern. Lower limbs and trunk kinematics were collected through 8 wearable inertial sensors (100Hz, MTw Awinda, Xsens). Data were normalized to include the deceleration and acceleration phase of the cut. Normative kinematics was presented for male and female separately. Intraclass correlation coefficient (ICC) and coefficient of multiple correlation (CMC) were used to compare peak and waveform kinematics in test-retest and side-to-side differences.

Results: Male and female differed in both pCOD and uCOD: females showed greater external knee rotation, hip external rotation, ankle eversion and lower limb and trunk flexion in pCOD (p 0.041 - $<$ 0.001). Greater hip and knee external rotation, hip extension, and trunk contralateral rotation were noted in uCOD (p 0.047 - $<$ 0.001). Test-retest ICC and CMC were poor-to-moderate at knee (0.25 - 0.49), moderate at ankle, pelvis, and trunk (0.41 - 0.69), moderate-to-excellent at hip (0.60 - 0.82). Side-to-side ICC and CMC were poor-to-moderate at knee, ankle, pelvis, trunk (0.19 - 0.65), and poor-to-excellent at hip (0.21 - 0.76).

Conclusions: Female athletes exhibited biomechanical risk factors in line with the ACL injury mechanisms from literature (2). Greater frontal and transverse plane differences emerged in football-specific task. Test-retest reliability was acceptable for most of the joints, but caution should be used when interpreting small differences. Normative and reliability values might help future researchers to shape and objectify injury prevention programs for ACL injury in football academies.

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Exploring the true burden of a time-loss injury: full vs partial time-loss in academy football

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Background/aim: In football, the number of days without full participation in training/competition is often used as a surrogate measure for time-loss (TL) caused by injury. However, injury management and return-to-play processes frequently include modified participation, which to date has only been recorded through self-reports such as the Oslo Sports Trauma Research Centre Questionnaire on Health Problems. This study aims to demonstrate the differentiation between 'full' (no participation in team football) and 'partial' (reduced/modified participation in team football) injury burden.

Methods: Injury and exposure data were collected from 118 male elite footballers (U13–U18) over 3 consecutive seasons according to the Football Consensus Statement. TL injury burden was calculated separately as the number of total, 'full' and 'partial' days lost per 1000 hours of exposure.

Results/Conclusions: Injury burden (137.2 days lost/1000h, 95% CI 133.4 – 141.0) was comprised of 23% (31.9 days lost/1000h, 95% CI 30.1 – 33.8) partial TL and 77% (105.3 days lost/1000h, 95% CI 102.0 - 108.6) full TL burden. Injuries of moderate severity (8-28 days lost) showed 40% of partial TL. TL injury incidence rate (6.6 injuries/1000h, 95% CI 5.8 – 7.5), the number of severe injuries (16%) and the distribution of TL and non-TL injuries (56% and 44%) were comparable to other reports in elite youth footballers. Almost one quarter of the TL injury burden showed that injured players were still included in some team football activities, which, for injuries with TL >7 days, was likely related to the return to play process. Therefore, reporting on partial TL provides insight into the true impact of injury on participation levels.

Relationship of physical characteristics and injury in elite youth female soccer players

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Background/aim: Female soccer talent development programmes have been associated with an increased risk of injury compared to recreational soccer participation. Limited research is available examining the influence of anthropometrics and physical quality parameters on injury in youth female soccer and to the authors knowledge, the influence of growth and biological maturation have not been considered. Therefore, this study aimed to investigate the influence of cross sectional and longitudinal changes of player anthropometrics, biological maturation, and strength characteristics on the injury status of elite youth female soccer players.

Methods: Two-hundred and twenty-six elite youth female soccer players, training and playing in two-year age bandings (Under 12 (U12), n=86, U14, n=96; U16, n=44), representing seven girls' soccer academies during the 2021-2022 competitive soccer season were investigated. Player anthropometrics (height, body-mass, body-mass index (BMI)) and strength characteristics (absolute and relative isometric mid-thigh pull) were assessed during pre-, mid- and end of season time periods; time-loss injuries and player exposure hours were recorded during the season. Player biological maturation was assessed using estimated years from peak height velocity (YPHV). Longitudinal change in anthropometric and strength variables were calculated by dividing the change in these variables between testing points by time-duration in months between testing dates. Binomial regression models were fit to assess differences in cross-sectional and longitudinal changes in anthropometrics, biological maturation, and strength variables between injured and uninjured players.

Results: Forty players sustained 61 injuries equating to an injury incidence of 2.4 (95% CIs: 1.9-3.1) injuries per 1000 hours. Univariate analysis identified that age, height, body-mass, BMI and YPHV were significantly associated with injury in the U12 age group. Multivariate analysis showed that only body-mass remained significantly, positively associated with injury (OR, 7.970, 95% CIs: 1.906-33.322, $p=0.004$). No significant associations were found at the U14 and U16 age group.

Conclusion: Based on the findings of this study, greater body-mass is associated with an increased injury risk at the U12 age groups. Whilst this factor is likely driven by maturation at this age and cannot be modified, practitioners can identify individuals potentially more susceptible to injury and manage accordingly through appropriate strategies. No significant associations were found at the U14 and U16 age group suggesting factors outside of player growth, biological maturation and strength may influence injury.

Analysis of injury with size and playing position in male adolescent community rugby union

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Background/aim: There is perceived injury risk due to player size mismatch in adolescent rugby union. However, self-reported injury data suggests size is not associated with injury (1). This investigation reports injury in a prospective cohort of male adolescent community rugby union players with analysis of player size, maturation and somatotype.

Methods: Injury surveillance took place over two seasons in male adolescent (U13, U14, U15, U17) community rugby (n=316, age 15.04 ±0.02) recording time-loss injuries and severity calculated per 1000 match exposure hours following the Rugby Union Injury Consensus Statement (2). Height (cm) and mass (kg) were measured using a portable stadiometer and scale. Age at peak height velocity was estimated to calculate maturity offset. Body composition was measured in 93 players to calculate somatotype.

Results: 63 time-loss injuries were recorded from 2004 exposure hours for an incidence of 31.4/1000hours (95%CI 24-40) and burden of 426days/1000hours (95%CI 398-455). Height, mass, maturity offset, somatotype and age-grade weren't associated with incidence or burden. Backs and forwards had similar incidence and burden. However, burden in loose forwards (112days/1000hours, 95%CI 98-127) was significantly higher than front row (30days/1000hours, 95%CI 23-39), second row (61days/1000hours, 95%CI 51-73), centres (21days/1000hours, 95%CI 16-29) and halves (48days/1000hours, 95%CI 39-59). Burden in outside backs (ie. wings and fullbacks) was significantly higher (153days/1000hours, 95%CI 137-171) than front row and halves (p<0.05). Collectively, 62% of total days lost was observed in loose forwards and outside backs, including 5 concussions (100days) and 2 dislocations (145days) which accounted for 29% of total days lost.

Conclusions: Injury burden within male adolescent community rugby union appears to be associated with playing position rather than simply size (stature or mass). Loose forwards and outside backs may be exposed to more frequent contact situations (tackle events and rucks). However, the burden observed in this investigation may have been skewed by severe injury.

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Effects of a simulated short-haul flight on sleep and sport-specific performance in football players

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Background/aim: Elite European football clubs are obliged to participate in several official tournaments (i.e., UEFA Champions League, UEFA Europa League) requiring frequent international short-haul air-travels (3-4 hours) throughout a season. Alongside the high physiological demands of team sports, football players experience additional stress caused by frequent air travel (1). The aim of this study was to investigate the impact of short-haul air travel on sleep and crucial aspects of football-specific performance.

Methods: Nineteen football players completed a simulated short-haul air travel of four hours duration (SHAT) and a control condition during which no simulated air travel was completed but players still reported in a sitting position to the laboratory. Sleep patterns were collected throughout a week before (Baseline) the experimental sessions and during three consecutive days of the SHAT (Day -1 of flight, Day of, Day +1 of flight) using wrist actigraphy. Football-specific performance (Hoff test) was measured at +24-hrs and the Loughborough Soccer Passing Test (LSPT) was completed at both +3-hrs and +24-hrs following the simulated air travel.

Results: Total sleep time was shorter the night before the SHAT compared to both baseline and control ($P < 0.001$). Compared to D-1, total sleep time was reduced by 114 minutes the night before (DT) the simulated flight ($P < 0.001$, $d = 1.22$). There were no significant differences in sleep efficiency, the number of awakening events, and the duration of awakenings between conditions ($P > 0.05$). Compared with the baseline and control, the total distance covered in the Hoff test was significantly shorter (-5%) following the SHAT. Moreover, performance in LSPT was significantly decreased both at +3-hrs and +24-hrs following the SHAT compared with the baseline and control trials ($P < 0.05$).

Conclusions: The principal findings of the study highlight that frequent short-haul air travel may have a detrimental impact on football-specific performance. Sleep loss and disturbance of individual routines are considered important factors that help to explain this decrement.

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Running performance changes during a football match in the context of ball in play time.

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Background/aim: In football, the ball is not actively in play more than 40% of the time, with ball in play time (BIP) on average 54.58 minutes (1). However, it is unknown how BIP is distributed over the different match periods, and how it affects player running performance (RP). Therefore, the aim was to investigate the differences in player RP between five-minute periods of matches, considering BIP.

Methods: The sample consisted of 39 3rd division (reserve team of 1st division elite club) Czech football players (20.40 ± 4.26 years). Official league matches ($n = 29$) were divided into 18 five-minute periods with stoppage time excluded from the analysis. RP variables, measured using 10Hz GPS, were as follows: Total distance (TD), high-speed running distance (HSR > 19.8 km/h), sprint running distance (SR > 25.2 km/h), and acceleration and deceleration distance (ACDC > 3 m/s/s). BIP was evaluated via video analysis. To control for the covariate variable BIP, RP variables were normalized to BIP. Repeated measures ANOVA was used to compare RP parameters between the match periods.

Results: Significant linear decreasing trends of RP during the match were observed (TDabs: $F = 152.32$, HSRabs: $F = 38.73$, SRabs: $F = 9.32$, ACDCabs: $F = 52.35$; $p < 0.05$). After considering the BIP parameter for the normalized values, these changed to level non-significant trends of RP during the match (TDrel: $F = 0.35$, HSRrel: $F = 2.25$, SRrel: $F = 0.13$, ACDCrel: $F = 3.81$; $p > 0.05$). The match average BIP was 50.74 ± 4.24 minutes (range: 42.72-58.05 minutes), decreasing significantly over the match ($F = 21.72$; $p < 0.05$).

Conclusions: It seems that physical fatigue is not primarily responsible for the player RP decline during a match. The major parameter that influences changes in player RP is BIP. Due to the lower BIP in later stages of the match, players had more time to rest and are able to perform at a similar or even higher intensity than at the beginning of the match. Researchers and practitioners should consider running performance variance and BIP to better understand the context of the match, when analysing RP and preparing training programmes for players.

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Reliability of velocity-based metrics in resistance training using free weights vs. Smith Machine.

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Background/aim: Velocity-based resistance training (RT) metrics may be used to detect changes in neuromuscular fatigue (NMF). Whether these metrics are more reliable when RT is performed using a Smith Machine (SM) vs. free weights (FW) is unclear. Identifying reliable protocols for assessing velocity-based RT metrics may improve the sensitivity of these measures for detecting changes in NMF over time.

Methods: Ten resistance trained males (aged 24.4 ± 4.7 years) participated in this study. After determining loads associated with a velocity of ~ 1 m.s⁻¹ (V1 load) and the one repetition maximum (1-RM) for the squat (SQ) and bench press (BP), participants completed a standardised RT session, involving three sets of eight repetitions at 70% 1-RM (for SQ and BP) on four occasions (twice using the SM and FW). Before and after RT, three maximal repetitions were performed with the V1 load. Velocities of each repetition were measured using a GymAware™ linear position transducer (Kinetic, Canberra). Velocity loss was determined by differences in velocities with the V1 load between pre-RT and post-RT. Reliability was assessed using intraclass correlation coefficients (ICC) and the coefficient of variation (CV).

Results: For SQ, velocity with the V1 load pre-RT was more reliable using SM (ICC: 0.89 CV%: 1.8) vs. FW (ICC: 0.69, CV%: 3.9), while for BP, FW showed greater reliability than SM (ICC: 0.93, CV%: 4.0 vs. ICC: 0.59, CV%: 2.3, respectively). Furthermore, velocity with the V1 load post-RT in SQ was comparably reliable for SM (ICC: 0.90, CV%: 2.7) vs. FW (ICC: 0.95, CV%: 2.4), while for BP, reliability was greater for FW (ICC: 0.96 CV%: 6.5) vs. SM (ICC: 0.53 CV%: 5.8). Changes in velocity with the V1 load from pre- to post-RT in SQ was more reliable in SM (ICC: 0.72) vs. FW (ICC: 0.10), yet BP was similar in SM (ICC: 0.64) vs. FW (ICC: 0.72).

Conclusions: For SQ, velocity-based RT metrics associated with NMF showed greater reliability in the SM vs. FW, whereas the opposite was generally observed for BP. These findings suggest use of the SM and FW may improve the sensitivity of velocity-based RT metrics when using SQ and BP.

Top-class women soccer performance: the peak and the distribution of maximal locomotor activities

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Background/aim: To determine the most demanding passages of match play (MDP) and the distribution of match-activities relative to maximum-intensities during official match in top-class woman soccer players.

Methods: Twenty-eight top-class women players competing in European championship and international UEFA competitions were monitored during 38 official matches (277 individual-samples). Maximum relative ($m \cdot \text{min}^{-1}$) total distance (TD), high-speed running (HSRD), very high-speed running (VHSRD), sprint, acceleration and deceleration distances were calculated across different durations (1-5, 10, 15, 90 min) using a rolling average analysis. Maximum-intensities (1-minpeak) were used as the reference value to determine the distribution of relative intensity across the whole-match demands (90-minavg). Time and distance higher than 90-minavg (>90-minavg) were also calculated.

Results: MDP showed moderate to very-large [effect-size (ES): 0.63/5.20] differences between 1-minpeak vs all durations for each parameter. The relative ($m \cdot \text{min}^{-1}$) 1-minpeak than 90-minavg was about +63% for TD, +358% for HSRD, +969% for VHSRD, +2785% for sprint, +1216% for acceleration, and +768% for deceleration. The total distance covered >90-minavg than 90-minavg was ~66.6(4.0)% for TD, ~84.8(1.9)% for HSRD, ~97.4(0.2)% for VHSRD, ~100(0.0)% for sprint, ~99.1(0.3)% for acceleration and ~98.2(0.5)% for deceleration. The relative distance >90-minavg was very largely (ES: 2.22 to 7.58) higher ($P < 0.05$) than the 90-minavg for each metric.

Conclusions: The present results may help practitioner to bridge the training/match gap for maximizing performance in top-class women soccer players.

The effect of training objectives on the game format and physical demands in small-sided games

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Background/aim: Small-sided games (SSGs) are used by soccer coaches to induce simultaneous physical, technical, and tactical stimuli in practice. Coaches use various pitch dimensions and team sizes to adjust for intended outcomes based on the training objectives, which will result in varying physical demands of those formats. Although much research has focused on manipulating SSGs, it remains unclear what type of SSGs are predominantly used by coaches for different training objectives and how that might affect the physical demands. Therefore, the aim is to investigate the effect of training objectives on external load during SSGs.

Methods: Twenty-one female soccer players of one under-21 academy team were monitored during training across one season. Seventy-three SSGs were included in the study, which were categorised based on the training focus (physical vs. technical-tactical) alongside relative pitch area (RPA; small: <100m²·player, medium: 100-200m²·player and large: >200m²·player). Training objectives were obtained from the coaches' daily practice plan. The distribution of training objectives was analysed (chi-squared). Physical demands were determined using Catapult S7 player tracking technology (Melbourne, Australia). Total distance (TD), high-speed running (HSRD) and sprint distance (SD), accelerations, and changes of direction (CoD) were statistically evaluated for the type of SSG and training objective (MANOVA).

Results: Coaches predominately utilized SSGs for technical-tactical development (67%) with far fewer focused on physical outcomes (33%). When the focus included physical development, larger RPAs were used 75% of the time. Whereas technical and tactical training most commonly took place in medium RPAs (51%).

Further, training objectives and RPA had a significant effect on the physical demands. TD, HSR and SD were greater in SSGs with a physical focus, but acceleration were smaller and no differences for CoD. Additionally, large RPAs induced greater HSRD and SD, but greater TD and more accelerations and CoD were observed on small RPAs.

Conclusions: Training objectives determine the type of SSGs played with a tendency of large RPAs for a physical training aim. Consequently, this induces greater running demands by the players in SSGs. A SSG emphasizing technical-tactical demands are typically played on smaller RPAs, but this resulted in more accelerations and CoD. Coaches adjust SSGs for an intended training aim and this affects the running demands and acceleration profiles in training.

How elite level Australian Rules Football recruiters perceive and assess talent

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Background/aim: An important element of an elite athlete's talent pathway is the process of talent identification and recruitment. While the goal for many athlete and recruiter is to identify the next big superstar of the sport, there is still limited understanding of the specific information and processes used by expert recruiters/scouts to inform these talent identification decisions. Therefore, the purpose of this study was to examine the perspectives of high-performance talent identifiers (Australian Football League Recruiters) in relation to the information they collect and interpret to inform their talent identification decisions.

Methods: Thirteen Heads of Recruitment at elite level Australian Football League clubs, who were responsible for the selection and recruitment of players for their associated senior professional club participated in the study. Data were collected via semi-structured interviews, with thematic analysis used to identify key themes.

Results: Thematic analysis of interview data generated two first-order themes; 1) Understanding Talent; and 2) Talent Identification Processes, with four second order themes emerging from the data; 1a) Defining Talent; 1b) Athlete Attributes; 2a) Talent List Development; and 2b) Recruiter Tasks.

Conclusions: In particular, the findings highlight how the elite level recruiters assess talent based upon game performance and the psychological profile of the athletes. Overall, the findings emphasize the complexity associated with elite level talent identification and provide insight for practitioners and researchers aiming to understand and explain the talent identification process.

Beyond the coaches eye: understanding maturity selection biases in male academy soccer

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Background/aim: In sport, children are grouped by chronological age, however, same age peers can differ by several years in terms of their biological maturation (skeletal age) (1,2). This presents significant challenges for those working with youth athletes, as maturity timing has important implications for talent identification, development, and selection.² Research shows maturation selection biases towards players who mature in advance of their peers, which increases with age and competitive level (1,2) Little research has qualitatively explored 'how' and 'why' these selection biases exist. The aim of this study was to explore and understand how youth academy football coaches perceive, experience, and manage their group of male adolescent academy football players, where individual differences in biological maturation exist.

Methods: This study followed 98 under 12-16 male English Premier League Academy players for 12 months, measuring their maturity status (percentage of predicted adult height), growth velocity and coaches' perceived performance grade for every game. Interviews with their nine respective male coaches were conducted in parallel. The qualitative and quantitative data were then combined to generate a contextualised richer understanding; four themes and four case studies of specific players providing archetypal examples are presented.

Results: Findings can be summarised under the following four themes. Coaches perceived various advantages and disadvantages to players maturing earlier than their peers (1) and in delay of their peers (2). Coaches had different expectations of performance, based upon a player's maturity status, where players advanced in maturation had higher expectations and responsibility placed upon them (3). Finally, the timing of biological maturation had important implications for selection, retention, and release decisions (4).

Conclusions: This study highlights the challenges of developing, managing, and selecting adolescent players in elite male youth football. Individual differences in biological maturation in one age group appears to influence perceptions of performance and potential, player development, and talent identification and selection decisions. Biological maturation confounds talent identification and development, and academy environments need to monitor maturity status and educate coaches and selectors.

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Advances in soccer talent identification through selection psychology: the case for coaches & scouts.

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Background/aim: Talent identification in soccer involves the prediction of future soccer performance. In practice, talented soccer players are typically identified by soccer coaches and scouts, who make predictions based on assessments of players' in-game performance. However, relatively few studies have examined how these coaches and scouts assess and predict performance. In this presentation, I identify a promising avenue for future talent identification research based on insights from selection psychology -- namely, the implementation of better-structured assessment methods to improve the reliability and predictive validity of coaches' and scouts' performance assessments (1). I will demonstrate an overview of recent empirical findings on this topic.

Methods: A total of n = 240 soccer coaches and scouts participated in three studies on structured soccer assessments. These studies included a survey examining the extent to which scouts predict performance in an intuitive- or structured manner. Moreover, these studies included an observational study at a professional club and an elaborate experiment, both comparing an intuitive approach against a structured assessment approach. Specifically, we compared the participants' soccer assessments in terms of inter-rater reliability and predictive validity.

Results: We found that scouts predicted performance in a structured manner, but still formed their overall performance assessment on intuition. Moreover, findings from the observational study and experiment suggested that a structured assessment approach could improve the inter-rater reliability and predictive validity of coaches' and scouts' assessments, but that the implementation in a soccer-related context remained challenging.

Conclusions: All in all, findings from the different studies demonstrate the merits of selection psychology for talent identification in practice. Given that soccer does not typically satisfy the conditions for intuitive prediction approaches [2], a structured assessment approach may improve the inter-rater reliability and predictive validity of soccer coaches' and scouts' performance assessments. Future research should further examine how different levels of structure affect the assessments of coaches and scouts, as well as their willingness to use these approaches in practice to form their final prediction.

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An inquiry into the perceptions of football curricula in relation to Youth Development.

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Background/aim: Football Australia (FA, formerly Football Federation Australia) initially produced the National Football Curriculum (NFC) in 2009 as a document that outlines a playing philosophy that all Australian players should follow (FFA, 2013). The NFC describes key technical and tactical foundations to the game of football (soccer) that builds the coaching model and, in turn, player development in Australia. The lack of research focusing on curriculum development in football opened opportunities to critically analyse its content and perceptions through a selection of technical directors and coach educators to better understand the document's performance in relation to youth development.

Methods: Three professional coach educators and technical directors from the federation and its members were specifically selected to participate in the study. These participants held an FA/AFC A-Licence or above and used the NFC in their day-to-day work. The participants were selected to examine each of their own beliefs and perceptions of the NFC as well as general viewpoints of the coaches they worked with. By using first-hand evidence of their experiences on its successes and limitations through a semi-structured interview format, the results offered much needed insight into this topic, which had not yet been analysed within academic literature.

Results/conclusions: Findings revealed that there were evident misconceptions over the objective of the NFC, causing coaches nationwide, at all levels, to consider the document to be stringent in the way football should be played where in fact, it was developed merely as a guide. There were some positives to note also, namely the unifying factor, as all coaches in Australia were using the same document to understand the game and to develop players.

Association between physical fitness, technical skill, and injury in female Australian football

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Background/aim: Australian football (AF) is a dynamic, contact invasion sport, with a rise in female participation since the inauguration of the Australian Football League Women's competition in 2017. Physical fitness preparation is one integral component of talent development and injury prevention programs purported to enhance athlete development when transitioning between competition levels and to aide players in meeting game demands. Understanding the association between physical fitness, technical skill, and injury is important when developing sex- and sport-specific talent development and injury prevention programs. Moreover, such research could guide future investigations intended to support participation longevity of female AF players whilst maximising sporting outcomes. This study had two aims: to investigate the association between physical fitness and i) technical skills, and ii) time-loss injury.

Methods: Utilising a subset of data from two prospective cohort studies (1, 2), 223 female AF players across talent and participation pathways completed physical fitness assessments and modified AF kicking and handballing tests during the 2018 / 2019 preseasons. Team personnel recorded time-loss injuries during one competitive season. Stepwise multiple linear and Cox proportional regressions examined associations.

Results: When adjusted for years of AF playing experience, increased running vertical jump height, greater hip abduction strength, and faster 6-m hop time demonstrated a relationship with kicking accuracy (adjusted $R^2 = 0.522$, $p < 0.001$). Faster agility time and increased lean mass were significantly related to handballing accuracy (adjusted $R^2 = 0.221$, $p < 0.001$). Multivariate Cox regressions revealed less agile players had an increased risk for sustaining a time-loss injury (adjusted HR 2.41, 95% CI 1.23, 4.73, $p = 0.010$), however this association no longer remained when adjusted for age and years of AF experience ($p = 0.166$).

Conclusions: Physical fitness may be a significant factor contributing to AF skills when developing female players; though, it may be of less importance in protecting against injury risk. Further research is needed to explore the complex phenomenon of talent development and injury prevention in female AF.

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Experiential knowledge of elite officials: Practice design recommendations for football referees

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Background/aim: Decisions made by referees are subject to intense media scrutiny. However, whilst decision-making of elite soccer players has been heavily studied, there is less research focused upon decision-making of soccer match officials. That research which has been undertaken on decision-making in soccer match officials is largely observational, descriptive and quantitative in nature. Researchers are increasingly making use of experiential knowledge from elite performers and have begun to recognise the importance of contextual information to behaviours and performance. This study aimed to explore and identify the informational constraints that influence performance and decision-making of elite soccer match officials with a view to presenting recommendations for practice and training design.

Methods: Experiential knowledge of three male professional soccer officials was collected via semi-structured interviews. All participants were practising officials in their nation's top-flight league and had officiated at the FIFA World Cup, UEFA Champions League and UEFA Europa League. Transcripts from interviews were analysed using a 6-stage thematic analysis and pragmatic approach.

Results: Eight lower order themes were identified and categorised into five higher order themes of performance environment, governing body environment, individual constraints, media and social media influence, and societal views. Higher order themes were placed in an ecological system and labelled as either a proximal or distal constraint on performance.

Conclusions: Two recommendations for practice design were identified. First, proximal constraints (e.g., crowd noise, context of decisions) should be incorporated into training programmes to enhance representativeness of the learning environment. Where this is not possible (e.g., simulating player behaviour), adjustments to existing methods should be made, such as presenting incidents in context when applying video training approaches. Second, strategies to support officials in dealing with pressure and negative social evaluation are important to promote affective learning.

Deferring draft picks: a blessing in disguise

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Background/aim: Player drafts are commonly used in closed competitions to allow for the equitable allocation of amateur talent. However, many leagues have allowed the picks themselves to be traded by the teams that own them, in lieu of a variety of considerations including picks in the future. Teams choosing to advance up the draft order in the current year have been known to trade heavily discounted future picks, owing to clubs favouring current-year picks (and by extension, access to high-quality recruits) to deliver immediate results. This study thereby aims to determine the actual discount rate factoring delay in expected performance within the Australian Football League (AFL) in order to gauge the implied rate used by decision-makers in evaluating trades creating the arbitrage.

Methods: Based on the hypotheses of a discount function that both varies and increases with the drafting order, a regression model was developed using the percentage difference between a draftee's first season and career seasonal average contribution to his team's winning margin as the determinant, controlling for a variety of factors. This was then retrofitted using a LOWESS curve to create a discount rate function per pick.

Results: The findings held both the preconceived assumptions creating a function hovering between 12% and 20%. However, the results also showed a small spike in the rate of discount for early selections. This was attributed to sunk investment plays causing the career seasonal contribution to artificially inflate. Upon further evaluating actual trades involving future picks in the league, using the discount rate table from this study and subsequent pick value index, we found that almost all parties infer a higher value on current-year selections, seeking instant returns over deferred options. The implied rates imputed on such trades revolved between two to ten times the actual discount rate that was calculated.

Conclusions: Whilst the AFL provides teams with the picks they are entitled to, based on their season standings, the option to trade is based on their own volition. Whilst the motivations behind these trades may vary, the result from this study allows teams to facilitate a form of parity in such exchanges. Yet, with teams advancing up the drafting order forfeiting future picks with higher implied rates, this study concludes that it may be best to retreat and defer the choice to pick a player in the current year and capitalise on the arbitrage.

Understanding dissatisfaction with commercialization as a lack of communication in German football

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Background/aim: Gammelsæter (2021) (1) asked if sports can survive its excessive commercialization. In many countries football fans are continuously protesting against a perceived over-commercialization of football. This paper aims to show the interconnection of the rejection voiced by many fans and the lack of communication between them and the federation, respectively a general lack of fan involvement.

Methods: A mixed-methods approach was chosen to understand fans' attitudes towards commercialization and to identify communication problems between different stakeholders. For study 1 a multipurpose online questionnaire was placed in German fan fora and 821 questionnaires were evaluated. Study 2 concentrates on the stakeholder of football clubs and the clubs themselves. Therefore, 27 expert interviews with representatives of clubs, active fans, the association, media, police, and sponsors were analyzed using content analysis.

Results: Different types of fans, distinguished according to their fan status (attendance/active fans) and favorite club (traditional/modern club), do not generally reject commercialization in professional football. However, most of the fans expressed that the limit of commercialization is reached and there is a danger that fans will turn away from professional football. Further statistical analyses (ANOVA) show, that e.g., the statement "Commercialisation in German professional football harms the fan scene" is assessed differently by the groups of respondents: "traditional active fans" with $M = 4.5^{***}$ ($SD = .07$) and "modern attendance" with $M = 3.3^{***}$ ($SD = .17$) (measured in five-point Likert scales). Furthermore, fans do not feel their opinions are taken into consideration, nor do they feel enough involved in decision-making, and communication with the association hardly takes place. Both active fans and the association use the clubs as mediators of their messages to the other party, whereby both complain that their messages are sometimes not passed on or not passed on correctly.

Conclusions: As both studies show, fans feel that their influence has been weakened by commercialization and are not involved in club decisions nor are they heard enough. It suggests problems in the stakeholder management of clubs and the association.

So, long-term, holistic communication between (active) fans and the association should be established. It is crucial to open up the 'black box' of the club and, for example, to make their voting behavior in the association's committees public.

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"Don't wait for change. Just do it: Women's football in Iceland"

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Background/aim: Women's football in Iceland has flourished since the national team became the country's first senior football team to qualify for a major tournament in 2009. In just over a decade since, women have pushed the glass ceilings of participation, empowerment, media exposure, and achievement.

Methods: This research examines this evolution through social and societal transformation theories and the viewpoints of five women who played pivotal roles during the change.

Results/conclusions: Career pathways run parallel for male and female footballers in Iceland. Clubs in Iceland are traditionally run by community organizers, who might be more driven to enact social change than clubs run as businesses. Most clubs have incorporated equal opportunity statements into their official strategies. Icelandic media has discovered that interest grows with exposure. For young women, visible role models can supercharge achievement motivation. Finally, the Football Association of Iceland has a single football strategy for males and females. That includes a licensing system, equal pay for national team players, and a marketing strategy promoting male and female stars side by side. Hopefully, the case of Iceland can encourage others to adopt a "just do it" mindset and strategies to accelerate the development of women's football.

Football in the Nordic countries: practices, equality and influence

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Background/aim/methods: The five Nordic countries – Denmark, Finland, Iceland, Norway, and Sweden – have hundreds of years of shared history. The Nordic welfare state model, with its strong public sector, civil society and comprehensive welfare system, has become a well-known role model for many countries. Regarding football, Scandinavia as a region has often been positioned on the semi-periphery of the football map. This presentation brings together key points from the book “Football in the Nordic Countries: Practices, Equality and Influence”, which is due to be published in summer 2023. This edited collection comprises 17 chapters from 31 authors, including historical, contemporary and critical aspects.

Results: Sport and physical activity in the Nordic countries is based on the voluntary activity of sports associations. The “sport for all” ideal and its basis in egalitarian values, along with a high level of participation, remain fundamental, even if the role of the private sports sector has increased on both the grassroots and elite levels. Other similarities to be highlighted are a strong public administration and civil society; similar phases of change in the history of football; and, broadly speaking, the countries’ status within the global football system. Despite their many similarities, a range of differences across the Nordic countries may also be identified. The Nordic model is not homogenous, and there are significant variations both between and within countries – and these are reflected in football as well. Key differences include the status of football compared to other sports; the popularity of football as a spectator sport; the number of football participants; the pace of development in women's football; and the level of professionalisation and commercialisation.

Conclusions: When measured by success in international competitions, the Nordic countries are not among the major football powers. Yet, football has had a significant status in their sporting culture. In the 2000s, the Nordic countries are more football countries than ever before. They have found success in major tournaments, actively shaped decision-making via sport diplomacy, and have increasingly acted as the conscience of the football world by speaking up for Nordic values and good governance. The Nordic countries form an entity within the global football system, as they do in other international communities.

Peak periods and associated performance changes in professional men's football matches.

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Aim: We aimed to analyse and outline peak 1-, 2- and 5-min periods and the associated 5-min recovery period minute by minute in elite football match-play.

Methods: A semi-automatic multicamera system (Prozone TM; Stats LLC, Chicago, IL, USA) was used to collect high-speed running distance (≥ 19.8 km/t; HSRD), sprint distance (≥ 25.2 km/t; SpD) and distance covered during intense acceleration (>3 m/s/s; AccD). Data from 479 (range 478-480) Danish Superliga players during matches in three seasons 2015/16; 2016/17; 2017/18 were included in the analysis resulting in a total of 6042 to 9671 match observations for each variable analysed for peak periods using rolling averages.

Results: Distances covered during the 1, 2 and 5-min peak period at high intensity (772, 431, and 207%), sprinting (1893, 1064, and 547%) and in intense acceleration (1196, 778, and 483%) were several-fold higher compared to the average for the match. Following the 1-, 2-, and 5-min peak period for HSRD, HSRD was 29, 6, 3, 2 and 2%; 35, 11, 0, 2 and 3%; 45, 29, 13, 8 and 4% lower than match average, respectively, during the following five 1-min periods. Furthermore, following the 1-, 2- and 5-min peak periods for SpD, SpD in the following five 1-min periods were lowered by 20, 3, 7, and 3% (4% higher in the 5 min); 24, 12, 3, 0, and 7%; 39, 29, 18, 17, and 12%, respectively, compared to match average. For AccD, a 68, 89, 94, 88, and 90%; 47, 86, 93, 90, and 88%; 23, 56, 76, 85, and 87% increase was observed in the following five 1-min periods after AccD 1-, 2- and 5 min peak periods respectively.

Conclusions: Even though intensity (m/min) was higher during the shortest peak periods, performance decrements lasted longer after the longest peak periods for HSRD and SpD, whereas players were able to cover distance with intense accelerations (AccD) immediately after the peak periods. These findings contribute to further to understanding the physical demands in football matches and especially performance changes after the most intense periods of football.

Physical, physiological and thermoregulatory responses in soccer players under heat stress

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Background/aim: The effects of heat stress may contribute to a decrease in physical and physiological responses in soccer (1). Therefore, the current study was designed to describe changes in physical and physiological responses of soccer players in different conditions of environmental temperature and humidity.

Methods: Eighteen highly-trained male adult soccer players (23.5 ± 3.1 years; mean \pm SD) performed two scrimmages (i.e., 11 vs. 11 players; performing in an area of $\sim 72 \times 64$ m; time spent ~ 80 min) in conditions of moderate heat stress (MHS) and high heat stress (HHS) based on the wet bulb globe temperature (WBGT) (1). Body core temperature (TC), environmental conditions, physical and physiological responses were measured using an ingestible temperature sensor, a WBGT sensor, GPS units and heart rate (HR) monitors, respectively. Body mass loss and estimated sweat rate were also analysed.

Results: Average WBGT and relative humidity were 24.8°C (95% confidence intervals, 24.5; 26.8) and 52.7% (52.3; 53.1), respectively, for MHS scrimmage (MHSS), and 30.1°C (29.2; 30.8) and 57.5% (57.2; 57.9), respectively, for HHS scrimmage (HHSS). Player's body mass loss was similar at the end of the MHSS and HHSS: 2.5% (1.7; 3.1) and 2.6% (1.9; 3.2), respectively. Estimated sweat rates were similar for MHSS and HHSS: 30.3 mL/min (28.4; 41.1) and 33.2 mL/min (28.2; 44.1), respectively. Peak TC and peak HR rose significantly compared with initial values (i.e., after warm-up) in both scrimmages, MHSS: 38.2°C (37.8; 38.5) and 153 bpm (135; 171), respectively, and HHSS: 38.6°C (38.3; 38.9) and 173 bpm (160; 185), respectively, ($P < 0.001$). Total distance covered in the first and second halves were 4685 m (3885; 5254) and 3991 m (3284; 4731), respectively, for the MHSS, and 4122 m (3597; 4856) and 3805 m (3227; 4483), respectively, for the HHSS. Players covered more distance (+ 694 m, + 563 m, and + 880 m; $P < 0.001$) in the first half of the MHSS than in the second half of the MHSS, and then the first and second half of HHSS, respectively.

Conclusions: In soccer scrimmages played at high environmental temperatures and humidity, physical and physiological responses of soccer players may decrease due to high thermal stress.

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Training load quantification during on field rehabilitation of soccer players: Is there progress?

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Background/aim: On-field rehabilitation bridges the gap between clinical rehabilitation and soccer training (1). Monitoring might help gradually increase training load for optimal performance. Next to traditional methods, a smart sensor short is developed to quantify lower extremity biomechanical load (2). The aim is to assess load progression of soccer players during the Return to Sport process. Secondly, the aim is to assess relationships between new biomechanical and traditionally used load indicators.

Methods: In this longitudinal observational study, 12 amateur soccer players (21.7 ± 3.7 years, 76.5 ± 10.2 kilograms, 1.81 ± 0.08 meter) were monitored during field rehabilitation training. Inertial sensors were used to quantify biomechanical load: Hip Load, Knee load (2), and Playerload. Furthermore, players wore a local position vest to quantify total, high intensity (19.8-25 km/h, HIRD), sprint (>25 km/h), and explosive (> 2.78 ms²) distance. Paired t-tests and Cohen's effect size were used to assess differences between first and last training session. Relationships were assessed with Pearson correlations.

Results: Training sessions were six weeks apart (range: 2 - 10 weeks), with average duration of 63 ± 13 minutes. There were no differences between first and last training sessions for Hip Load (55 ± 19 vs. 52 ± 13 , ES = -0.21, p = 0.34), Knee Load (115 ± 35 vs. 120 ± 28 , ES = 0.15, p = 0.98), Playerload (5.98 ± 1 vs. 5.41 ± 0.7 , ES = -0.65, p = 0.06), total (75 ± 7 vs. 72 ± 9 , ES = -0.34, p = 0.48), HIRD (2.57 ± 2 vs. 3.78 ± 2 , ES = 0.64, p = 0.14), sprint (0.16 ± 0.4 vs. 1.1 ± 1.3 , ES = 0.96, p = 0.053) or explosive distance (0.79 ± 0.50 vs. 1.68 ± 1.75 , ES = 0.69, p = 0.15). Hip and Knee Load were unrelated to most load indicators.

Conclusions: All training load indicators did not progress between first and last session. Correlations demonstrated that Hip and Knee load provide different information than traditional load indicators.

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An investigation into the change of direction demands of elite youth soccer

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Background/aim: Change of direction (COD) is an important consideration for performance, adaptation, and load management in football. The aim of this study was to quantify the frequency, intensity, and angles of COD in elite youth football match play.

Methods: Fourteen elite male academy players (16 ± 1 years) were monitored using foot-mounted inertial measurement units (PlayermakerTM) during fourteen under 16 matches. Two PlayermakerTM units were housed in two manufacturer-supplied tightly fitting silicone straps (one for each foot) and wore them over the boot for the entire game. Data was automatically uploaded to an online platform where matches were clipped for 1st half and 2nd half periods. Only players who completed full matches were included for the study. Metrics derived from the devices included the frequency of COD, COD with the ball, COD without the ball, medium intensity COD (2 m/s), high intensity COD (4.2 m/s), sideways COD (>30 - $<150^\circ$) and backward COD ($\geq 150^\circ$). Players were categorised into defenders, midfielders, and forwards according to their playing position. Differences in 1st and 2nd half frequencies were determined using paired sample t-tests. Differences between playing positions for were determined using one-way between subjects ANOVA.

Results: Elite youth footballers performed on average 241 ± 76 COD with 5% being without the ball. COD were mostly of medium intensity (77%) and sideways in direction (71%). COD frequency, medium intensity COD and high intensity COD were significantly greater (all $P < 0.001$) in the 1st half (135 ± 35 , 103 ± 30 and 31 ± 11 , respectively) compared with the 2nd half (113 ± 38 , 88 ± 33 and 25 ± 10 , respectively). From the positional data, defenders (77 ± 23) completed significant more backwards COD than midfielders (54 ± 22 ; $P = 0.029$), but not forwards (62 ± 16 ; $P = 0.063$). There were no significant positional differences for any other metric (all $P > 0.05$).

Conclusions: We conclude that elite youth soccer players perform 241 COD throughout under 16 match play, with clear decreases in COD frequencies and qualities from the 1st to 2nd half. In addition, there appears to be some differences in COD demands between playing positions, with defenders performing a greater number of backward turns than midfielders. Given the efficient and practical method of assessing COD through the foot-mounted inertial measurement units, this device seems to provide a new way of exploring these demands on a broader scale.

Quantifying the lead-in to sprint efforts in Australian football

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Background/aim: In football the ability to sprint is considered important. Players lead into sprint efforts in various ways based on the speed at which they begin accelerating and the rate of acceleration. In soccer, sprints have been classified as explosive or leading based on the rate of acceleration prior to the attainment of sprint speed (1). However, how players lead into sprint efforts has not been investigated in Australian football. Additionally, information on the distance and duration of the lead-in and sprint allows profiles to be created to assist with specific training or identify whether certain lead-in/sprint profiles are associated with game scenarios (e.g., evading an opponent). The aim of this study was to describe how Australian footballers achieve sprint efforts during matches by quantifying the lead-in.

Methods: Global Positioning System data from 37 footballers over the 2019 Australian Football League season (22 games) were analysed. Sprint efforts were identified using an absolute speed threshold of 7 m/s. The lead-in was determined by working backwards from the start of each sprint until acceleration was ≤ 0 m/s/s (when the player began accelerating). Duration, distance, and speed at which the lead-in commenced was calculated.

Results: A total of 4,260 efforts were recorded with players completing on average 10 ± 6 efforts per game. Sprint efforts had an average duration of 2 ± 1.5 s (range; 0.5 to 12.6 s) and distance of 16 ± 12 m (range; 4 to 94 m). The lead-in for each sprint effort had an average duration of 3.5 ± 2.4 s (range; 0.5 to 12.3 s) and distance of 18 ± 9 m (range; 3 to 54 m). Of all sprints 3 % commenced from standing (≤ 0.19 m/s, 36 % from walking (0.19-1.9 m/s), 30 % from jogging (1.9-4 m/s) and 31 % from running or higher (>4 m/s).

Conclusions: Australian footballers achieve efforts in different ways, shown by the distribution of commencement speeds and range of effort distances and durations. Practitioners should look to profile lead-in and sprint efforts of their players to support specific training from a tactical and conditioning perspective.

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Home and away teams' spatial control on the halves of the pitch determined by a probabilistic model

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Background/aim: The determination of the teams' dominant regions makes it possible to identify the spatial control of the teams in the defensive and offensive halves of the pitch. This study aimed to investigate the influence of the home and away teams on the dominant region in the halves of the pitch.

Methods: The sample of 109 professional Brazilian football players were analysed during four matches. The players' positions were registered using the tracking system of the DVideo© software. Players' dominant regions were determined using a probabilistic movement model based on kinematic variables of the players, and the areas computed according to previously proposed (1). The teams' dominant regions, determined through the sum of the dominant regions of their players relative to the sum of the dominant regions of all the players, were analysed considering the defensive and offensive halves of the pitch. Kruskal Wallis test used to compare the dominant regions of the home and away teams in the defensive and offensive halves with Bonferroni correction. The effect size (η^2) calculated and interpreted as small (0 – 0.05), medium (0.06 – 0.13) and large (> 0.14). The level of statistical significance adopted for all analyses was $P < 0.05$. Team's dominant regions percentage were presented as median and confidence intervals.

Results: The dominant region results showed differences ($H(3) = 103,372.79$; $P < 0.01$; $\eta^2 = 0.15$; Large) in relation to the teams and halves of the pitch. Home teams presented the dominant region of 66.71% (66.62 – 66.80) in the defensive and 35.46% (35.37 – 35.55) in the offensive half, while the away teams presented 64.54% (64.45 – 64.63) in the defensive and 33.29% (33.20 – 33.38) in the offensive half.

Conclusions: The higher values found for both teams in the defensive half in comparison to the offensive demonstrated that the teams have greater spatial control in their own pitch. The higher values presented in both halves of the pitch for the home teams suggest superiority in spatial control against the away teams.

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Biomechanism of lower limb motion in soccer trapping while sprinting

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Background/aim: Trapping techniques are a key component of the game of football. If the speed of the ball can be intentionally reduced when trapping, and if it is possible to connect quickly to the next action, it is thought to be possible to turn the game in an advantageous direction. The aim of this study was to clarify the biomechanics of football trapping while sprinting, such as trapping while approaching a pass, based on situations often seen in midfield during football matches, and to provide scientific knowledge useful for football practice and coaching.

Methods: In this study, university football club players are the research subjects, and they perform three types of traps: trapping in a standing position, trapping while jogging and trapping while sprinting. The distance of the pass is 10m. The data is collected and analyzed using the three-dimensional automatic movement analysis system VICON.

Results/discussion: In traps while sprinting, players with higher skill levels tended to externally rotate their hip joints to a greater extent at impact ($p < 0.05$) and to trap with their lower limbs not too far forward of their body ($p < 0.05$). Consequently, players with higher skill levels impacted the ball with a lower angular rate of hip internal rotation ($p < 0.05$) and had a comparatively slower ball velocity after impact ($p < 0.05$). In addition, because the landing point of the trapping foot was closer to the body's center of gravity ($p < 0.05$), the next step was taken earlier by players with higher skill levels.

Conclusions: In short, when trapping while sprinting, it is considered that trapping with a large external rotation of the hip joint and with the foot not too far forward of the body allows an earlier transition to the next action. This study objectively analyses the football trapping motion with realistic movement and creates an analytical index for coaching, which may help in the coaching to improve competitive performance on the field. At the same time, when used in conjunction with subjective assessment in the field, it can contribute to the development of more efficient skill learning and improve competitive football performance.

Data-efficient pattern detection in elite soccer

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Background/aim: The identification of strategies and tactical patterns is key to pre- and post-match analyses in team sports and analysts usually spend a great deal of their time watching and annotating video footage. We propose to study ways to (semi-)automatize this process based on tracking and event data. Our goal is to automatically annotate all patterns and events of interest, enabling the analyst to select the most relevant ones for further analyses. This task can in principle be solved with supervised machine learning, which however requires large amounts of labeled situations to successfully learn the target concepts. We thus propose to leverage self-supervised pre-training to learn representations of the data which allow to solve pattern and event detection in soccer with only a few annotated situations.

Methods: Self-supervised learning approaches are known for successful training of very large attention-based deep neural networks in natural language processing and computer vision. We generalize existing concepts and propose novel self-supervised approaches for spatio-temporal team sport data to enable data efficient training of subsequent pattern detection methods. Specifically, we build upon recently proposed self-supervised models (1) and transformer architectures (2) for multi-agent trajectory data. Empirically, we compare different approaches with self-supervised pre-training to supervised baselines on the task of event detection in soccer.

Results: We find that representations learned by the proposed self-supervised approaches significantly help with detecting events in tracking data from soccer. We show how approaches which include self-supervised representation learning achieve improved detection performance over baseline methods and already achieve comparative results with only a fraction of annotations.

Conclusions: We introduce pre-training with self-supervised machine learning approaches for tracking data. We show how the approaches enable us to build successful machine learning classifiers in light of sparse labels. Although the application focuses on soccer, the method is general and directly applicable to other team sports.

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Analysing Phases of Play in the 2018 and 2022 FIFA World Cup

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Background: Understanding the mechanisms underlying success, in football, is critical for coaches, players, managers, and other stakeholders. Lepschy et al. (2021) (1) suggest exploring ball possession in greater detail, to search for success related variables within world cup football.

Aim: Differentiate between eliminated and qualified teams in FIFA world cup football, across two consecutive tournaments. Secondary analysis will explore whether there is a relationship between the two tournaments, for variables associated with each Phase of Play (PoP).

Methods: Match performance data (n = 98) was categorised into a PoP, such as creating and finishing possession, defending, goalkeeping, transition and set pieces. The collected data was collected from www.fbref.com, with the data provided by OPTA. Only the games of the first stage (group stage) were used, to differentiate between 16 eliminated and 16 qualified teams (48 games). Data was analysed using a one-way between-groups multivariate analysis of variance, for each PoP, to differentiate between eliminated and qualified teams. In addition, mean values for each dependant variable, for the 2018 and 2022 FIFA world cup, will be analysed using a Pearson product-moment correlation coefficient.

Results: Data is being collected and processed for the 2022 FIFA World Cup, due to the unavailability of data. Initial findings, for the 2018 FIFA World Cup, suggest there are statistically significant differences between eliminated and qualified teams on the combined dependent variables for creating and finishing $F(22, 73) = 1.79, p = .034$, Wilks' Lambda = 0.65, partial eta squared = .35; possession $F(29, 66) = 1.74, p = .032$, Wilks' Lambda = 0.57, partial eta squared = .43 and goalkeepers $F(10, 85) = 3.02, p = .003$, Wilks' Lambda = 0.74, partial eta squared = .26. Each significant PoP was analysed further with 61% (n = 14) of the creating and finishing variables exhibiting significant differences, possession exhibiting significant differences in 62% (n = 18) of variables and the goalkeeper phase exhibiting significant differences in 40% (n = 4) of variables within this category.

Conclusions: By exploring PoP differences and relationships between consecutive tournaments, improvements can be made in creating or amending a national organisations philosophy. Findings suggest, focus should be placed on possession, creating and finishing and goalkeeping phases, when preparing for forthcoming performances.

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Relative Performance Indicators within Women's Rugby Union: A machine learning approach.

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Background/aim: The efficacy of isolated and relative performance indicators (PIs) has recently been compared within men's Rugby Union, the latter being more effective at discerning match outcomes (1). However, this methodology has yet to be applied within women's rugby. The aim of this study was to identify PIs that maximise prediction accuracy of match outcome, from isolated and relative datasets, in Women's Rugby Union.

Methods: PIs were selected from 110 matches of women's international rugby from 2017-2022. The isolated dataset comprised of 26 PIs, each selected based off previous research to characterise different aspects of the game, including attack, defence, set piece and infringements (2). Relative datasets were determined by subtracting corresponding opposition PIs. Random forest classification was used to analyse both datasets; feature selection methods were used to simplify models and variable importance measures were collected to interpret key PIs. These models were used to predict match outcome for games played in the 2021 Rugby World Cup, and McNemar's test was utilised to test for differences in prediction accuracy.

Results: The isolated full model correctly classified 77% of match outcomes with a confidence interval (CI) of 71%-83%, whereas the relative full model correctly classified 82% (CI (77%, 87%)). When simplified, the respective models correctly classified 79% (CI (73%, 84%)) and 81% (CI (75%, 86%)) of match outcomes. In the test dataset, simplified models correctly predicted 85% and 96% of match outcomes for isolated and relative data, respectively. There was no statistically significant difference in prediction accuracy between the two datasets ($p > 0.05$). Within the relative data model, five PIs were significant in differentiating between wins and losses: these include relative metres made, clean breaks, lineouts lost, kicks from hand, and free kicks.

Conclusions: This study demonstrated that while relative data does report higher prediction accuracy, the improvement is not statistically significant within women's Rugby Union, despite studies demonstrating this within different men's competitions (1). Findings also established that increased relative metres made, clean breaks, kicks from hand, free kicks as well as decreased lineouts lost were associated with match success in women's Rugby Union.

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Analysis of alpha-actinin-3 rs1815739 polymorphism in Turkish professional football players

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Background/aim: The determination of the genetic profiles of successful athletes and the effects of these genetic parameters on athletic performance is gaining increasing interest. The focus is on the rs1815739 polymorphism that occurs as a result of the cytosine-thymine transition (C>T) in the 16th exon of the α -actin-3 (ACTN3). As a result of this change, the codon encoding the 577th amino acid of the protein causes the formation of a stop codon (X) instead of the codon encoding arginine (R). A deficiency of ACTN3 protein is observed in individuals with this polymorphism (1).

The aim of this study is to examine the distribution of the relationship between ACTN3 rs1815739 polymorphism and sportive performance on Turkish male football players.

Methods: 107 male football players (age = 22 \pm 4 years) and 130 sedentary individuals (age = 25 \pm 3 years) control group participated in our research. DNA isolation was performed from the buccal epithelial cells of the individuals participating in the study, Real Time PCR was used for genotyping of the ACTN3 rs1815739 polymorphism. In the statistical analysis of the results obtained, χ^2 (chi-square) analysis was performed using the SPSS 25.0 program. A value of $p < 0.05$ was accepted as statistically significant.

Results: The respective percentage of the football players (n=107), ACTN3 rs1815739 CC, CT and TT genotypes were 29.9%, 38.3% and 31.8%. The allelic counts were 50.9% for T and 49.1% for the C alleles. The respective percentage of the control group (n=130), ACTN3 rs1815739 CC, CT and TT genotypes were 23.8%, 38.5% and 37.7%. The allelic counts were 56.9% for T and 43.1% for the C alleles. In the χ^2 analysis, no statistically significant difference was found between the genotype ($p=0.4971$) and allelic frequencies ($p=0.1928$) in the athletes and control groups.

Conclusions: Our results showed that ACTN3 rs1815739 polymorphisms TT genotype and T allele, which is associated with the endurance phenotype, was more dominant in our cohort. Studies have shown that ACTN3 rs1815739 polymorphism is an important biomarker in determining endurance and speed characteristics in football players.

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Technical and possession statistics of academy players across different age groups in match play

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Background: At the chronological age of 16, youth football players in the UK transition into the professional game. Understanding the differences between these standards can help coaches and clubs to support players during this transition.

Objectives: To (i) assess the difference of technical and possession statistics between different age groups (U16, U18, U23) and positions (GK, CD, WD, CM, AM, WM, ST), within an English academy programme, during match play; ii) to understand the influence of contextual factors within academy match play on these metrics.

Methods: All matches and training sessions were monitored using foot-mounted inertial measurements units (PlayermakerTM) to quantify the technical (touches and Releases) and individual possession statistics (Time on the ball, Time on the ball per possession) from each match. Teams were instructed to play a 1-4-3-3 formation as part of their clubs playing philosophy, with positions defined per this formation. Data was analysed using a multi-variate ANOVA.

Results: Initial results indicate that trivial to small effect sizes were observed across age groups for both technical and possession-based statistics during match play. Across all age groups and positions, CBs had the highest number of technical actions (touches and releases), whereas ST and AM, had the highest amount of time in possession of the ball. Further, positional analysis showed ST and AM had moderate to large decreases in time on the ball per possession at the U23's age group in comparison to the U16 and U18's, with no technical differences observed within the same positional analysis. Further analysis is required to assess the contextual factors associated to match play.

Conclusions: Attacking players (AM & ST) are required to move the ball quicker as they progress from U16 to U23's within the current English football academy. Further exploration is required to assess if these changes are due to any context given requirements of those age groups.

Youth to professional soccer: A longitudinal study of successful and unsuccessful academy graduates

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Background/aim: To optimise use of available resources, professional academies develop strategies to assess, monitor, and evaluate players as they progress through adolescence towards adulthood. However, longitudinal study designs examining performance throughout adolescence, and the transition from youth to professional soccer are underrepresented.

Methods: We examined differences in the age of player recruitment alongside longitudinal performance differences on field-based fitness tests of successful vs. unsuccessful graduates across the entire age spectrum recruited by a professional soccer academy. Altogether, 537 youth soccer players volunteered to participate. We recorded the age of recruitment, biannual fitness test performance, and subsequent success in attaining a senior professional contract at the club across a period of 12 years.

Results: Only 53 (10%) of players were successful in obtaining a professional contract, with 68% of players who became professional being recruited at 12 years of age or older. Individuals recruited at an earlier age did not display a higher probability of success in attaining a professional contract. Bayesian regression models reported a consistent interaction between age and group for data on all performance measures. Moreover, “successful” academy graduates only physically outperformed their “unsuccessful” counterparts from age ~13-14 years onward, with either no differences in performance, or, performance on physical fitness tests favouring “unsuccessful” players prior to this age.

Conclusions: Findings suggest that high achievers during childhood and early-adolescence may not develop into successful senior professionals, raising concerns about the predictive utility of talent identification models.

The peak and the distribution of maximal demands during official match in U18 elite soccer players

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Background/aim: In top-class soccer, the most demanding passages of match-play (MDP) and the distribution of match-activities relative to maximum-intensities during official match are utilized as a tool to maximize high-performance. However, few information for MDP and none for the distribution of match-activities are still available in youth football. The current study aimed to determine these issues in fourteen U18 elite male players competing in European youth championship.

Methods: 71 individual-samples across 15 official matches were monitored. Maximum relative ($m \cdot \min^{-1}$) total distance (TD), high-speed running (HSRD), very high-speed running (VHSRD), sprint, acceleration and deceleration distances were calculated across different durations (1-5, 10, 15, 90-min) using a rolling average analysis. Maximum-intensities (1-minpeak) were used as the reference value to determine the distribution of relative intensity across the whole-match demands (90-minavg). Time and distance higher than 90-minavg (>90-minavg) were also calculated.

Results: MDP showed large to very-large [effect-size (ES): 1.29/5.23] differences between 1-minpeak vs all durations for each parameter. The relative ($m \cdot \min^{-1}$) 1-minpeak than 90-minavg was about +63% for TD, +278% for HSRD, +629% for VHSRD, +1700% for sprint, +736% for acceleration and +657% for deceleration. The total distance covered >90-minavg than 90-minavg was ~67.1(5.2)% for TD, ~86.6(3.4)% for HSRD, ~97.0(0.4)% for VHSRD, ~100(0.0)% for sprint, ~98.3(0.5)% for acceleration and ~97.1(1.1)% for deceleration. The relative distance >90-minavg was large (ES: 1.66 to 1.76) for TD and HSRD, and very large (ES: 3.32 to 10.28) for VHSRD, sprint, acceleration and deceleration.

Conclusions: The MDP and the locomotor intensity >90-minavg may help to intensify training for maximizing performance in elite youth football players.

Force-Velocity profile U10, U12, U14, U16 and U18 youth football players during a competitive season

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Background/aim: Several studies have analyzed the F-V profile in professional players (1). However, in the child and youth population, there is not as much scientific evidence on how the F-V profile can be modified depending on age, category or over the course of a season. Aim of this study was to analyze the changes over the course of a season (start of season, mid-season, and end of season) and between the different playing categories in the F-V sprint profile and 30m running time of young players in a football academy.

Methods: 64 football children divided into five groups according to their category (U10, U12, U14, U16, U18). It was analyzed in three phases of the season: beginning, middle and end of the season. Force-Velocity profile (F0 (N), F0 (N.kg⁻¹), V0, V0 (m/s-1), Pmax (W), Pmax (W.kg⁻¹), F-V slope, RF peak and DRF), were assessed using standardized procedures (GNSS and GPS). A Two-way mixed ANOVA was used.

Results: F0 (N) was significantly higher in the third period with respect to the first in U14, U16, and U18 ($p < 0.05$) categories and with respect to the second in U14 players ($p < 0.05$) and significantly lower in U16 ($p < 0.05$). The V0 (m.s-1) magnitude was significantly higher in the third period with respect to the first in U12 players ($p = p < 0.05$) and with respect to the second period in U12, and U16 ($p = p < 0.05$) players. F0 (N), the U10 and U12 players have significantly lower values in the three periods with respect to the U14, U16 and U18 players ($p < 0.05$). U10 and U12 players obtained lower values for V0 (m.s-1) than U14, U16 and U18 players in all periods ($p < 0.05$).

Conclusions: The F-V profile over the course of a season in young players of a football academy shows how strength and speed values increase in all categories after 9 months of football training. However, holiday periods or breaks in football practice negatively affect the profile. As for the results according to category, both theoretical maximum strength and theoretical maximum speed and their derived variables are higher in U16 and U18 players.

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Change of direction demands in German high-performance soccer

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Background/aim: This study aimed to compare the change of direction (COD) demands of German Bundesliga soccer match play relative to playing position using an optical-tracking-system. COD data were collected from German Bundesliga soccer teams (2017–2018 season; 17 matches).

Methods: An event in which a player completed a deceleration ($\leq -2 \text{ m}\cdot\text{s}^{-2}$), an angular change in the direction of motion ($\geq 20^\circ$), and a subsequent acceleration ($\geq 2 \text{ m}\cdot\text{s}^{-2}$) within a duration of 1 second was defined as a COD. These thresholds have typically been used to classify accelerations and decelerations above a moderate intensity level during a team sports match (1, 2). Directional changes were subdivided by entry

velocity ($< 3.0 \text{ m}\cdot\text{s}^{-1}$, $3.0\text{--}5.5 \text{ m}\cdot\text{s}^{-1}$, $5.5\text{--}7.0 \text{ m}\cdot\text{s}^{-1}$, and $> 7.0 \text{ m}\cdot\text{s}^{-1}$) and rotation angle (Low: $20\text{--}59^\circ$; Medium: $60\text{--}119^\circ$; and High: $120\text{--}180^\circ$). The frequency of total COD, the subcategories of entry velocity and rotation angle for each position, and the average, standard deviation, maximum and minimum values were calculated.

Results: ANOVA revealed significant group effects for COD60 ($p < 0.001$; $\eta^2 = 0.08$), COD120 ($p < 0.001$; $\eta^2 = 0.63$), COD180, ($p < 0.001$; $\eta^2 = 0.05$) between positions. Post hoc tests revealed significant differences between positions for all angles. Further, ANOVA revealed significant group effects for COD3 ($p < 0.001$; $\eta^2 = 0.07$), COD3_5.5 ($p < 0.001$; $\eta^2 = 0.20$), COD5.5_7 ($p < 0.001$; $\eta^2 = 0.14$) and COD7 ($p = 0.034$; $\eta^2 = 0.02$). Post hoc test revealed significant differences for all entry velocities, except COD7.

Approximately, 90% of COD during matches were performed with entry speeds $< 5.5 \text{ m}\cdot\text{s}^{-1}$ and about 70% were low ($\sim 40\%$) and moderate ($\sim 30\%$) angled turns.

Conclusions: This study provides insights into the COD demands of German Bundesliga soccer matches, which can be used to guide position-specific physical preparation strategies, to monitor player load, to develop performance tests and to give recommendations for rehab and return to play standards.

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Broadcast analytics – Opportunities and limitations of single-camera player tracking systems

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Background/aim: The collection of tracking data in football allows analysts to quantify individual and team performance. Although most professional clubs and leagues are currently collecting tracking data, the operation of tracking systems is not feasible for small clubs and sub professional leagues. Additionally, data is not shared across leagues. Recently, data providers have emerged, that extract tracking data from single cameras, (e.g., TV-broadcast videos) using computer vision (1). However, the quality of this data depends on camera settings and field of view (FOV). If players are not visible in the video, their position cannot be tracked. Therefore, the aim of this study was to investigate the inherent limitation of single-camera systems due to player visibility.

Methods: Data from 4 matches of the 2014/15 season of the German Bundesliga were analyzed. Ground Truth (GT) tracking data was collected using TRACAB Gen 4. We applied the sports field registration by Theiner et al. (1) to videos from TV Broadcast (BC) and Scoutingfeed (SF). The resulting homography matrix was used to project the cameras' FOV onto the GT tracking data, excluding all players not visible in the video. The effect of the FOV was evaluated with the average percentage of players visible and the formation recognition by Müller-Budack et al. (2).

Results: While GT contains 100% of the players, the BC include 64% and SF includes 85% of the players on average. The formation detection resulted in 69% Top-1 accuracy for GT, 54% for BC and 63% for SF. Top-5 accuracies on the formation detection were 0.92, 0.81 and 0.88 for GT, BC, and SF, respectively.

Conclusions: For all analyses, BC showed the lowest accuracies and visibility of players. The SF only excludes 15% of players on average which leads to similar results as GT in the formation detection. This leads to the conclusion, that video-based tracking systems can be used for tactical analysis if the camera is stationary and has a wide FOV, like SF. Contrarily, analysis of individual players, should be performed carefully, especially when based on BC videos.

Accessible, transparent and reproducible football analytics with floodlight

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Background/aim: Football performance analysis based on data is a complex and challenging task that increasingly requires an advanced computer science skill set (1, 2). Furthermore, algorithms and implementations of proposed methods are rarely shared within the community. These days, both developments could strongly reduce the accessibility, transparency and reproducibility of data-based football analytics. The recently released open source Python framework floodlight (2) is an attempt to create an access point to advanced performance metrics and a community tool to publish and share code between researchers working with any team sport data.

Methods: We extend the original software (2) with additional metrics and algorithms from the literature (e.g. space control with Voronoi cells in square and hexagonal mesh grids). Further, we develop and present a showcase application that demonstrates how large-scale analyses can be easily conducted, shared and reproduced with basic programming knowledge.

Results: Results show how an exemplary data science pipeline can be established with floodlight that (i) analyzes match data with advanced performance metrics and minimal code, (ii) can be used interchangeably for more than ten different data providers, (iii) produces code that can be shared and reproduced by peers, (iv) is fast and easy to handle.

Conclusions: Providing low-threshold access to data-based performance analyses that require advanced computing, as well as fostering an open science mentality within the sports analytics community are important steps in the future. As our analysis shows, the floodlight software can serve as a platform and key building block within this endeavor.

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„I still think he wasn't offside “ – Fans' reception of the Semi-Automated Offside Technology (SAOT)

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Background/aim:

The FIFA World Cup 2022 (WC) was among the first major competitions that used SAOT to determine the objective parts of offsides decisions: the moment the ball is touched the last time by a teammate and the distance of each player to the goal line. FIFA uses a chip in the ball to determine touches and markerless limb tracking to measure players' positions. While FIFA is not publicly providing information about the accuracy of SAOT, it is reasonable to have concerns looking at current state of research concerning markerless limb tracking (e.g. (1)). This is why we have started a project to explore to what extent fans trusted the SAOT during the WC.

Methods: Tweets were extracted for WC games in which predefined SAOT incidents took place. For the analysis, two observers developed three coding schemes based on a subsample of 300 tweets: One coding scheme to determine if a tweet was related to SAOT ($k=0.99$), one to rate if users trusted the decision ($k=0.86$) and one to identify discussed themes using an inductive approach (17 themes, $k=0.63$). As performed successfully for the Video Assistant Referee (2), automated text-classifiers will be developed to allow extensive analysis based on this coding schemes at a later stage of this project.

Pilot results and conclusion: With the study still being in process at the time of abstract submission, we performed a pilot study based on 800 tweets from the match Iran vs USA. 28.9% of the eligible tweets provided indications that the final decision made by the SAOT was not trusted, with the most frequent themes detected being complaints about the offside rule (23.3%), rule explanations (18.6%) and concerns about the standard of review (12.7%). This raises the suspicion that people often react negative towards SAOT, which is a common issue for technological officiating aids (2). However, we want to stress that this is an ongoing study and conclusions should be drawn carefully at this point.

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The effect of maturation on foot morphology, and the role of both in postural stability in football

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Background/aim: Football is a multi-directional sport that places a high neuromuscular load on the ankle-foot complex of adolescents. Biological maturity and foot morphology can independently alter this loading, causing stability deficits and increasing injury risk factors. However, no research has examined the influence of maturation on three-dimensional foot shape, and how much both are linked to neuromuscular load. Thus, the research aims were: i) to investigate the effect of maturation on foot morphology, and ii) discover to what extent both factors explain the variance in postural stability performance in adolescent footballers.

Methods: Over one season, 399 three-dimensional foot scans were gathered from 72 players (U12-U15). Principal component analysis determined the nine principal components (PCs) that explained the most variance in foot morphology. Maturity status was determined by the equation of Khamis & Roche (Advanced, On-Time, Delayed). Timing of maturation was estimated by the equations of Khamis & Roche (Pubertal Status) and Mirwald et al. (Peak Height Velocity (PHV)). Postural stability was measured in bilateral and unilateral stances, with centre of pressure displacement calculated. An ANCOVA determined the effect of timing of maturation on the nine foot PCs, with Age, Height, Weight, Playing Position, and Foot Dominance as covariate factors. Step-wise linear regression analysis determined the explanation of postural stability by all the above mentioned factors. Significance was determined as $p < 0.05$.

Results: Post-Pubertal footballers had a significantly more pronated foot compared to those Pre-Pubertal and Pubertal, and the foot was significantly more pronated as adolescents went through PHV. Timing of PHV also revealed that foot length and tibial rotation relative to the foot were significantly different between Circa- and Post-PHV groups. Maturity status and four foot PCs (foot arch and width, great toe width and length) were significant predictors in all postural stability tests. However, these factors only explained a small amount of the common variance in the regression models for each test ($R^2 = 0.105-0.180$).

Conclusions: This is the first study to describe the effect of maturation on foot morphology. These findings indicate that researchers should be aware of the timing of maturation in adolescent footballers when assessing the foot. This could also have implications for footwear design to minimise discomfort. While they only explained a small amount of variance, determining maturity status and foot morphology may identify those who require additional attention to postural stability performance.

Exploration of the moderator effect of cultural diversity on team performance across 45 leagues

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Aim: The research aimed to investigate the relationship between team sporting performance and other factors, including teams' cultural diversity, their wealth and reliance on particular styles of play. The study was grounded in ecological and cross-cultural understandings of movement behaviors.

Methods: Based on a sample of 23,186 matches played by 728 teams across 45 leagues during the 2020/21 season, moderated regression analyses were conducted to examine the effect on sporting results of the interaction between teams' cultural diversity, their market value and dominant playing style. Playing styles were measured by running PCA analysis on 20 team-level performance indicators drawn from the Wyscout database.

Results: A new theoretical model, the Integrative Categorization-Intentionality Model (ICIM), was proposed to explain four key findings. First, it was revealed that cultural diversity contributed to sporting success only in less affluent teams ($p < .01$) explaining 15.4% of the model variance. Second, CDI's role as a cross-cultural moderator was confirmed in relation to all three styles of play: possession-based, constructive attacking and defensive. Results showed that cultural heterogeneity significantly contributed to goal scoring in teams reliant on the first two styles ($p < .05$; $p < .01$). Conversely, defensively-oriented teams were more likely to improve performance with increasing cultural homogeneity ($p < .05$). Finally, empirical evidence linked enhanced performance to a higher proportion of domestic defensive players in defensively oriented teams ($R^2 \text{ adj.} = .35$, $F(3,722) = 133.8$, $p < .001$), and, similarly, between a higher proportion of foreign offensive players in offensively-oriented teams ($R^2 \text{ adj.} = .35$, $F(3,722) = 130$, $p < .001$).

Conclusions: The study has practical implications for scouting/recruitment of players when strategizing on team cultural and functional composition, as well as for coaches in terms of designing suitable training practices gauged to match and develop multicultural teams' diverse skill set, or more generally, in relation to managing multicultural teams.

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Experiences of conflict, power, and psychological safety in German football youth academies

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Background/aim: Talent development environments (TDEs) have been researched to determine conditions promoting youth athletes' chances to transition into elite sports (e.g., psychological safety). With few exceptions, environmental attributes hindering talent development remain largely disregarded (1). This is particularly evident for such social phenomenon like conflict which - if managed unsuccessfully - may contribute to a destructive organizational culture impeding athletes' development and the performance of entire TDEs. Taking a systemic approach, this study therefore aimed to explore how perceptions of psychological safety and power shaped conflict experiences within football youth academies (YA).

Methods: Using a qualitative design, data was collected from members of ten YAs across Germany, including eight focus groups with players and 45 semi-structured interviews with coaches (N=25) and managerial staff (N=20). The first author then conducted an inductive reflexive thematic analysis (2) for each YA before subsequently merging the findings. Carrying out an initial case analysis allowed to understand the organizational dynamics within one YA before developing overarching meaning patterns across multiple YAs. Throughout this process, developed themes were continuously discussed with the research group and selected participants to ensure depth and credibility of the findings.

Results: The results revealed a pattern regarding the experiences of conflict across various stakeholders and in relation to the environmental characteristics of the respective YAs. The three main themes resulting from the analysis differ in the predominantly used narrative describing the attitudes towards and nature of conflict (e.g., avoidance vs. purposeful use). Further, participants' conflict experiences seemed to be linked to the degree of perceived psychological safety (e.g., suspicious vs. trusting attitudes towards others) and lived hierarchical processes (e.g., autocratic vs. democratic leadership, social distance vs. closeness). It was especially notable, how attitudes towards conflict hold by individuals of high status (e.g., academy directors) extended to hierarchical lower levels within the organization (e.g., coaches, players).

Conclusions: This study highlights the importance of understanding the social dynamics within YAs more broadly rather than merely focusing on dyadic or team relationships. It further positions leadership staff as key agents within a network of interdependent social relationships.

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The home advantage stays robust even with COVID-19 restrictions and the introduction of the VAR

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Background/aim: Early research on competitive game outcomes in football has shown that under a balanced schedules – playing the same number of games at home and away – home teams tend to win more matches than away teams (Pollard, 1986). This so-called home advantage (HA) is driven by many factors, however, the presence of a crowd and its influence on the referees' decision-making have been identified to be among the most dominant forces (2). These two factors have been significantly altered in recent history. First, due to the COVID-19 pandemic, spectators were excluded from high-level football matches. Second, the Video Assistant Referee (VAR) was introduced to help referees arrive at the correct decision in crucial situations of the game. Both events provide the ground for new natural experiments that assess the influence of both the crowd and the referee bias on the HA.

Methods: In the first study, we analyzed the effect of the COVID-19 restrictions on the 2019/2020 season using match outcomes and referee decisions (e.g., yellow cards). Because of the small sample size, we created 1,000,000 randomized samples from the previous four seasons with the exact same number of matches played behind closed doors in the top leagues of Germany, Italy, England, and Spain. In the second study, we assessed the difference of the match outcomes and referee decisions between the four seasons prior to the VAR introduction in 2017 (in the German Bundesliga) and the four seasons following it.

Results: Study 1 showed that the exclusion of the spectators has decreased the HA significantly in the German Bundesliga, while other European top leagues were virtually unaffected. Interestingly, in most countries, the distribution of yellow cards between home and away teams tended to be more balanced out than in previous years. Study 2 yielded no significant reduction in the HA since the introduction of the VAR. However, overall, teams seem to commit fewer fouls since the VAR was introduced.

Conclusions: The HA seems to remain robust despite the rather significant changes induced by the attendance restriction under COVID-19 and the introduction of the VAR. This means that although these factors are seemingly crucial components of the HA, they do not suffice to significantly shake the robustness of this phenomenon.

Effects of emotion-regulation and family communication patterns on young athlete's wellbeing

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Background/aim: It is known that competitive football is psychologically demanding. Some athletes face difficulties in handling these demands, which potentially disrupt their athletic wellbeing. In the sports context, wellbeing of elite athletes is highly related to their satisfaction of basic needs, which is a construct related to intrinsic motivation. Growing up in a communicative family environment and developing adaptive emotion regulation strategies are potentially influential factors on athletic wellbeing. However, the literature lacks a study that examines the special associations between emotion regulation (ER), family communication patterns (FCP) and athletic wellbeing of young football players. This study aims to reconceptualize emotion regulation and wellbeing in the sports context and discover the direct and indirect relationships of these factors with family communication.

Methods: Participants consist of 58 elite male football players from various football academies in the Netherlands including the national youth team of the Royal Dutch Football Association (KNVB), ranging from 14 to 19 years of age. The data were collected as a part of a 300-question survey, that includes various scales of psychological measurement including the scales of the current study.

Results: Two adaptive ER mechanisms (reframing coping and future-focused coping), and two maladaptive ER mechanisms (passive coping and past-focused coping) are being extracted. For the athletic wellbeing three dimensions are determined (sport-related adversity, frustration of basic needs and state of flourish). Results of the Linear Regression Analysis found that conversation-orientation correlates with two adaptive ER strategies: reframing coping and future-focused coping. Reframing coping and future-focused coping positively correlates with state of flourish. Only future-focused coping correlates negatively with the frustration of the basic psychological needs. Past-focused coping correlates with state of flourish negatively. The mediation analyses found a significant mediator role of family communication between emotion regulation and wellbeing.

Conclusions: Findings of this study can be beneficial for practitioners. Sport psychologists can design a wellbeing-enhancing intervention program educating athletes to use adaptive ER strategies and inform their parents about the significance of conversation openness in the family communication.

Are we there yet? Return to sports testing after an ACL reconstruction.

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Background/aim: Most patients expect to return to the pre-injury level of sports after an anterior cruciate ligament reconstruction (ACLR). Unfortunately, rates for return to sports (RTS) are sub-optimal (1). Additionally, around 20% of patients will sustain a second ACL injury (2). The decision whether a patient can RTS after ACLR is complex in nature and therefore, the use of multifactorial test batteries is recommended, including criteria that patients need to pass before RTS. However, it is unknown if passing RTS test batteries results in higher RTS rates and decreased risk for second ACL injury. The aim of the current study was to compare the results of a RTS test battery between patients who returned to the pre-injury level of sport and patients who did not. In addition, we compared the test results between patients who sustained a second ACL injury and patients who did not.

Methods: Sixty-four patients after an ACLR (age 27.8 ± 8.8 years) were included. All patients followed the same rehabilitation program and performed a RTS test battery at the end of the rehabilitation (10.1 ± 1.0 months after ACLR), including strength- and hop tests and patient reported outcome measures. Two years after ACLR, a web-based questionnaire was conducted to investigate RTS success and potential second ACL injuries.

Results: Patients who successfully RTS had better test scores compared to patients who did not RTS. However, no differences were found between patients who sustain a second ACL injury and patients who did not.

Conclusions: Even though passing current RTS criteria is associated with increased likelihood for returning to the pre-injury level of sport, it fails to identify risk for second ACL injury. This indicates that a second ACL injury cannot be predicted so far. Future research should focus on sport specific RTS tests that reflect the patients' movement behavior when performing their sport.

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Between-day reliability of wearable tech parameters in soccer specific change of direction test

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Background/aim: This study aimed to assess between-day reliability of change of direction biomechanics and speed in youth soccer players with measurements obtained using inertial measurement units and video.

Methods: A soccer-specific change of direction test including a 180° pivot turn was performed in both directions by 15 elite female (M± SD: 15.3±0.6 yrs old, 162.6±5.5 cm, 56.7±7.1 kg) and 22 male (M±SD: 15.4±0.5 yrs old, 169±5.9 cm, 58.5±8.5 kg) youth soccer players in two consecutive days. The reliability of the variables was quantified by using intra-class correlation (ICC) analysis with limits of agreement (LoA) and Bland-Altman plots.

Results: Based on the results, neither peak resultant acceleration or peak angular velocity is a reliable measure for 180° pivot turn biomechanics (poor reliability, <0.5) but time to turn and total time accomplish acceptable to good reliability (0.9>; >0.7). Acceleration and angular velocity ICC's for females were better than for males (z-score >1.96).

Conclusions: Acceptable to good reliability with reasonable limits of agreement imply that speed measures in different phases of change of direction could reliably reproduce individual differences in 180° pivot turn technique. Sex-related differences in repeatability of acceleration and angular velocity call for more comprehensive research in the future. A longer follow-up period is warranted to determine the variability of wearable technology measurements throughout the season.

Emphasize motor actions or information exploration. Different decision-making tasks effects

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Background/aim: The goal of coaches is to design tasks that improve player performance during competition. To create such scenarios, coaches often vary the difficulty of the task by changing the possible actions and thus the decision-making process (1). Nevertheless, there is little information on how tasks with different levels of decision-making can acutely affect players' performance. Therefore, this study investigated how training tasks with varying levels of decision-making affect subsequent ball control and passing accuracy in small games (SSG) in youth soccer

Methods: Sixteen youth players (U14) participated in three experimental conditions: i) Low decision-making (Low- DM, repetitive training in which players performed a predefined ball control and passing sequence); ii) Moderate decision-making (Mod- DM, in a square formation 4 players hold possession with two balls; iii) High decision-making (High- DM, a 3vs3+2 neutral possession game). To understand the acute effect of practicing each task on players' subsequent performance, a pre-post-test design was conducted with a 6-min Gk+4vs4+Gk SSG followed by 6-min experimental tasks and finally a 6-min Gk+4vs4+Gk SSG. Player behavior was measured using notation analysis, the Game Performance Evaluation Tool, and GPS.

Results: In general, higher average post-test scores were found after the High DM task, with significant effects on ball control and ball orientation ($p = 0.016$). Conversely, the Mod- DM task decreased players' ability to pass the ball to teammates in more offensive positions ($p = 0.016$). When comparing the effects between training groups (pre-post between-group effects), the low- DM task showed lower values for ball control execution ($p = 0.030$), appropriateness ($p = 0.031$), motor space ($p = 0.025$), and distance traveled while sprinting ($p = 0.042$) than the Mod- DM task. These results suggest that repetitive tasks (Low DM) may limit players' ability to fine-tune with the environment, while tasks that do not require players to move (Mod DM) may also acutely reduce their ability to explore offensive passing solutions. Conversely, game-based situations (High DM) showed a positive effect on players' ball control and passing performance, possibly due to higher contextual dependency (1).

Conclusions: Overall, coaches should carefully consider the type of exercise structure when designing tasks to improve players' motor skills in team sports.

Exploring the role of players and tactical systems on players' performance during small-sided games

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Background/aim: In football, training session tasks are designed to improve players' performance under specific tactical systems and collective principles. For that, coaches vary task boundary conditions to amplify opportunities for action (1). Therefore, this study explored how varying the team system and the players' role affected players physical performance during small-sided games.

Methods: Twenty-eight university players' participated in three Gk+6vs6+Gk: experimental conditions: i) Low-boundaries (Low-BD), two teams played without any previous information; ii) Moderate-boundaries (Mod-BD), players' were instructed to play in a Gk+2+3+1 formation; and iii) High-boundaries (High-BD), one team had a defensive role (4 defenders + 2 midfielders) by protecting one regular goal and scoring in three small goals, while the other had an attacking role (2 defensive midfielders, 3 attacking midfielders and 1 forward) by having the opposing aim. GPS devices (WIMU ProTM; Realtrack Systems, Almeria, Spain) were used to collect physical performance of players.

Results: In general, High-BD registered lower total distance ($F = 8.18$, $p < 0.01$), lower distance covered while running ($F = 5.28$, $p = 0.007$) and higher distance walking ($X^2 = 7.06$, $p = 0.029$) in comparison to Low and moderate-BD. Also, higher number of decelerations (> 3.0 m/s, $X^2 = 9.04$, $p = 0.011$) were registered in the Mod-BD compared to Low-BD and High-BD.

Conclusions: In conclusion, high definition of tactical systems and players' roles seems to decrease general players' displacements and external load. In opposition, the low definition of boundaries of tactical systems and playing roles, increased the number of high intensity decelerations, probably because promoted high number of 1vs1 situations and individual actions with the ball. It is suggested that tasks with high boundaries should be used in days closer to the game (e.g., MD-2) for strategical purposes under lower external demands, while tasks with low boundaries should be used to promote more individual and group adaptive behaviours at high intensity (e.g., MD-4).

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Influence of playing style on success, physical & technical match performance in professional soccer

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Background/aim: The offensive style of play describes characteristic behavioural features of the players at team level that can be observed time and again. This study aimed to investigate the effect of offensive playing style (i.e. while in ball possession) on physical and technical match performance during offensive play as well as success-related factors.

Methods: The sample consisted of official tracking and event data of 153 matches of the 2020/21 German Bundesliga season (= half of the season). In every match, for both teams, an offensive playing style coefficient [PSC] was calculated to locate teams on a continuum between counter-attacking and ball possession style. In addition, dependent physical (e.g. accelerations), technical (e.g. dribblings), and success-related (e.g. goals) variables were examined. A separate linear mixed model was calculated for each dependent variable.

Results: While teams with lower PSC values (= counter-attacking style) covered more high-intensity and sprinting distances per second in possession, teams with higher PSC values (= ball possession style) were physically more demanded over a whole match (e.g. more accelerations, decelerations, high-intensity, sprint distance) ($p \leq 0.03$; $R^2 = 0.08-0.69$). Furthermore, teams with higher PSC values played more horizontal passes and revealed better passing success rates ($p < 0.01$; $R^2 = 0.17-0.73$). In contrast, teams with lower PSC values played more long passes ($p < 0.01$; $R^2 = 0.58$). The influence of the PSC on success-related variables was smaller ($p \leq 0.36$; $R^2 = 0.10-0.13$).

Conclusions: Concluding, offensive playing style affects physical and technical match performance, but has limited influence on success. Hence, coaches can use the findings to optimize training contents before and recovery processes after matches.

Measuring pace of play in elite female soccer

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Background/aim: Soccer scouts must assess how potential signings' skills will translate to a new league which is challenging as the league level and style of play might differ. This is particularly difficult within the women's game due to the rapid developments, lack of open-source market values for all players, and fewer inter-league matches and transfers than in men's soccer (1). To overcome these challenges, we look at a specific aspect of the game that covers multiple skills and could be an indicator of a league's level: pace of play (2). The higher the level, the less time one has to control the ball. We introduce a Pace Metric that measures pace of play as the time in which players move the ball after receiving it. This serves as a proxy for a player's technical, physical and cognitive skills.

Methods: We consider ball event data for all matches ($n=3117$) played since 2017 in the women's first divisions of England, Spain, Germany, France, and US, and the Champions League. We compute our Pace Metric (PM) for every pass ($n=1556140$) made after receiving the ball from a teammate. The PM is defined as the time in seconds between the timestamp associated with the teammate's pass and the timestamp associated with the player's pass. We analyze 1218 player transfers to test whether a player's PM at their previous team is correlated to their playing time for their new team. Firstly, we compute a player's median PM for their previous team. Secondly, we compute z-scores comparing these PM values to the average PM in their new league. Lastly, we perform a t-test on Pearson's correlation coefficient between these z-scores and the number of matches played per season for their new team.

Results: The PM value is related to competition quality. First, the Champions League knockout matches have the lowest average PM value ($3.84 \pm 0.74s$). Second, the players' z-scores are significantly negatively correlated ($r=-0.15$, $p<0.01$) with the number of matches played for their new team: players with a lower average PM (playing faster) compared to their new league appear in more matches for their new team.

Conclusions: Our Pace Metric can help with recruitment as it correlates with playing time. However, it has the limitations of ignoring the positioning of other players, tactics, and playing style.

Improving the Evaluation of Expected Goals Models through the Use of Probabilistic Measures

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Expected Goals (xG) is a measure of the probability of a shot resulting in a goal, estimated via Machine Learning. The reason for estimating this probability is that the outcome of single shots is highly prone to randomness (1) and therefore the number of goals scored might be affected by chance. As a consequence, xG models do not aim at accurately predicting the outcome of a single shot, but rather at identifying its underlying success probability. On the long term, the sums of expected and observed goals should converge. Consequently, estimating xG values is, like sports forecasting [2], not a classification task, but rather a probabilistic forecasting task. Therefore, the prediction target is the underlying success probability, not the observed class, which makes evaluation metrics relying on the predicted class, like F1-Score, inappropriate. Instead, scoring rules like Brier Score, which evaluate predicted probabilities instead of classes, are used (3). However, scoring rules validate the predictions against the observed class, which is problematic because the actual criterion is success probability. Since this probability is unknown, however, the only way to assess the quality (calibration) of a probabilistic forecast is to group similar shots together and compare the average predicted probability per group with the relative frequency of goals per group. While this approach is suggested e.g., by Robberechts and Davies (3) and lies at the heart of calibration plots, a widely used method to visually inspect the calibration of predictions (2), no attempt has been made to quantify calibration in this way. Therefore, we propose a method to quantify the calibration of predictions, derived from calibration plots, where Brier Score is calculated for groups of shots instead of single shots. We simulate 100000 shots for which true probabilities are pretended to be known and demonstrate that Brier Score favors a biased model over a theoretically perfect model. The proposed metric correctly identifies the perfect model.

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What are the factors that influence subjective judgements about recovery status? A correlational study in professional soccer players

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Background/aim: Coaches often ask players to judge, either formally or informally, their state of recovery. The aim of this study was to explore the factors that correlate with such judgements in a group of professional soccer players.

Methods: 101 players from four professional Italian soccer clubs competing in Serie C were recruited for this study. A complete season was recorded for a total of 16989 training sessions and matches. Every morning, the players rated fatigue, sleep quality, muscle soreness, stress and mood 1. At the same time, they formally judged their recovery status using the Total Quality Recovery questionnaire (TQR) 2. After each training session or match, the session Rating of Perceived Exertion (sRPE) was obtained and multiplied by duration to calculate the Training Load (TL). A framework of big data analytics of time series was employed to detect the factors associated with subjective recovery.

Results: Big data analytics suggest that TQR scores are primarily associated with ratings of fatigue and muscle soreness at the time of such judgments. Other factors such as sRPE of the previous training session and other athlete-reported outcome measures and their daily, acute and chronic aggregations seem to be less important.

Conclusions: The findings of this study suggest that, in order to maximize subjective recovery of professional soccer players, coaches should adjust TL to minimize fatigue and muscle soreness on match or training day, using appropriate training periodization and recovery strategies. Future experimental studies are required to confirm these correlational findings.

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Physical Metrics Vary with Phase of Play and are Related to 'Fast Break' Performance Outcomes

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Background/aim: Elite soccer is dynamic in nature and limited evidence exists on how physical intensity changes according to technical/tactical phases of match-play. Furthermore, the relationship between physical intensity and performance during crucial phases is unknown. This study compared the physical metrics between five different phases of play, and during fast breaks assessed the relationship between physical metrics and performance outcomes.

Methods: Event and tracking data (Stats Perform SportVU system) from two seasons of a major European league were analysed. The duration of each match (n=579) was categorised as one of five phases: build-up, progression, chance creation, transition or fast break. Physical metrics were rates of distance covered ($\text{m}\cdot\text{min}^{-1}$) in total and within five speed categories during ball-in-play (BIP), and according to phase of play. Performance measures during fast breaks included: total number of shots or goals scored, and the probability of a team scoring in the next 10 seconds (i.e. Expected Threat (xThreat)).

Results: The proportion of BIP time made up by each phase was: build-up (36.2%), progression (23.6%), chance creation (13.9%), transition (17.7%) and fast break (8.5%). All phases differed for rates of distance covered in total (build up: $128 \pm 8 \text{ m}\cdot\text{min}^{-1}$, progression: $142 \pm 10 \text{ m}\cdot\text{min}^{-1}$, chance creation: $131 \pm 9 \text{ m}\cdot\text{min}^{-1}$, fast break: $196 \pm 15 \text{ m}\cdot\text{min}^{-1}$, transition: $145 \pm 8 \text{ m}\cdot\text{min}^{-1}$; Bonferroni, all $p < 0.05$; except build-up and chance creation, $p = 0.06$), and particularly at higher speeds during fast breaks compared to all other phases (running: 1.8 to 2.5-fold higher, high-speed: 2.6 to 5.9-fold higher, sprinting: 4.4 to 17.5-fold higher). During fast breaks, the rates of distance covered in total, and at high-speed and sprinting were moderately associated with total shots ($r = 0.46-0.50$; all $p < 0.05$), total goals ($r = 0.42-0.48$; all $p < 0.05$), and strongly related to a team's xThreat during fast breaks ($r = 0.64-0.71$; all $p < 0.001$).

Conclusions: Phase of play had a large effect on match physical intensity and thus should be considered when quantifying match physical metrics. During fast breaks greater physical intensity was strongly/moderately related to critical performance outcomes, uniquely demonstrating the importance of physical metrics for soccer performance during fast breaks.

Peak Kinematic and Mechanical Demands in Elite Women's International Football Competitions.

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Background/aim: Current methods of identifying and characterizing the most intense periods (MIP) in elite football using a univariate approach may be limited as they negate considerations of the complexity of locomotor activities and the concurrence of high-intensity activity performance variables. The current study utilizes a multivariate approach to identify and characterize the peak kinematic (MIPk) and mechanical (MIPm) demands in a 5-min period by considering the combined and specific maximal kinematic and mechanical demands within and between elite women's football competitions.

Methods: Global positioning system (GPS; 10Hz) data was collected from 21 outfield players who completed matches (n=112 observations) across three international women's football competitions, including the 2019 FIFA Women's World Cup (WC), the 2022 UEFA European Women's Football Championship (EM), and the 2020 Summer Olympics (OL). The MIPk comprised of the peak total distance covered by moderate-speed (12.5-18.9 km·h⁻¹), high-speed (19-22.4 km·h⁻¹), and sprint (≥22.5 km·h⁻¹) running performance, while MIPm comprised of the peak average of absolute high-intensity accelerations ≥3m·s⁻².

Results: Large significant differences were observed in 5'MIPk ($\chi^2=133.14$ (15, N=112), $p\leq 0.001$; $W=1.09$) and 5'MIPm ($\chi^2=28.29$ (15, N=112), $p=0.020$; $W=0.5$) frequency distributions across matches. Comparisons between competitions revealed that 5'MIPm magnitude ($r=0.56$), number of efforts ($r=0.41-0.44$), and duration ($r=0.54-0.60$) were significantly ($p\leq 0.001$) lower in the WC when compared to EM and OL. In contrast, no statistically significant ($p\leq 0.05$) differences were observed in 5'MIPk magnitude, number of efforts, and duration between competitions.

Conclusions: Greater variability in 5'MIPm distribution and performance within and between competitions, may suggest that peak mechanical performance is more susceptible to contextual variables surrounding matches and competitions when compared to peak kinematic performance (5'MIPk), which is more stable. Differences in 5'MIPk and 5'MIPm performance profiles may therefore require targeted training of specific locomotor activities to enhance overall peak kinematic and mechanical performance in elite women's football. Findings of the study are relevant to establishing more effective training and player monitoring practices to better prepare players for peak match demands.

The congested International Match Calendar in football: views of 1,055 professional male players

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Background/aim: The International Match Calendar congestion affects players' recovery. The views of a worldwide cohort of professional football players are shared in this communication.

Methods: A cross-sectional observational study recruited players through Fédération Internationale des Associations de Footballeurs Professionnel's national members. An electronic survey was shared in English, French, Italian and Spanish, with 1,055 players consenting and completing it anonymously in November 2021.

Results: A total of 42% of respondents believe back-to-back matches should be limited to three. Most respondents (69%) felt clubs or national teams infringe off or in-season breaks and 83% believe regulations should protect them. A total of 55% of players believed they sustained one or more injuries due to the overload and it has affected 52% of respondents' mental state.

Conclusions: The congested International Match Calendar poses a risk to professional footballers' physical and mental health. Poor recovery between matches may affect player availability and performance. Active players should represent players when International Match Calendar scheduling decisions are made. Administrators should seek medical guidance regarding the effects of overload on performance prior to making decisions. This study allows the opportunity for a larger national team player sample to be studied.

Injury prevention strategies in soccer: A three step approach to keep players injury free.

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Background/aim: Football is one of the most popular sports in the world, with players participating in many games during the season where the duration is long and the intensity high. With recovery between games being insufficient, the quality of the pitches sometimes being not good and the knowledge of professional players around injury prevention and how to protect their bodies being little, the danger of injury sustainment is always high. The implement of a well-organized injury prevention program combined with monitoring strategies have been shown to be really effective regarding the prevention of injuries and the improvement of players' performance. This study presents a scientific-based strategy that can be used to design injury prevention programs which combined with monitoring routines aims to reduce injury risk and keep players injury free.

Methods: Standard systematic review methodology was modified and adopted for this review and electronic-searching tools were used to locate the papers needed.

Results: A total number of 68 studies were analyzed. Three different stages were adopted as the most important and useful when designing injury prevention programs for football players. Those stages were: A) Player Profiling, B) Analysis of Scientific data and C) Design and Application of the injury prevention program.

Conclusions: According to scientific literature the application of those three stages combined with good monitoring routines is a safe and effective way to reduce the injury risk and improve athletic performance of football players.

A machine learning approach to detect neuromuscular fatigue in football (soccer) players.

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Background/aim: Different monitoring strategies have been implemented in football to assess the neuromuscular status of the players. However, most of these evaluations require additional time. For this reason, detecting fatigue conditions within the training session could bring several advantages as constant daily monitoring. Barrett et al. (1) identified the ratio between Player Load and total distance as a measure of locomotor efficiency. Therefore, the current study aims to use a machine-learning (ML) approach to predict the Player Load players' response based on the external load cumulated during small-sided games (SSGs). The hypothesis is that when the actual Player Load is higher than the value predicted by the ML model, the player shows a lower locomotor efficiency, consequently, a fatigue status.

Methods: Eighty-three elite soccer players (First team=32; U19=24; U18=27) were involved. External training load was collected during SSGs using GPS system (WIMU Pro device). Twenty-one workload parameters were extracted. The weekly load for total distance (WTD) was estimated and binned into four groups using the quantile method: low WTD (3258–34954 m), medium WTD (34963–41778 m), high WTD (41779–48053 m), very high WTD (48059–70392 m). In addition, Player LoadRT (PLRT) was calculated. XGBoost regression model was employed to predict the PLRT of the players during SSGs. The goodness of the classifier was determined using the root mean squared error (RMSE). The difference between predicted vs. real PLRT was calculated and identified as the locomotor efficiency index (PLRT Δ). A one-way ANOVA, followed by Bonferroni post-hoc test, was employed to analyze differences in the PLRT Δ in relation to WTD groups.

Results: The average PLRT recorded during the SSGs was 30.8 ± 19.7 AU. The XGBoost model showed a RMSE of 4.2. One-way ANOVA showed that the PLRT Δ changed in relation to the WTD. Particularly, the very high WTD condition induced a significant ($p < 0.01$) lower LEI value than the other groups.

Conclusions: Similar to previous studies, it was hypothesized that a negative PLRT Δ could suggest a higher required load than expected during SSGs. The results showed that the PLRT Δ was sensitive to weekly load. Particularly, a very high WTD induced a significant decrease in the index. Therefore, the PLRT Δ could be used to monitor the players' fatigue status on a daily basis.

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Improvement in football-specific performance in female players with a neuromuscular training program.

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Background/aim: Despite the promising results of neuromuscular training programs on injuries, scientific evidence on the effects of these interventions on performance remains scarce (1). Therefore, to evaluate the effects of a neuromuscular training program on physical performance in female football players.

Methods: 38 adult female soccer players participated in this study. Participants were assigned to an experimental (EG;) or a control group. Participants in the EG received NT program (12 weeks, 3 times per week, 25 min per session). The NT program included lower limb strength, agility, stability, dynamic mobility and core exercises. The players were tested at the beginning and the end of the intervention on bilateral countermovement (CMJ) and horizontal (HJ) jump tests, 40m sprint and 180° COD test. Paired t-test was conducted to detect significant differences between the pre and post-tests in both groups. Statistical significance was inferred from $p < 0.05$.

Results: EG made significantly more significant improvement than CG did on HJ (GE (pre 179.9 ± 9 vs post 180.9 ± 8.7 cm $p < 0.01$; GC pre 168.1 ± 10.3 vs post 167.9 ± 10.2), CMJ (GE (pre 27.1 ± 10.3 vs post 27.7 ± 10.3 cm $p < 0.01$; GC pre 28.2 ± 2.0 vs post 28.2 ± 2.16), 40m (GE (pre 5.87 ± 0.3 vs post 5.69 ± 0.28 s $p < 0.01$; GC pre 6.36 ± 0.26 vs post 6.40 ± 0.31), 180° COD right (GE (pre 2.66 ± 0.2 vs post 2.58 ± 0.2 s $p = 0.01$; GC pre 2.61 ± 0.2 vs post 2.62 ± 0.1 s) and 180° COD left (GE (pre 2.65 ± 0.2 vs post 2.55 ± 0.2 s $p = 0.01$; GC pre 2.58 ± 0.2 vs post 2.61 ± 0.2 s).

Conclusions: We conclude that a 10-week neuromuscular training program can be a sufficient stimulus to improve football-specific performance variables in female football players. Therefore, female players and coaches should be aware that weekly inclusion of strength, power and dynamic balance exercises following a neuromuscular paradigm is helpful for football-specific performance improvement.

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Sprint and endurance performance in young elite soccer players at different playing positions.

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Background/aim: Soccer players have to perform many consecutive sprints at high speed, requiring a combination of both sprint and endurance abilities. Previous literature in other sports has shown an inverse relationship between sprint and endurance performance, suggesting that optimizing these two physical traits simultaneously is challenging. This study investigates the relationship between sprint and endurance performance in soccer players, with respect to individual playing positions and match-specific outcomes.

Methods: Twenty-four young elite soccer players at a professional football club (U18 & U21, age = 18.0 ± 1.2 , height = 180.0 ± 6.7 weight = 72.9 ± 8.7 ; mean \pm standard deviation) performed a maximal incremental treadmill test with gas exchange analysis to measure their $\dot{V}O_{2max}$, which was normalized to lean body mass^{2/3} to eliminate the influence of body size. In addition, sprinting speed was measured over 20 meters using local position measurement. Linear regression analysis was used to evaluate the association between the sprint performance and normalized $\dot{V}O_{2max}$. Moreover, match-specific performance data was obtained. Differences in sprint and endurance test and match performance outcomes were compared between player positions (forwards (F), attacking midfielders (AM), defending midfielders (DM), backs (B) and central defenders (CD) using one-way ANOVA.

Results: No significant association between the average sprint speed and the normalized $\dot{V}O_{2max}$ was found in this player group ($R^2 = 0.09$; $p = 0.11$). There were also no significant differences in sprint speed ($p > 0.32$) or normalized $\dot{V}O_{2max}$ ($p > 0.45$) between positions. However, substantial differences were shown within groups. Also, there were match-specific differences in total distance (DM = AM = F > B > CD, $p < 0.05$) and total sprint distance (B = F > DM = CD, $p < 0.05$; B > AM > CD, $p < 0.05$).

Conclusions: Although there were differences in match performance outcomes, these were not reflected in the maximal sprint and endurance capacity of the present group of young elite players and no significant relationship between these two physical traits could be found. Maximal sprint and endurance performance values did vary substantially between groups, which suggests that some players may benefit from individualized training. Implications for optimization of training are discussed.

Heat acclimation of a professional soccer referee prior to the 2022 FIFA World Cup: A case study.

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Background/aim: The 2022 FIFA World Cup was held in Qatar, where environmental conditions were expected to present a thermoregulatory challenge for referees. Athletes typically undertake heat acclimation program prior to major sporting events occurring in the heat. However, these programs are typically based on completing multiple sessions within a short period of time (~10-14 days). Logistical challenges arise when referees still have officiating duties during this acclimation window. The aim of the study was to document the heat acclimation program used by a referee prior to the 2022 FIFA World Cup.

Methods: One male professional English referee (age: 44 years) undertook a heat acclimation program over 22 days. On days one (pre-intervention [PRE]) and 22 (post-intervention [POST]), a heat tolerance test (30 minutes running at 9 km.h⁻¹ with 2% gradient in 40°C and 40% relative humidity) was performed. Core body temperature, skin temperature, heart rate, sweat rate, thermal sensation and thermal comfort were measured. In the 19 days between tests, various methods of heat exposure were used to overcome logistical constraints. Seven sessions were performed in the environmental chamber (ranging between 60-90 minutes, 30-40°C and 40-70% relative humidity), two 30-minute saunas at 90°C and two unsupervised 30-minute hot baths at ~40°C. Additionally in this 19-day period, the referee officiated three English Premier League and two Champions League matches.

Results: Compared with the PRE test smaller increases during the POST test were observed for core temperature (change [range], PRE: 1.74°C [36.66-38.40]; POST: 1.52°C [36.48-38.00]) and heart rate (PRE: 109 b.min⁻¹ [58-167]; POST: 104 b.min⁻¹ [58-162]). Compared with the PRE test greater increases in the POST test were observed for skin temperature (PRE: 3.4°C [33.3-36.7]; POST: 3.5°C [32.7-36.2]) and sweat rate (PRE: 1.94 L.h⁻¹; POST: 2.27 L.h⁻¹). Thermal sensation (mean: PRE: 6.3 AU; POST: 6.5 AU) was rated higher and thermal comfort rated lower (PRE: 3.2 AU; POST: 2.5 AU) in the POST test compared with the PRE test.

Conclusions: The acclimation program elicited positive changes in physiological measures during exercise in the heat, despite the chaotic officiating schedule of the referee during the program. This highlights that a variety of heat acclimation methods can be effectively employed by practitioners to overcome logistical constraints.

Link between and discriminative power of domain-specific and generic cognition in youth football.

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Background/aim: From a sport psychological perspective, cognitive aspects are considered as potential talent predictors in football. A debate remains about the relationship between domain-specific and generic cognitive tests and their usefulness for talent identification (1). Therefore, this study aims to investigate the relationship between three existing and prominently used domain-specific and generic cognitive diagnostics (purpose 1) and the extent to which these tests differentiate between age group (age) and skill level (purpose 2).

Methods: Youth football players (N = 110) from the U11 to U15 age groups competing at Youth Academy and local level conducted three cognitive tests in random order: the Determinationtest (DT) aiming to measure reactive stress tolerance, and BrainsFirst (BF), a test battery of four tests intending to assess working memory, anticipation, control, and attention were used as generic tests. Additionally, a domain-specific decision-making test using Virtual Reality (VR) glasses and 360° videos was applied. The global results of each test were z-transformed, yielding in six dependent variables. Partial correlations controlling for age (purpose 1) and multifactorial multivariate analysis of variance (MANOVA; purpose 2) were conducted.

Results: Correlations between domain-specific and generic cognitive aspects range from $.12 \leq r_p \leq .47$, between different generic cognitive aspects from $.22 \leq r_p \leq .67$ (purpose 1). Multifactorial MANOVA results show a significant main effect of age ($p < .001$, $\eta^2 = .188$) and skill level ($p < .001$, $\eta^2 = .568$) and a significant interaction of both factors ($p < .001$, $\eta^2 = .126$). Four significant main effects of age on generic cognitive test results ($p < .05$, $.116 \leq \eta^2 \leq .362$), and a significant main effect of age on domain-specific test results ($p < .001$, $\eta^2 = .389$) emerged. Regarding players skill level, four significant main effects on generic cognitive aspects ($p < .05$, $.042 \leq \eta^2 \leq .432$) and a significant main effect on domain-specific cognitive aspects ($p < .001$, $\eta^2 = .258$) were found (purpose 2).

Conclusions: The present study provides further findings showing the relationship between domain-specific and generic cognitive diagnostics, additionally pointing towards a limited value of the DT for talent identification purposes. Both VR and BF seem to have potential to differentiate between skill level, and to a lower extent between age. Potential implications of cognitive diagnostics for talent identification are discussed.

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The Relationship Between Vestibulo-Ocular Reflex Gain and Short Distance Soccer Passing.

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Background/aim: The Vestibulo-Ocular Reflex (VOR) functions as a vision stabilization system during rapid head movements through vestibular input into the semicircular canals of the inner ear, and thus enables, for example, player and ball orientation whilst in motion. VOR-Gain is the amount of eye speed in relation to the speed of head movement, with a score of 1.0 being a perfect match, and VOR-Gain symmetry within canals is vital for the balance of sensory input and affect postural orientation of the body. Therefore, a mismatch of the eye and head speed may hinder a player's ability to visually track, pass, and receive the ball at high velocities. The purpose of this study was to examine if there is a positive correlation between VOR-Gain and football passing performance among semi-professional soccer players.

Methods: Forty-one semi-professional soccer players (20.5 ± 2.3 years) from the 4th league in German soccer completed a video Head Impulse Test (VHIT) using the NeuroCom® InVision system to assess VOR-Gain of the horizontal, superior, and posterior canals. The Loughborough Soccer Passing Test (LSPT) was then conducted on an outdoor artificial pitch to assess short distance passing accuracy, ball control, reaction speed, dribbling, and decision-making. The players completed two trials of the passing test with the average of the two being taken as the final time score.

Results: Results showed an overall average VOR-Gain of 0.92 ± 0.06 with a significantly greater mean VOR-Gain for the right horizontal (1.00 ± 0.07 ; $p < 0.001$) and right posterior (0.898 ± 0.06 ; $p < 0.001$) canals compared to the left horizontal and left anterior. The average LSPT completion time was 47.8 ± 5.1 seconds. Linear regression analysis showed that VOR-Gain performance was not significantly correlated to LSPT time ($p > 0.68$) or accuracy ($p > 0.41$). Moreover, correlations between VOR-Gain asymmetry and the LSPT were also insignificant ($p > 0.82$).

Conclusions: Although the Vestibulo-Ocular Reflex has been established as an important mechanism behind gaze and postural stability during head and bodily movements, the results of this study found no positive correlation between VOR-Gain and short-distance passing performance among semi-professional soccer players. This observational study provides a foundation for further investigations into training-induced changes and variations over time.

Influence of situational variables on match performance parameters in professional soccer players.

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Background/aim: Match analysis not only indicates the strengths and weaknesses of a team but also plays an essential role to determine key performance indicators. The great majority of the performance analysis-related studies investigated the higher-ranked leagues in Europe such as the English Premier League, Spanish La Liga, Italian Serie A, German Bundesliga, French Ligue 1, or high-level international tournaments such as UEFA Champions League and FIFA World Cup. Thus, there is limited evidence across lower-ranked leagues such as the Turkish Super League, which is ranked 20th based on UEFA Country Coefficients. Therefore, this study aimed to investigate the variations in physical and technical performance parameters of professional soccer players according to match outcome, team quality, and quality of opposition.

Methods: The data was collected from 122 matches of the Turkish Super League during the 2019-2020 season using the semi-automatic multi-camera tracking system. Concerning the match outcomes, the sample consisted of team data from 85 wins, 85 losses, and 74 draws. Regarding the second contextual variable, team quality, the played games were categorized as the top (team data from first six-ranked, n=80), middle (team data from second six-ranked, n=89), and bottom (team data from third six-ranked, n=75) according to their final ranking at the end of the season. To examine the last contextual variable, quality of opposition, the teams were classified as superior (first nine-ranked teams) or inferior (last nine-ranked teams).

Results: The results revealed that the winning teams performed greater high-intensity running activities, particularly when in possession and afforded a higher number of shots on target. The distance covered in high-intensity running and sprinting when in possession, and successful crosses, shots on target, corner kicks, and short passes were greater in top-ranked teams. The results also indicated that the percentage of ball possession, number of shots on target, and successful crosses were greater for both inferior and superior teams when they played against the inferior teams. While both groups played against superior teams, high-intensity running distance out of possession was greater.

Conclusions: The coaches, performance analysts, and practitioners should consider performance parameters that are influenced by situational variables before designing training programs and match evaluations.

Peak periods and subsequent recovery in elite football matches – no difference between time points.

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Background/aim: The aim of the present study was to investigate the timing of the peak 5-min running periods and their subsequent 5-min periods in relation to fatigue in elite football matches.

Methods: A semi-automatic multicamera system (Prozone TM) was used to collect high-speed running distance (≥ 19.8 km/t; HSRD) and sprint distance (≥ 25.2 km/t; SpD) from professional Danish male football players during matches in 2015/16; 2016/17; 2017/18 seasons. Only data from full-game-players were included. A total of 480 players were included in the analysis resulting in a total of up to 9586 match observations analysed for peak 5-min periods using rolling averages. The subsequent 5 minutes were analysed minute-by-minute (R1, R2, etc). Peak periods and recovery periods were categorized into 5-min according to the start time of the peak period. As data was not normally distributed, a Kruskal-Wallis test with Dunn's post hoc test was applied.

Results: Number of peak periods for HSRD was highest in the first 5-min period of the 1st and 2nd half (1243 and 934) and dropped towards the end of each half. Peak HSRD was not different ($P > 0.05$) between 5-min periods. HSRD covered during recovery periods was lower than match average in all five 1-min periods, but the drop was only larger in 20-25 min than 0-5 min for R1, and 65-70 min for R2 with no other differences.

Number of peak periods for SpD was highest in the first 5-min period of both half (906 and 747) and dropped during each half. Peak SpD was higher in 55-60 min than 60-65 min with no other differences between 5-min periods. SpD covered during recovery periods was lower than match average in all five 1-min periods, but the drop was not different between 5-min periods throughout the match.

Conclusions: In conclusion, even though most peak periods were observed in the beginning of each half, no difference was observed in HSRD and SpD during peak periods regardless of, when the peak periods occurred in the match. Moreover, the subsequent drop in HSRD and SpD was not different after peak periods at various time points during match, indicating that players were able to perform maximally regardless of the time point and did not experience extra fatigue towards the end of the match.

Attack phase in football.

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Background/aim: In order for football coaches to do their job successfully, they need to receive and forward feedback to the athletes about their performance (1). This research attempted to answer the question of whether there are statistically significant differences between the four national teams of the first group at the 2014 FIFA World Cup in eighteen characteristics of the attack phase. Statistically significant differences are expected between the National teams that advanced to the knockout phase and those that did not.

Methods: A total of 12 matches were analyzed, 3 matches for each National team. The characteristics of the attack phase were analyzed: ball possession, active playing time, corners, shots on goal and shots on goal were compared. Ball possession was measured at the level of the entire game, then by zones of the field: defense, attack organization and attack, and also for three fields within each zone: A1, A2, A3, B1, B2, B3, C1, C2 and C3. The Kruskal Wallis test was used to examine differences at the group level, and the Mann Whitney test was used to compare pairs of representations.

Results: At the group level using the Chi-Square test and based on the value of the statistical significance level $p \leq 0.05$, it can be concluded that no statistically significant differences were found between the national teams: Brazil, Mexico, Croatia and Cameroon in the analyzed characteristics of the attack phase. However, when comparing pairs of national teams using the Mann Whitney test, statistically significant differences were found between the national teams of Brazil and Mexico in shots on goal $p = 0.050$ and between the national teams of Brazil and Cameroon in total ball possession $p \leq 0.050$, active playing time $p \leq 0.050$ and shots in goal frame $p \leq 0.050$. Among the other pairs of representations, no statistically significant differences were found.

Conclusions: No statistically significant differences were found in most of the 18 characteristics of the attack phase between the National teams of the first group that qualified for the knockout phase of the 2014 World Championship and the National teams that did not qualify for the rest of the competition.

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Is there synchrony in the most demanding passages of the soccer players during competition?

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Background/aim: The objective of this study was to analyse when and in what way the most demanding passages (MDP) of the soccer players are synchronized throughout the match.

Methods: Eight official league matches of a semi-professional football team belonging to the Women's Second Division of Spain were analysed. To calculate the MDP (using a 1-minute rolling average) the following physical variables were recorded: total distance (TD), high-speed running distance (HSR, >19 km/h) and acceleration distance (ACC, >2 m/s²). The 100% of MDP actions were calculated for each player in each half of the match. Players were monitored with WIMU PRO devices using Global Positioning System technology. Descriptive statistics were obtained to show how often the MDP occurred within each half. Differences between the duration of synchronies were tested by a one-way ANOVA analysis of variance, using post-hoc Bonferroni's test ($p < 0.05$).

Results: In TD there were 28 (23.9%) individuals, 6 (5.1%) doubles, 7 (6.0%) triples and 4 (3.6%) quadruples or more MDP in the first half (1H), and 47 (40.2%) individuals, 15 (12.8%) doubles, 5 (4.3%) triples and 5 (4.3%) quadruples or more in the second half (2H). In HSR there were 42 (29.4%) individuals, 10 (7.0%) doubles, 5 (3.5%) triples and 1 (0.7%) quadruple or more MDP in the 1H, and 64 (44.8%) individuals, 16 (11.2%) doubles, 4 (2.8%) triples and 1 (0.7%) quadruple or more in the 2H. In ACC there were 49 (30.1%) individuals, 13 (8.0%) doubles and 2 (1.2%) triples MDP in the 1H, and 86 (52.8%) individuals, 11 (6.7%) doubles and 2 (1.2%) triples in the 2H. No significant differences were found in the duration of the synchronies with mean values between 43.3-50.7 s in TD, 48.8-57.0 s in HSR, and 35.0-45.5 s in ACC.

Conclusions: Most MDP actions are individual (74%) and occur in the 2H. Regarding the MDP synchronies, most of them are doubles and also occur in the 2H, except for the ACC variable. Therefore, it should not be neglected that the MDP must be trained considering also the simultaneity of the players.

Match running performance in elite soccer: comparison between successful and unsuccessful teams.

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Background/aim: Numerous investigations have examined the relationship between physical performance and match outcomes (1)(2). The results are conflicting as Rampinini et al, (1) found that in elite Italian soccer, less successful teams covered more distance and high-intensity running than successful teams. However, Di Salvo et al, (2) reported that players in the 2nd tier of English soccer (Championship) had higher physical performances than the top tier (English Premiership). The aim of the current study was to investigate whether successful teams had higher physical performances than unsuccessful teams.

Methods: Data was obtained from 476 individual matches from 571 soccer players (26.3 ± 1.1 years) from 28 MLS teams. Data was collected across the 2022 regular season. Goalkeepers were excluded from the study. Individual data from players were divided into two groups according to their final league position. Teams that made the MLS playoffs (Top 14 teams) were classified as 'Successful' teams (n=274) and teams that did not make the MLS playoffs (Bottom 14 teams) were classified as 'Unsuccessful' (n=297). Measures of physical performance include Total Distance covered (m), High-speed running (m) (>20km.h⁻¹), sprint distance (>25.2km.h⁻¹), number of sprints and max speed (m/s). These metrics were collected via optical tracking system (Second Spectrum, California, USA). Statistical significance was set at P<0.05.

Results: The findings from the current study show a significant difference between successful and unsuccessful teams. Unsuccessful teams covered more distance than successful teams (p=0.002) while successful teams had higher levels of sprints distance (p=0.014) and number of sprints (p=0.011).

Conclusions: The main findings of the study are that unsuccessful teams cover more total distance than successful teams while successful teams have greater sprint distance and number of sprints. The results do suggest the importance of high-intensity running such as sprinting in elite soccer.

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Poster presentations

The Utilisation and User Experience of Data in Elite Gaelic Football.

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Background/aim: The need for data and evidence to support the decision-making processes within this sporting organisation has never been higher, with an increase in type and volume of high-quality technology to assist in improving performance. The aim of the present study was to evaluate the use of and user experience of data in elite Gaelic football.

Methods: Specific challenges in relation to the collection, storage, and communication of data within Gaelic football are identified and assessed integrating the role of technology, by assessing the current knowledge of leading practitioners within the sporting organisation. The methodological approach followed in the current study was an exploratory-correctional scope using semi-structured interviews questions followed by a thematic analysis of experienced practitioners. By investigating how practitioners gather, analyse, and communicate their data, we can better understand the individual and organisational factors that make data literacy practices within the sporting domain productive and practical.

Results: The results highlight the need for and possible lack of basic data analyses measures and expertise to generate these analyses. Appropriate data feedback system in the organisation are in their infancy. Practitioners wish to ensure all stakeholders are informed of the decision-making process. Operations to do so must be time efficient which can be done through centralisation. The need for consistent technology to help with data collection and fluency in all departments is required.

Conclusions: The findings of the present study present opportunities for practitioners and coaching staff alike in Gaelic football to consider the influence of organisational and technological contexts on data practices. The pilot work can guide the next stages needed to understand such nuances to develop experiences and learning tools for data literacy within the domain.

CiteSpace-based analysis of the research situation of China's soccer reform.

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Background/aim: The year 2022 marks the 30th anniversary of China's soccer reform, during which various experts and scholars produced a large amount of soccer-related literature.

Methods: In this study, we analyzed and sorted out the development pulse, research hotspots and frontiers of Chinese soccer research in the past 30 years by visualizing 5603 core journal documents about soccer in the Chinese literature database CNKI.

Results: In the visualization analysis through CiteSpace visualization software, the most frequently occurring keywords are "soccer", "campus soccer" and "World Cup". We can see that there are more studies on these three keywords. From the keyword occurrences, it can be seen that "school soccer" and "school sports" have continued since the outbreak in 2015, and the intensity of the outbreak is large and the number of studies is large. This is mainly due to the introduction and implementation of "school soccer" in 2015, which has led to a surge in research intensity. "Physical education" is also a hot topic of research since its outbreak in 2014. As shown in the graph of authors, Zhang Ting'an has published 67 articles, Gong Bo has published 40 articles, and Yang Yimin has published 38 articles. The scholars such as Zhang Ting'an, Zhou Yi and Gong Bo have a strong intermediary centrality and form a complete knowledge network through close cooperation with other related scholars. The number of articles published by institutions shows that Beijing University of Physical Education (341 articles) and Shanghai Institute of Physical Education (332 articles) are far ahead of other institutions, followed by 153 articles published by Guangzhou Institute of Physical Education. Meanwhile, Beijing University of Physical Education, Shanghai Institute of Physical Education and the Institute of Sports Science of the State General Administration of Sport have strong intermediary centrality and close cooperation with other institutions.

Conclusions: In recent years, Chinese football-related research has mostly focused on "school soccer" and "school sports", with a focus on the development of reserve talents. In the future, the various fields of research can exchange and cooperate with each other to promote the development of soccer. This study provides theoretical and data reference and reference for the subsequent studies.

Reliability and validity of Polar Team Pro and Playermaker in outdoor and indoor situations.

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Background/aim: Elite sport athletes often use global positioning systems (GPS) and/or inertial measurement unit (IMU) systems to quantify physical variables during training. More studies are needed to compare both systems, taking into account that both are frequently used to measure physical load. The purpose of this study was to test reliability and validity of measurements made by Polar Team Pro and Playermaker on velocity, and distance run at different intensities in outdoor and indoor conditions.

Methods: In three test sessions in total 4 subjects (age 30.0 ± 5.1 years, body mass 76.3 ± 5.3 kg, body height 1.79 ± 0.09 m) performed 100m runs with different prescribes intensities varying from 8 to 24 $\text{km} \cdot \text{h}^{-1}$. The 100m runs were performed in a straight-line or in a square under outdoor and indoor conditions.

Results: For all conditions, both Polar Team Pro and Playermaker was underestimating the total distance compared with the actual distance. Also, PlayerMaker underestimated the average velocity which increased with increasing intensity while Polar Team Pro overestimated average velocity at 8 $\text{km} \cdot \text{h}^{-1}$. Furthermore, there were no difference in estimated average velocity by Polar Team Pro at any other intensities except at 20 $\text{km} \cdot \text{h}^{-1}$ of which was underestimated by 2%. Reliability between the sensors was good with a coefficient of variation (CV) of $<2\%$ for all conditions except when measuring Polar Team Pro indoor (CV= $\sim 10\%$). Intraclass correlation (ICC) within the sensors varied from 0.47 to 0.99 and significantly lower ICCs were found at 8, 10 and 12 $\text{km} \cdot \text{h}^{-1}$ compared with the other three intensities. ICC increased significantly at 20 $\text{km} \cdot \text{h}^{-1}$ compared with the rest when all other factors were taken together. Post hoc comparison revealed that the ICC for velocity and distance at the square indoor situation was significantly higher than during the other two conditions and that the ICC at the straight-line condition was significantly higher for PlayerMaker compared with the Polar Team Pro.

Conclusions: Both systems provides acceptable validity of total distance, despite a small underestimation of the actual distance for all conditions. Furthermore, the validity of distances in different intensities seems to worsens with increasing velocities. Polar Team Pro have poor validity and reliability in indoor conditions. For outdoor conditions both systems provides good reliability between the sensors. The reliability within the sensors varies with different velocities.

Analysis of the impact of travel distance on team's running performance in Chinese Super League.

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Background/aim: Elite soccer players are increasingly required to travel for away matches domestically and internationally, often resulting in travel fatigue, which further affects their physical performance. Despite previous research pointing out that travel has an impact on physical performance, understanding the effects that different mileage traveled by teams may cause, needs more attention. Therefore, the aim of this study is to investigate how the length of traveling affects a team's running performance.

Methods: The material consisted of 221 observations of 16 teams in the context of matches played at the 2017 Chinese Super League. First, the k-means cluster for quantitative variables was used to establish cut-off point values for the traveling distance of each team. Then, three clusters were identified for this variable establishing long-distance traveling team (LD) (n=46), medium-distance traveling team (MD) (n=96), and short-distance traveling team (SD) (n=79). Differences among categories were calculated using the Kruskal–Wallis H test. Then a post-hoc Conover–Iman test was performed when a significant effect size was found.

Results: Teams with different travel distances have significant differences in indicators: first-half sprint (1stS), first-half high-intensity running (1stHR), first-half sprint in possession phase (1stSIP), second-half sprint in possession phase (2ndSIP), full-time sprint in possession phase (FSIP), first half sprint out of possession (1stSOP), first half high-intensity running out of possession (1stHROP), and second half injury time high-intensity running (2ndIHR). Specifically, the distance covered by LD in 1stS and 1stHR was significantly less than SD ($p=0.013$), MD ($p=0.006$) and SD ($p=0.033$), MD ($p=0.018$), respectively. Compared with MD in 1stSIP ($p=0.01$), 2ndSIP ($p=0.03$), FSIP ($p=0.39$), and 1stSOP ($p=0.047$), the distance covered by LD was significantly less. The distance covered by LD in the 1stHROP and 2nd IHR was significantly less than SD ($p=0.045$), MD ($p=0.040$) and SD ($p=0.015$), MD ($p=0.007$), respectively.

Conclusions: Long-distance traveling may reduce the running performance of the team in the Chinese Super League. Short and medium distances traveling had no significant effect on the team's running performance. Coaches could use this information for targeted training and physical preparation.

Contextualization of individual tactical efforts with reference to players' positions.

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Background/aim: Futsal is a team sport distinguished by its fast pace and a myriad of physical, psychological and tactical – technical parameters that sustain team performance 1. Due to space and time constraints, futsal can be classified as a high-intensity intermittent sport in which players perform high-intensity activities (HIA) to change their speed or direction, as well as high braking events 1.

Aim: The purpose of this study was to contextualize players' HIA with individual tactical actions during match play with special reference to the characterization of playing positions.

Methods: Tracking data was obtained using local positioning system devices from 19 male players of an elite futsal team across seven competitive matches (n=4234 observations). HIA measures included high-intensity acceleration (ACC; $\geq 3 \text{ m}\cdot\text{s}^{-2}$), high-intensity deceleration (DEC; $\geq 3 \text{ m}\cdot\text{s}^{-2}$) and high-speed running distance (HSR; $\geq 18 \text{ km}\cdot\text{h}^{-1}$). Video-match analysis was used to code players' physical performance and 16 individual tactical actions (with and without the ball) following synchronization of tracking data and match footage. The association between HIA and tactical actions were determined using a chi-square test. A Pearson one sample chi-square test was used to investigate the relationship between HIA within each individual tactical action 2.

Results: A small statistically significant association was observed between HIA and players' actions (with or without the ball; $\chi^2 = 183.27$ (2, N=4234), $p < .001$; Cramer's $V = 0.21$). In general, tactical actions with the ball consisted of significantly greater DEC efforts than both ACC and HSR. However, ACC efforts were significantly greater during tactical actions without the ball than DEC and HSR. Similar trends were observed within each playing position during with ball actions. However, distinct performance profiles were observed between positions during without the ball tactical actions specifically according to marking ball and opposition trajectories and supporting movements. While no statistically significant differences were observed.

Conclusions: Our results demonstrate that HIA in elite futsal are associated with specific tactical actions which have distinct mechanical and kinematic effort profiles. Further, the frequency and type of individual tactical actions vary according to playing positions. Thus, distinct player and position tactical action profiles should be considered to inform training design to prepare players more effectively according to their specific roles during the match.

Validation of the widely used wellness questionnaire items in soccer.

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Background/aim: Athlete Self-Reported Measures (AROMs) are widely used in soccer and research to measure the training response with a dramatic increase in the last years. Whilst there are many AROMs and measurement tools available, the most commonly used are the single or 'wellness' items, but most have not been properly validated or validated at all. Therefore, there is a urgent need to develop and examine the validity of instruments adopted by practitioners for daily monitoring.

Methods: More than 300 team sport athletes (mainly soccer players) volunteered to take part in this cross sectional web-based study to investigate construct validity of 5 single items' questionnaires investigating fatigue, sleep quality, muscle soreness, stress and mood. Of these participants, 49 completed the survey a second time under the same conditions to investigate reliability. Exclusion criteria was < 18 years. Data is being collected and managed between January 2023 and May 2023 using Qualtrics. The survey was advertised through social media and industry contacts. The survey was voluntary, with no monetary incentives.

Results: Fatigue, Sleep Quality and Muscle Soreness scales suggest a very strong correlation with the related validated single items. Sleep Quality also appear to have a strong correlation with the GSQS but not with the GSDS (weekly report).

The multifactorial constructs as stress and mood reveal a significant relationship as well.

Specifically, DASS Stress and BRUMS Tension are positively related with the Stress scale; Depression and Total Mood Disturbance appear to be positively related with the Mood scale.

Conclusions: The findings of this study suggest that these single items questionnaires provides a simple and noninvasive method for the daily measurement of acute training effects. Every scale should be analyzed on its own as "wellness" appears to be an incorrect construct.

Future studies should increase the psychometric quality of the scales for a higher construct validity.

Locomotor intensities in soccer: differences in first and second half considering playing position.

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Background/aim: One of the major challenges in soccer is building training exercises that allow players to be confronted with real match intensities. Total distance (TD) and High-Speed Running (HSR) are key locomotor determinants that affect players' performance. The purposes were to analyze the TD and HSR considering different intensities (i.e., 1, 3, 5-minutes, and total) and to investigate the change in the TD and HSR between the 1st and 2nd half of the match, considering the intensity intervals and each sectorial position.

Methods: A professional team from the 1st Portuguese league was monitored during a soccer season in 32 matches. 5 defenders, 3 midfielders, and 2 forwards entered the database independently for each game, making up a global sample of observations in 125-defenders, 94-midfielders, and 80-forwards. Players' TD and HSR were monitored using 10-Hz GPS (Apex pro series, StatSports). A mixed between-within-subjects analysis of variance was conducted to assess the impact of sectorial positions on TD and HSR across 1st and 2nd half.

Results: In TD, there was a significant interaction between sectorial positions and the 1st and 2nd half: 3-minute ($p=.019$, $r=.03$), 5-minute ($p=.025$, $r=.03$), and total ($p<.0001$, $r=.24$). There was a substantial main effect for the 1st and 2nd half: 3-minute ($p<.0001$, $r=.23$), 5-minute ($p<.0001$, $r=.32$), and total ($p<.0001$, $r=.49$), with lower total distances seen in the 2nd half. The main effect comparing the 3 sectorial positions was significant in 1, 3, and 5 minutes and total ($ps<.011$; $.03>r<.31$).

In HSR, there was a significant interaction between sectorial positions and the 1st and 2nd half in total ($p<.0001$, $r=.17$). There was also a substantial main effect for the 1st and 2nd half: 3-minute ($p=.0001$, $r=.04$), 5-minute ($p<.0001$, $r=.08$), and total ($p<.0001$, $r=.49$), with lower HSR seen in the 2nd half of the match. The main effect comparing the 3 sectorial positions was significant in 3, 5, and total ($ps<.0001$; $.05>r<.16$).

Conclusions: TD and HSR were significantly lower in the 2nd half. The changing pattern of the sectorial position was different throughout the match. The defenders showed the lowest TD and HSR. This study brings new insights into training targets' intensity loads according to sectorial positions.

Training load monitoring: practices and perceptions of soccer coaches in Zimbabwe.

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Background/aim: The purpose of the study was to examine the practices and perceptions of monitoring training loads among soccer coaches in Zimbabwe.

Methods: A total of 75 soccer coaches (66 male and 9 female; Mage = 42.70, SD = 7.28; Mexperience = 5.88, SD = 3.02) took part in the study. A questionnaire developed by Weston (2018) was used to assess factors that influence planning of training, training load practices, and training load feedback and usefulness among Zimbabwean coaches. Coaches accessed and completed the questionnaire using google form via a shared link through email and other social media platforms.

Results: The findings indicated that most clubs do not have a sports science department (81%). There was an agreement that coaches were mostly and completely responsible for planning training than sports scientist. Coaches agreed that the purpose of monitoring training loads was to maximise performance (60%). Coach perception (55%) was considered as the commonly used training load monitoring methods. The results showed that coach perception (29%), GPS (24%) and sports science (21%) were some of the methods used to monitor training loads. Although there was no significant difference if the clubs have proper equipment for monitoring training loads, most coaches indicated that clubs do not have proper equipment.

Conclusions: This study showed that there is limited knowledge among coaches on practices and perceptions of monitoring training loads. There is a need for coaches to buy-in and appreciate the usefulness and effectiveness of monitoring training loads.

Relationship between vertical stiffness and workload.

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Background/aim: To optimize load in elite sports, monitoring strategies to evaluate fatigue status are needed. Submaximal tests are now widely used in team sports, as they are time-efficient and easy to administrate. Standardized running tests (box to box runs) are a valid tool to assess neuromuscular status of players through the calculation of vertical stiffness (Kvert) (1). However, the sensitivity of Kvert to changes in training load remains unknown. Therefore, the current study aims to evaluate players' Kvert responses in relation to weekly training loads.

Methods: Sixty elite soccer players (First team=32; U19=28) were involved. The submaximal test consisted of four 70m runs paced at ≈ 21 Km/h with 33 seconds of recovery between trials. Kvert was calculated (2) and normalized based on running speed. Z-score transformation was employed to evaluate individual player Kvert variation.

External training load was collected during training and matches using GPS system (WIMU Pro device). The following parameters were extracted: total distance (TD), distance above 19.8 km/h ($D > 19.8$), distance above 25.2 km/h ($D > 25.2$), number of sprints above 25.2 km/h (N°Sprints) and mechanical work (MW). For each GPS variable, the weekly load (WL), week-to-week variation (W-W) and acute:chronic load (A:C) were calculated. A generalized linear model analysis was performed. The GPS variables were used as independent variables, while Kvert was used as dependent variable.

Results: WL, W-W and A:C above 19.8 km/h were significantly ($p < 0.05$) associated with a reduction of the z-score ($\beta = -0.185, -0.141, -0.499$, respectively). The A:C $D > 25$ and the N°Sprints showed a positive impact ($p < 0.05$; $\beta = 0, 189, 307$, respectively).

Conclusions: The results showed that Kvert was sensitive to weekly load. Particularly, a very high $D > 19$ load induced a significant decrease in the neuromuscular status, while N°Sprint and A:C $D > 25$ increased it. Practitioners should monitor $D > 19.8$ as it seems the variable most related to neuromuscular fatigue in football players, and avoid high increase in it to avoid fatigue. However, programming sprint training should have an impact on players stiffness and could be beneficial for performance.

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An investigation of dietary intake in academy football players: evidence of in-season periodisation.

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Background/aim: Recent evidence in English youth football players has indicated relative homogeneity in energy intake (EI) and expenditure (EE) (1). However, further analysis demonstrated trends of sub-optimal macronutrient intake (MI), predominantly resulting from inadequate carbohydrates (CHO) to satisfy the dynamic training/match demands. Training loads (TL) within football microcycles are dynamic (2), warranting the periodisation of dietary strategies to correspond to work demands. Therefore, the aims of the current study were to identify if training periodisation was evident within football academies, and subsequently to quantify dietary intake relative to these findings, to identify if dietary periodisation was both present, and/or necessary.

Methods: Seventeen male players from an English Category 1 academy took part in this study (under [U] 18, n = 8; U15/U16, n = 9). Total EI and MI were quantified using a 7-day written food diary, supplemented with the use of images via a smartphone application. Pitch and gym TL were recorded via global positioning system (GPS; StatSports, Ireland) devices and ratings of perceived exertion (RPE), respectively.

Results: One way analysis of variance (ANOVA) indicated significant main effects of day on training outputs (total distance, high intensity distance, and volume of accelerations) in both groups ($p < .05$). Independent samples T tests indicated greater mean absolute and relative protein intake in the U18 group compared to the U15/U16 ($p < .05$), while mean absolute and relative CHO intake was higher in the U15/U16 group ($p < .05$). Within groups ANOVA data also showed mean EI, absolute and relative CHO intake to be significantly greater in the U18 group on match day ($p < .05$) compared to other training days, however this wasn't present in the U15/U16 group for EI ($p = .351$), nor absolute ($p = .659$), or relative CHO intake ($p = .722$).

Conclusions: There is evidence of training periodisation within academy football, and some indication that nutritional strategies were aligned by manipulating MI accordingly. Dietary periodisation appeared evident with EI significantly greater on matchday, likely due to deliberate increased CHO intake. Estimated EI and CHO intake were markedly below literary recommendations; however, this may reflect under-reporting which should be considered if similar measurement tools are used in similar populations. Future research may seek to build upon these findings by analysing meal distribution of EI and MI to further identify if nutritional strategies are optimal to support performance/adaptation.

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In-season internal training load in elite Norwegian women's football.

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Background/aim: The structuring of training during in-season is of great interest to coaches and sport scientists. However, to date only a few studies have described the in-season internal training load in elite women's football (1). Thus, the aim of this study was to describe in-season weekly training cycles of various lengths in elite women's football using subjective session-RPE (s-RPE).

Methods: We collected daily s-RPE (RPE x duration) data from two elite teams in two seasons, split into cycles depending on the number of days between matches.

Only starting outfield players in the previous match were included. Missing s-RPE on match day (MD) +1 or MD+2 in a training cycle with more than 4 training days, was set as 0. Otherwise, observations were excluded if missing. The final dataset consisted of 2213 observations from 35 players. A linear mixed model estimated the interaction between day and cycle length, with player ID set as a random effect. Post-hoc comparisons were done using Tukey's HSD.

Results: Longer cycles (>5-day turnover) included at least one day in the midweek (MD+3, MD+4) with higher ($p < 0.001$) s-RPE compared to recovery days (MD+1 or MD+2), ranging from 510 [CI: 129-891] AU in a 5-day turnover to 640 [CI: 539-741] AU in an 8-day turnover. Furthermore, s-RPE was also higher ($p < 0.001$) in the midweek compared to tapering days (MD+5-7), ranging from 345 [CI: 247-444] AU in a 6-day turnover to 571 [CI: 450-693] AU in an 8-day turnover. Finally, tapering days (MD+5-7) were also higher ($p < 0.001$) in s-RPE compared to recovery days, between 72 [CI: 46-190] to 204 [CI: 103-305] AU, but lower ($p < 0.001$) in s-RPE than midweek days, from -196 [CI: -90-(-302)] to -357 [CI: -265-(-451)] AU.

Conclusions: Our data shows that Norwegian elite women's teams follow a horizontal alternations in s-RPE, adjusting the load based on the day and cycle length.

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Relationship between external and internal load and fatigue in HIIT and SSG trainings.

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Background/aim: Combining a variety of effective and time-optimized training strategies, such as High Intensity Interval Training (HIIT) and Small Sided Games (SSG) is very important for trainers and motor preparation trainers. The aim of the research was to determine the relationship between the development of fatigue and the player's load during HIIT and SSG trainings.

Methods: The study involved 24 football players from U-18 youth team of one of the leading football clubs from Wrocław which participates in the macroregional league competitions. The players were randomly assigned to 2 research groups: HIIT and SSG. Trainings procedures: - HIIT: 3 sets, 6 x (15s / 15s) - one set / 3 min restitution after each set, intensity: 90-100% HR max. SSG – 3 x 3 + goalkeeper + "neutral": 3 sets (3 min effort – one set / 3 min restitution after each set), intensity: 90-100% HR max. Trainings were monitored using Rating Perceived Exertion (RPE), wellness questionnaires, restitution index (WSR), „Catapult Sports” GPS system; parameters of the external load (Catapult Player Load - CPL) and internal load (Heart Rate Exertion - HRE). The research project took 4 weeks mesocycle with two training units per microcycle.

Results: The main findings in HIIT group: positive, high correlation between CPL and fatigue ($r = 0.53$) on the post-training day; positive, average correlation between CPL and muscle pain on the post-training day ($r = 0.48$). In the SSG group, there was a positive, high correlation between HRE and fatigue ($r = 0.51$) on the post-training day. Conclusion: When analyzing the wellness questionnaires and training load during HIIT interventions it was shown that the higher the CPL the greater the fatigue and muscle pain on the post-training day. However, during the SSG intervention, it was shown that the higher the HRE, the greater the fatigue on the post-training day.

Conclusions: To sum up, the holistic approach to monitoring of the training process gives the trainers the possibility of a multidimensional view on the relation between training and the athlete's body. It demonstrates the possibility of combining simple monitoring methods with advanced technology and the mutual relationship between them. As a result, trainers and people involved in training athletes can optimize the training process more effectively.

Are the External Loads influenced by a Team's Tactical Formation?

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Background/aim: One of the most discussed topics in the last few years amongst sports science researchers in soccer is which playing formation is best for obtaining the best results. Playing formations cannot tell us all about the team's dynamics, but they can affect the game's positional requirements. This study aimed to answer if the playing formation is, in fact, a determinant of the gameplay when it comes to external load metrics. Also, it investigated the differences in each external load metric considering playing positional roles and tactical formation.

Methods: This study analyzed the external load metrics of 22 professional soccer players from one team participating in the Portuguese First League. The age of this group was 25.7 ± 3.3 years old. We considered in the analyses players that completed at least the first half of the game (45 minutes or more). This study collected data from one season (33 matchdays, 2018-2019). A 10-Hz GPS Unit recorded the matches' external load (Evosports Catapult, Melbourne, Australia). Relatively to positional roles, it was considered four full-backs (FB), four central defenders (CD), seven central midfielders (CD) (including defensive and offensive midfielders), five wingers (WIN), and two strikers (ST). Concerning tactical formation, we considered 20 match days of 1-4-3-3 and 13 matchdays of 1-4-4-2.

Results: This study analyzed the external load metrics of 22 professional soccer players from one team participating in the Portuguese First League. The age of this group was 25.7 ± 3.3 years old. We considered in the analyses players that completed at least the first half of the game (45 minutes or more). This study collected data from one season (33 matchdays, 2018-2019). A 10-Hz GPS Unit recorded the matches' external load (Evosports Catapult, Melbourne, Australia). Relatively to positional roles, it was considered four full-backs (FB), four central defenders (CD), seven central midfielders (CD) (including defensive and offensive midfielders), five wingers (WIN), and two strikers (ST). Concerning tactical formation, we considered 20 match days of 1-4-3-3 and 13 matchdays of 1-4-4-2. Across the 33 matchdays, the team won 12 times, lost 18 times, and tied 3 times. In this study, we only consider winning or losing. The results suggest that during a whole season, it was not verified any significant difference in total distance, distance covered in Z5 (18 to 23,9 km/h-1), distance covered in high-intensity (>24 km/h-1), or maximum speed between the two team's tactical formations (1-4-4-2 Versus 1-4-3-3). However, there was a statistically significant difference at $p < .05$ level in all external loads' metrics attending to player position in both teams' tactical formation.

Conclusions: The results obtained in this study seem to support that tactical formation does not directly influence the external loads of the players. It may suggest that tactical formation is not as

important as team strategy and dynamics, which can vary according to unforeseen emergent situations, opponents' dynamics, or even the team's characteristics.

Effective playing time affects physical match performance in soccer: A position-specific analysis.

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Background/aim: This study aimed to analyze the influence of effective playing time on physical match performance according to playing position in professional soccer.

Methods: Official match data from 267 matches (3,731 single observations) during the 2018/2019 season of the German Bundesliga were used and the effective playing time (duration of play after subtracting the time taken up by stoppages, substitutions, injuries, and goals) was captured for each match. The physical match performance parameters total distance, high-intensity distance, sprinting distance, maximum velocity, and accelerations were analyzed. Players were categorized as central defender, wide defender, central defensive midfielder, central offensive midfielder, wide midfielder, and forward.

Results: Effective playing time influenced physical match performance, with total distance and accelerations ($r=0.48-0.61$) being the most and high-intensity distance, sprinting distance, and maximum velocity ($r=-0.17-0.03$) the least affected parameters, respectively. Players covered on average 10% more total distance and performed 13% more accelerations, while sprinting 7–10% less in matches with high (>65 min) compared to low (<50 min) effective playing times. The influence of effective playing time was rather similar between playing positions. Still, physical performance of wide midfielders and forwards partly deviated from the pattern observed in the other positions.

Conclusions: Coaches and practitioners should be aware that effective playing time influences physical match performance in the German Bundesliga, while special attention should be given to wide midfielders and forwards. Effective playing time and its general and position-specific effects should be taken into account when interpreting physical match performance, thereby facilitating load management practices and training design (1).

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Is accumulated workload an injury indicator when comparing to other players of the same position?

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Background/aim: Hamstring tears are the most common injuries in football (1), which can have significant economic and absenteeism impacts on professional football (2). Managing workload is essential in reducing the risk of overuse hamstring injuries (3). The aim of this study is to analyze the influence of various GPS variables related to workload on hamstring injuries.

Methods: A longitudinal study was conducted over a period of four years (2018-2022) to analyze 20 hamstring injuries that occurred in a professional football team. External load variables, as measured by GPS, were recorded for each participant with a hamstring injury, who was classified as an "injury player." The external workload of each injury player was analyzed for four different time windows before the injury: 7 days; 14 days; 21 days; 28 days. A "non-injured group" was created by adding players from the same position as the injured players. The normality distribution and homogeneity of variance were tested using Kolmogorov-Smirnov and Levene's tests, respectively, and no normal distributions were found. A Kruskal-Wallis test for independent samples was performed on the variables total distance (TD), high-speed running (HSR), acceleration distance (ACC), deceleration distance (DCC), and explosive distance (EXPD). The accumulated load for the four weeks was analyzed and compared between the injured group (n=20) and the non-injured group (n=183).

Results: Results showed no significance difference in mean differences between the injured group and the non-injured for any of the variables analyzed.

Conclusions: Accumulated workload between players of the same position is not an effective indicator to predict injuries. Practitioners should focus on comparing intra-player workload changes rather than comparing the team workload as an indicator of overload.

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Fitness coaches in professional soccer: A qualitative study.

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Background/aim: Physical trainers are in charge of managing the load, to optimize performance and lower the risk of injury. However, information regarding how they operate in practice is scant. This study inquired about the work carried out by physical trainers in professional soccer.

Methods: Eight physical trainers from different from European and South American professional leagues were interviewed, using a semi-structured interview. The interview was structured to extract information concerning three topics: (1) the evaluation of physical abilities; (2) monitoring and control of training; and (3) injury prevention. The interviews were then videotaped, transcribed, and analyzed using a content analysis approach (using Nvivo software).

Results: The results obtained suggest, in the first place, that the physical capacities are evaluated at the beginning of the season, trying to replicate this process during the competitive period in a partial and general way, if possible. Second, for training monitoring and control, the perception of exertion scale is widely used to estimate the internal load, while for the external load the use of the Global Positioning System (GPS) is common. Third, all physical trainers design and apply complementary programs to prevent injuries or optimize physical capacities, which generally had a multicomponent format.

Conclusions: This evidence can be used as a point of reference, to understand what elements must be mastered by future physical trainers who want to enter professional soccer, who do not have experience and who aspire to improve the way they operate on the field.

Keywords: physical abilities, evaluation, monitoring and control, injury prevention, optimization, professional football.

Effect of menstrual cycle phases on physical performance in elite women soccer players.

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Background/aim: The impact of the menstrual cycle (MC) on performance is one of the most critical topics in female sports. Hormonal fluctuation and symptoms related to different MC phases can influence performance in professional women soccer players. Indeed, as reported in previous studies, this fluctuation seems to affect parameters related to internal and external load (1). To date, different studies tried to investigate this phenomenon, but results are still unclear. The aim of the present study was to investigate the effect of different menstrual phases on distinct performance parameters in a professional women soccer player during official matches in the Italian first division.

Methods: Twenty-five female soccer players (Age: 23.59 ± 4.11 yrs; Height: 1.67 ± 0.05 m; Weight: 62.44 ± 4.56 kg) were involved in the current study. Players were grouped according to the MC phases. Three different phases were identified: Follicular (days 1-12), Ovulation (days 13-15), Luteal (days 16-28) phases. Information about MC Phase, recovery status, quality of sleep, stress, fatigue, and muscle soreness was recorded by adopting a morning survey. External load parameters were collected during matches using GPS system (WIMU Pro device). At the end of each match, the rating of perceived exertion (RPE) was recorded. The players that played for at least 45 minutes were selected, and the GPS data were normalized by duration of play. One-way ANOVA, followed by Bonferroni post-hoc, was performed to analyze differences between the three MC phases for all the parameters collected.

Results: Distance above 14 km/h per minute (D14/min) was significant highest ($p < 0.05$) in the luteal phase and total distance per minute (TD/min) showed a statistical trend ($p = 0.058$) increase in the luteal phase

Conclusions: A greater running intensity above 14 km/h in the luteal phase in female soccer players was evidenced by our results. As reported in previous studies, the distance covered above 14 km/h is highly correlated with the Yo-Yo intermittent recovery test, commonly performed to evaluate the aerobic-fitness level of soccer players. We can speculate that this variation in aerobic performance was related to the high levels of progesterone and estradiol of the luteal phase. This result highlights the important role of female sex steroid hormones as determinant of aerobic performance of women soccer players in different phases of MC.

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Measuring net energy expenditure in football using indirect calorimetry and GNSS.

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Background/aim: Energy expenditure (EE) is one of the most reliable indexes of internal load during endurance exercises. A doubly-labelled water study previously showed the total EE, including the basal metabolic rate, in professional football players. The net EE in football is conventionally estimated using the heart rate response. The objective of the present study was to obtain the net EE in football using an indirect calorimeter and the global navigation positioning system (GNSS) through an experimental small-sided football game.

Methods: Ten male collegiate football players participated in the present study. The experiment consisted of a resting period, warm-up period, and football period. All participants first performed a standardized warm-up; thereafter, the net EE was obtained by calculating the deviation between two experiments. The EE was also calculated using GNSS outcomes according to the equation of di Prampero (1). During the football period, a small-sided football game took place for a total playing time of 10 min in an outdoor natural grass court (25×42 m); each team comprised four outfield players and one goalkeeper. The participants wore both a calibrated indirect calorimeter (Metamax-3B, Cortex) and a validated GNSS device (SPI-pro X, GPSPORTS) continuously throughout the experiment.

Results: During the football game, the net EE measured by the indirect calorimeter was 35 to 45 mL/kg/min. The EE was positively associated with the time for a moderate-speed run (7 to 15 km/h) and high-speed run (>15 km/h) and the average acceleration ($p < 0.05$) and was negatively associated with the time for walking (<7 km/h, $p < 0.05$). The EE assessed by the indirect calorimeter and GNSS outcomes (di Prampero's equation) did not differ significantly and were strongly correlated ($r = 0.80$, $p < 0.01$).

Conclusions: The present study demonstrates that the EE of a small-sided football game is 11 to 14 metabolic equivalents using an indirect calorimeter. Furthermore, the EE estimated using the GNSS is consistent with that estimated using an indirect calorimeter.

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The VO₂max and performance in youth football: influence on training and competition indicators.

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Background/aim: Football is a modality of intermittent intensity, inserted in the collective sports games (1), which requires an adequate physical condition to obtain a successful performance in the techno-tactical and psychic dimensions (2). In a football match, the contribution of aerobic metabolism is fundamental, where maximal oxygen consumption (VO₂ max) stands out as the physiological variable that best describes the functional capacity of the respiratory and cardiovascular systems (3). The aim of study was to evaluate the relationship between maximum oxygen consumption and the time played, game position and the attractor player.

Methods: 22 male athletes participated in the study (17.09 ± 0.6 years; 67.9 ± 8.3 kg; 176.8 ± 7.1 cm) football players from the Sport Clube Vila Real U19 during the 2019/2020 sports season. All players performed the Yo-Yo IR2 test, validated for football players at the competitive level of the sample.

Results: Maximum and minimum values (VO₂ max) of 57.3 and 51.3 ml/min/kg (respectively) were verified with an average of 52.9 ± 1.68 ml/min/kg. There was a high dispersion in the position of Medium in the relationship between VO₂ max. and the general position, as well as, in the relation between the variables VO₂max and the volume of game. A possible trend was verified in the midfield and forward positions, where the players with the highest average of VO₂max stood out more often as attracting players.

Conclusions: There were no relationships between VO₂ max. and the general position and volume of play. The study showed that high average values of VO₂max can positively influence the predominance of the player in the behavioral dynamics of the team, and the average position took me as predominant at the level of the interaction network.

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Dose-response relationships between training load and physical performance outcomes in youth soccer.

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Background/aim: Elite level football clubs and their youth academies periodically carry out physiological assessments to systematically monitor individual players longitudinal adaptations to training and match load. The aim of this study is to evaluate the dose-response relationships between internal and external training load variables recorded over acute and chronic periods with changes in elite youth soccer players physical fitness.

Methods: A retrospective observational design was employed to assess the relationship between training loads and variations in youth players physical fitness outcomes across 5 competitive seasons (2017-18 to 2021-22). Players from U16, U17 and U19 age groups (n = 102) perform a standardized battery of physical evaluations, assessing different fitness characteristics (i.e., Mognoni Test, HIT Test and a Countermovement Jump Test), four times a season. Internal and external training loads accumulated 1-week and 4-weeks prior to each test session were calculated for the analysis. A two-way repeated measures ANOVA was conducted to investigate differences between test period and age groups in the three physical evaluations. Three separate linear mixed-effect models were applied to determine which internal or external load variables included are associated with positive or negative variations in test outcome measures.

Results: Aerobic and intermittent running capacity improves in preseason ($p < 0.002$), with no significant changes observed across in season test periods. No improvement was recorded in muscular performance following preseason, prior to a progressive increase across the in season phase ($p < 0.025$). No variables included were associated with changes in aerobic fitness. A small significant positive association was found between high-intensity heart rate recorded across 4-week period and HIT capacity ($p = 0.0155$, $d = 0.21$). Distance covered at very high-speed running ($>20\text{km/h}$) accumulated over 4-weeks has a positive impact on CMJ performance ($p < 0.0003$, $d = 0.23$) and a trend for HIT ($p = 0.0547$, $d = 0.21$). Session RPE training load 1-week before testing also impacted CMJ and HIT outcomes.

Conclusions: Youth soccer players endurance and intermittent running capacity benefit from the increased levels of load performed during preseason. The present findings only identified a limited number of relationships with training loads accumulated over 1- and 4-week periods, suggesting more details regarding the periodization of load within these time frames are required. Assessing intensity and volume of load separately may help to shed further light on the nature of these relationships.

The effects of acute supplementation in young elite soccer athletes: A systematic review.

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Background/aim: Young elite soccer athletes are exposed to strenuous training. As a result, those individuals often consume pre-workout supplements in their competitions in order to improve their performance. Nonetheless, little is known about the impacts of this supplements on their health. Objective: The purpose of this systematic review was to synthesize the available scientific evidence concerning the impact on performance after acute supplementary dosages in soccer players (under 18 years old).

Methods: A systematic review of PubMed, Scopus, Web of Science databases was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. The following keywords were used: (soccer OR "team sport") AND ("ergogenic effect" OR "ergogenic aid" OR "ergogenic substance\$" OR "dietary supplement\$" OR "food supplement*" OR carbo* OR resveratrol OR taurine OR beetroot OR ATP OR phosphocreatine OR choline OR magnesium OR vitamin*) AND (Performance) AND (youth OR young OR kid* OR Child* OR "pre puberty" OR "young athlete"). There was no limitation on language or date of publication. The following issues were included: experimental studies of acute dosage, athletes younger than 18 years old, both sexes, which evaluated the effects on the sample performance.

Results: From the initial 2365 studies identified, 6 meet the inclusion criteria and were included in this review. Of these, 2 articles carried out an intervention with soccer players, while the others studies evaluated team sports athletes. Sample sizes ranged from 7 to 22 individuals and participants' ages ranged from 13 to 17 years. 3 studies analyzed both sexes. Only one research examined caffeine, whereas carbohydrates were ministered in the others ones. Feeding control was performed in only some studies. The protocols applied were Yo-yo test, game simulation, Want and LIST. Only the caffeine study did not obtain positive results.

Conclusions: Before competitions, many young athletes feel tempted to consume acute pre-workout commercial supplements, which are well-known to be harmful to adults when consumed in high doses. Consequently, it is fundamental to have more studies to fully understand such effects specifically on the young population.

Effect of fatigue on the force-velocity profile during repeated sprints in elite youth soccer.

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Background/aim: In soccer, the ability of players to perform sprint bouts repeatedly and resist fatigue is a key element of performance. Research in senior amateur players has shown that mechanical sprinting properties are negatively impacted during repeated sprint activity (notably theoretical maximal values of force [F₀], velocity [V₀], and power [P_{max}] expressed in the direction of running) (1). However, to our knowledge, no similar research exists in elite and/or youth standard players. Hence, the aim of this study was to analyse changes in mechanical sprinting properties in elite youth soccer players during a test of repeated-sprint ability (RSA).

Methods: Altogether, 18 elite (age: 14.3±0.3) elite youth academy players participated. An overground RSA test was conducted on an artificial pitch (six 30-m sprints separated by a 30-s active recovery interval). Horizontal force-velocity mechanical outputs using F₀ (N.kg⁻¹), V₀ (m.s⁻¹) and P_{max} (W.kg⁻¹) values were assessed using a reliable high-speed camera based application (2). Fatigue-induced changes were analysed comparing values obtained for the best versus both the worst sprint and the mean for all sprints using percentage change and effect sizes for mean differences (ES, classified as small [0.2], moderate [0.6], large [1.2], very large [2.0] and extremely large [4.0]).

Results: Decrements observed respectively between the best and worst sprints for F₀, V₀, and P_{max} were -17.8±7.6% (ES: -2.7, very large), -6.4±2.5% (ES: -0.9, moderate) and -14.7±6.9% (ES: -1.2, large). For the best versus mean for all sprints, respective decrements for F₀, V₀, and P_{max} were -8.8±2.5 (ES: -1.3, large), -3.4±2.4% (ES: -0.5, small) and -7.3±3.8% (ES: -0.6, moderate).

Conclusions: In the present elite youth soccer players, the ability to produce sprint acceleration-specific horizontal force (F₀) was substantially impaired when repeating sprints (very large and large decrements for best versus worst and mean sprint values) while horizontal force capability at very high running velocities (V₀) was also impaired, albeit to a lesser extent (moderate and small reductions). As such, large and moderate decreases in maximal power-output capability (P_{max}) in the horizontal direction during sprinting were observed although these seem more related to an impairment in force production at lower rather than maximal velocities.

The Effects of Wattbike RST training on the ground (sprint running) in football players.

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Background/aim: The performance of sprint running is a critical aspect of football. In particular, it requires the ability to accelerate to achieve higher speeds in shorter time and to repeat high-intensity exercises at short recovery intervals without loss of intensity. However, It is obvious that high-intensity, supramaximal exercises such as sprint running increase the risk of acute injuries, such as muscle strains, which has become a prevalent issue in practice when combined with the increased load of an overcrowded schedule. To prevent injuries and to practice at optimal load, pedaling training has potential at high quality and quantity, instead of sprint running and jumping. The purpose of this study was to investigate the effects of repeated sprint training (RST) using Wattbike on sprint running performance and repeated sprint ability (RSA) in football players.

Methods: Six male college football players engaged in RST (2 sets 5-6 reps 10s sprint pedaling, 60s rest between reps, 10min rest between sets, 1-2 times/week, 4 weeks) on Wattbike Pro. A repeated sprint ability test (RSAT) was conducted through both a 40 m sprint running and a 6s sprint pedaling. Changes in sprint time, step variables, and kinematics during sprint running, while pedaling force through the chain of sprint pedaling were evaluated using effect size (Cohen's d). We focused on the first and second steps of sprint running and initial 3 downstrokes of sprint pedaling.

Results: There was an increase in peak power ($d > 0.5$: Medium) and a decrease in the time required to reach peak cadence and peak power ($d > 0.8$: Large) both before and after the training period. Improvements in 5m and 15m time in the 40m sprint running RSAT ($d > 0.8$: Large) were also observed. An examination of changes in step variables between pre-post revealed a small to moderate increase in the SF/SL ratio with an increase in step frequency and a decrease in step length. The fatigue indexes of performance were improved in both modes of exercise. It is possible that the increase in step frequency and SF/SL ratio in the 40m sprint running RSAT was a result of not only the magnitude of force production in pedaling, but also more efficient pedaling.

Conclusions: It is suggested that football players utilize pedaling RST with a focus on pedaling technique to enhance sprint running performance and RSA.

Physiological responses to different protocols of fiet-based HIIE in female and male futsal players.

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Background/aim: The aim of the study was to compare the physiological responses between three different high intensity intermittent exercise (HIIE) protocols prescribed from peak speed of Futsal Intermittent Endurance Test (PSFIET); 2) compare the responses during HIIE performed at 86% PSFIET between males and females.

Methods: Eleven female and 11 male futsal players were enrolled to perform the FIET to determine PSFIET and maximum heart rate (HRmax). Two types of HIIE with different effort:pause ratio (EPR) and change of direction (COD) formats were prescribed for males (HIIE1M and HIIE3M) and females (HIIE2F and HIIE3F): (HIIE1M: 4x6 min - 92% PSFIET / 7.5s:10s EPR / COD every 3.75 s / 84 CODs; HIIE2F - 4x4min - 89% PSFIET / 7.5s:7.5s EPR / COD every 3.5s / 68 CODs; HIIE3F: 4 x 4 min - 86% PSFIET / 15s:15s EPR / COD every 3.75s / 108 CODs and; HIIE3M -5x4 min at 86% PSFIET / 15s:15s EPR / COD every 3.75s / 135 CODs). During all HIIE models 3 min of passive recovery between sets were given. Analyses were carried out using established Bayesian inference methods to provide the variability (spread) between-subject's responses at the first set and the time course among the other sets (sets≠1st) in each HIIE model.

Results: Mean %HRmax was higher than 93% in all HIIEs (HIIE1M: 93.6 [91.9, 95.4]; HIIE2F: 93.5 [91.8, 95.2]; HIIE3M: 93.2 [91.0, 95.3]; HIIE3F: 93.5 [91.5, 95.5]). Males presented higher lactate response [La] along the HIIE with a higher COD frequency (HIIE3M) and similar HR and rate of perceived exertion (RPE) throughout both HIIE models. Females presented similar HR response along two types of HIIE, but higher [La] and RPE along the HIIE designed with more COD (HIIE3F). Males presented lower HR, [La] along HIIE and post-exercise [La] than females.

Conclusions: PSFIET can be used as a reference for HIIE to impose high cardiovascular demand in male and female futsal athletes (>93% HRmax). Increasing the number of CODs during drills might be an effective method to increase the metabolic load in female and male players. For the same %PSFIET and an equivalent number of CODs females presents higher metabolic demand, probably due to a lower recovery capacity than males in each short interval between bouts and lower aerobic fitness, elicited by a higher [La].

Activity distribution among the hamstring muscles during high-speed running with multichannel EMG.

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Background/aim: Hamstring injuries are the most prevalent type of injuries in sports, generally occurring during high-speed running. It has been suggested that the bi-articular hamstring muscles (biceps femoris long head, semitendinosus and semimembranosus) are most susceptible to injury during the late-swing phase of the stride cycle of high-speed running. Activation patterns differ both within and between the biceps femoris long head and semitendinosus during various exercises. Hamstring injuries might occur because of an inadequate distribution of individual contributions of muscles. A high contribution of biceps femoris long head during strenuous exercise compared to the semitendinosus and semimembranosus was associated with an increased risk of a first-time injury. A better understanding of muscle activation patterns is required to provide more insight into the aetiology of hamstring injuries. The aim of this study was to characterize muscle activity within and between the three hamstring muscles during high-speed running.

Methods: In this descriptive study, participants performed three trials of high-speed running on a treadmill, during which electromyography (EMG) and hip and knee joint angles were measured. EMG was measured at 15 locations with to describe muscle activity within and between the individual hamstring muscles. Characteristic changes in knee joint angle were used for time-normalization and differentiation in three phases. Statistical parametric mapping was used for statistical analyses of muscle activity over time.

Results: Twenty-nine non-injured basketball players were included (mean age: 17±1yrs, mass; 85±9kg, height; 193±9cm). Heterogeneous activity was found for all individual hamstring muscles (biceps femoris long head; $df(4,112)$, $F=4.68$, $p<0.05$, semitendinosus; $df(3,84)$, $F=5.65$, $p<0.05$, semimembranosus; $df(5,140)$, $F=4.19$, $p<0.05$) across multiple events of the stride cycle. Between muscles, muscle activity differed significantly in the early-swing, late-swing and stance phase ($df(2,56)$, $F=7.31$, $p<0.05$). In the late-swing phase, muscle activity of the semimembranosus was significantly higher than of the semitendinosus.

Conclusions: Hamstring muscles were most active in the late-swing phase during high-speed running. In this phase, the semimembranosus was most active and the semitendinosus was least active. Within the biceps femoris long head, the most proximal region was significantly more active in the late-swing phase, compared to other muscle regions which corresponds to the region most susceptible for injury.

The epidemiology of muscle strain in female Japanese collegiate football players.

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Background/aim: Football requires physical contact, and therefore associates with a large number of injuries in both sexes. Injuries to the lower extremity are common in football players, and the injury with the highest risk occurring matches the muscle strain. However, the actual status of muscle strain among Japanese collegiate female football players are unclear. The purpose of this study was to investigate the muscle strains in Japanese female collegiate football players during five seasons.

Methods: The prospective cohort study registered 54 female football players (mean height=160.9±5.0cm, mean weight=56.1±5.8kg) from one university club. The numbers of muscle strain and time-loss post injuries, and exposure in training and matches were recorded by a team athletic trainer during the 2017-2021 playing seasons. We investigated the injury rate, injury burden, injury location, injury situation, and re-injury.

Results: Overall, 32,764.0hours (match: 5,309.6, training: 27,454.4) of exposure time were recorded over three seasons, during which 37 muscle strain (match: 13, training: 24) occurred.

The incidence of a muscle strain during five seasons was 1.13 injuries/1000 players-hours (95% confidence interval [CI]: 0.77-1.49). Injury rate during match of 2.45 injuries/1000 players-hours (95%CI: 1.12-3.78) and during practice of 0.87/1000 players-hours (95%CI: 0.52-1.22). Injury burden during match of 24.5 days/1000 players-hours and during practice of 11.8 days/1000 players-hours. Muscle strain were located in quadriceps (51.3%), hamstring (35.1%), and gluteus maximus (5.4%).

Conclusions: Injury rate and injury burden of muscle strain were higher during match than during training. Injury location of muscle strain was higher quadriceps than hamstring, it was considered necessary to take countermeasures against the load applied not only during sprinting but also during kicking. These results suggest prevention strategies to reduce muscle strains for female Japanese collegiate football players.

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The relationship between COL1A1 rs1800012 polymorphism and soft-tissue injury in football players.

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Background/aim: Football is an intermittent team sport with high physiological demands. Due to these high physiological demands, sports injuries occur very frequently in football players (1). Type 1 collagen is the main protein of tendon and connective tissues. The COL1A1 gene, which encodes type I collagen, is located on chromosome 17q21. COL1A1 rs1800012 polymorphism causes overexpression of COL1A1 protein and causes connective tissue disorder by forming weak type 1 collagen homotrimer. Soft-tissue injuries caused by the COL1A1 rs1800012 polymorphism can be given as examples of Achilles tendon injury and shoulder dislocation (2). The aim of this study was to determine the distribution of the COL1A1 rs1800012 polymorphism associated with soft-tissue injuries in Turkish male football players.

Methods: 97 male football players (age = 23 ± 3 years) and 183 sedentary individuals (age = 24 ± 5 years) control group participated in our research. DNA isolation was performed from the buccal epithelial cells of the individuals participating in the study, Real Time PCR was used for genotyping of the COL1A1 rs1800012 polymorphism. In the statistical analysis of the results obtained, χ^2 (chi-square) analysis was performed using the SPSS 25.0 program. A value of $p < 0.05$ was accepted as statistically significant.

Results: The respective percentage of the football players (n=97), COL1A1 GG, GT and TT genotypes were 72.2%, 23.7% and 4.1%. The allelic counts were 84% for G and 16% for the T alleles. The respective percentage of the control group (n=139), COL1A1 GG, GT and TT genotypes were 76.0%, 21.3% and 2.7%. The allelic counts were 86.6% for G and 13.4% for the T alleles. In the χ^2 analysis, no statistically significant difference was found between the genotype ($p=0.7623$) and allelic frequencies ($p=0.7094$) in the athletes and control groups.

Conclusions: According to our results and literature, TT genotype and T allele in COL1A1 rs1800012 polymorphism are considered protective in soft-tissue injuries. Understanding the role of differences in tendon structure in injuries will provide important information in determining soft-tissue injury profiles.

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Injury prevention in men's football.

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Background/aim: The number of injuries of the lower extremities during soccer matches is high, and effective injury preventions programs can reduce the incidence rate. In recent years, there has been an increase in the scientific evidence in issues related to injuries in men's soccer players, generating a large number of systematic reviews. This umbrella aimed to synthesize, the published systematic reviews and meta-analyses that investigated the effects of injury prevention programs in male soccer players.

Methods: The search was carried out in accordance with the PRISMA guidelines, in databases (Web of Science, Scopus, SPORTDiscus and PubMed) for studies published before June 2021. Studies were eligible if they included male soccer players (amateur to professional), included studies incorporating injury prevention programs with a control and intervention group, and were in the form of a systematic review (with or without meta-analysis). The methodological quality of the evidence was assessed using the AMSTAR 2 tool.

Results: Eight systematic reviews (no meta-analyses) were eligible for analysis in this umbrella review. The evidence collected focused primarily on lower extremity injury prevention, with a primary focus on the hamstrings. Prevention programs that mainly include strengthening, proprioception, and multicomponent programs (balance, core stability, functional strength, and mobility) have shown positive effects on the incidence and severity of injuries. Implementation of an eccentric hamstring training regimen has been shown to reduce hamstring injuries, and proprioceptive exercises have reduced the risk of ankle sprains. Dynamic warm-up was also shown to be effective in reducing injury incidence, but not injury severity. In contrast, the evidence in the current overview suggests that programs focused on static stretching show uncertain injury prevention effects.

Conclusions: Evidence suggests that prevention programs that develop muscle strength and proprioception are effective in reducing the incidence and severity of injuries (time-out). Dynamic movements performed before a match are effective in reducing the incidence of injury, while the effects of warm-ups that incorporate static stretching are unclear.

Keywords: Soccer, review, synthesize, evaluate, efficacy, methodological quality

What do we currently know about the talent development process in soccer? A systematic review.

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Background/aim: To effectively organise talent development in soccer, theorists and practitioners benefit from understanding what factors shape players' development. Research in soccer increasingly suggests that talent development is driven by interactions between multiple, individual-specific, and dynamic factors (1). Hence, one should examine this process accordingly. The purpose of this systematic review is to evaluate the current understanding of the talent development process by examining the conceptual and methodological approach taken in previous research. Based on a two-dimensional taxonomy, talent research in soccer is classified as adopting a 1. static or dynamic, and 2. intra- or interindividual approach.

Methods: A database search was conducted to return peer-reviewed journal articles on soccer talent since 2000. Following inclusion and screening, the studies were classified in one of four quadrants created by combining both dimensions. That is, a static-interindividual, static-intraindividual, dynamic-interindividual, and dynamic-intraindividual quadrant. Classification included the appraisal of the study's applied methodology, (statistical) procedure and measurements. Thereby, the question was (1) if the temporal property of the talent development process was considered (static or dynamic), and (2) if the process was examined at individual- or group-level (intra- or interindividual).

Results: Most of the 85 studies included in this review contained quantitative data (n = 65; 76.5%), while the other 20 studies (23.5%) included qualitative data. The majority of the studies (n = 60; 70.6%) was assigned to the static-interindividual quadrant. This reflects a research tradition of examining and comparing aggregate group-level variables such as anthropometrics and psychological characteristics across future successful and non-successful players. Remaining studies were classified as dynamic-interindividual (n = 17; 20.0%), static-intraindividual (n = 5; 5.9%), or dynamic-intraindividual (n = 3; 3.5%).

Conclusions: Most talent research proceeds from a static and group-level approach. This limits our current understanding of talent development in soccer, especially since developmental processes at group-level might not generalise to the individual. To date, only three studies explicitly examined the intraindividual dynamics of the talent development process. As such, future work is encouraged to acknowledge the dynamic and intraindividual nature of this process, proceeding from a framework that enables the analysis of the intraindividual dynamics of talent development (1).

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The Royal Dutch Football Association Relative Age Solutions Project-Part One: A Call for Action.

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Background/aim: Relative age effects (RAEs) provide relatively older youth (i.e., those born near the start of the selection cut-off date) with variety of developmental advantages over their relatively younger peers (i.e., those born towards the end of the selection cut-off date). Despite its widespread prevalence in youth soccer, there seems to be no widely implemented intervention to moderate or overcome RAEs (1). The purpose of this study was a call to action for stakeholders (e.g., researchers, coaches, practitioners) to propose relative age solutions to the Royal Dutch Football Association (KNVB).

Methods: The call to action consisted of a standardised, open-access questionnaire that contained questions focussed on: (a) the mechanisms of the proposal, (b) the hypothesised effects, and (c) reference to empirical findings if applicable. The online submission form yielded a total of 185 responses. Following analysis of each submission, 51 were excluded because they did not provide consent or propose any solution. This left 134 eligible responses, with eight submissions proposing multiple solutions (two n=7; three n=1), resulting in a total of 143 proposed solutions.

Results: Each of the proposed solutions were categorised by two project members based on the taxonomy provided by Mann (2). This taxonomy consisted of three higher order themes of different approaches designed to reduce RAEs when performance is evaluated subjectively: (a) alters the behaviour of observers, (b) implements rules when selecting teams, and (c) adjusts competition structures. From this, 13 lower-order independent solutions were categorised.

Conclusions: The findings from this study present a useful first step in identifying possible relative age solutions for stakeholders and organisations to consider. Based on the number of proposed solutions and their anecdotal nature, the next step for the KNVB was to utilise the knowledge of experts in the field via an adapted Delphi study to identify the most effective and feasible solutions to implement in practice (Study 2).

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The World Congress on Science and Football Groningen, Netherlands 2023.

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The notion of sports talent and more particularly the process of selecting young footballers is nowadays at the center of strategies for detecting young talents within the most prestigious football clubs in the world and other national sports federations. We propose in this article to identify, through current practices, the best existing detection systems in a documentary research approach. Given the known practices in this area, can we speak of a universal model? This question leads to others: what is a sporting talent? What is detection in football? How important is scouting in football? What are the criteria to be used in a detection process? What are the limits and consequences of detection in football? What are the expected benefits within sports clubs and federations following a well-honed detection process?

Relative age & coaches assessment influences playing time in elite soccer academies.

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Background/aim: The relative age effects (RAE) refer to the consequences of the phenomenon of chronological age asymmetry found within the same age group, the RAE are very present within elite soccer academies. Although RAE have been widely linked to talent identification, the progression within those elite academies at later stages does not seem to be highly influenced by the RAE (1). In contrast, coaches' assessment of players current and future performance plays a crucial role in their sporting career. The main objective is to observe whether RAE influences the competition playing time and the coaches' assessment of players current and future performance (CP & FP).

Methods: The sample was composed by 345 male players (U13-U16) from different Spanish elite academies. Within each age group category, the players were classified according to their birth quartile (BQ1-BQ4). The Chi-Square test were used to explore the birth asymmetries in the sample, with Odds Ratio tests to determine the probability of belonging to the different birth quarters. Analysis of variance (ANOVAs), were used to determine whether RAE influence the playing time and the Coaches Assessment of players Current (CP) and Future Performance (FP). Correlation analysis were also carried out to explore the relationship between the percentage of playing time and the coaches' assessment of players' performance.

Results: Our results showed that the RAE are present in elite academies ($p < .05$), , showing BQ1 players a higher representation in all categories ($p < .05$). RAE also influenced significantly the playing time in favour of early born players. No differences associated to RAE were found in CA & FP. Interestingly, moderate correlations were observed between the percentage of playing time and CP ($r = .622^{**}$) and FP ($r = .514^{**}$).

Conclusions: The RAE are very present in Spanish elite academies, with relatively older players having also greater participation in the competition. However, RAE does not seem to influence the coaches' assessment of players' current and future performance. Playing time is not distributed equally, and coaches provide more competition minutes to the players with higher assessment of current performance.

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Relative age and percentage of adult height. Influence on coaches' assessment of performance.

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Background/aim: Relative Age Effect (RAE) and maturity seem to be two influencing biases in the processes of talent selection, but it is interesting to treat them as independent constructs (Cumming et al., 2017). The main objective of this study is to study the prevalence of RAE in elite academies and the percentage of adult height (%AH) of the players to explore potential associations between both variables. Moreover, we are interested in analyzing whether these variables may influence coaches' assessment of current (CP) and future performance (FP) of the players.

Methods: 456 male players (U11-U16) from different Spanish elite football academies were evaluated. Player's relative age was defined according to their birth quarter (BQ1-BQ2-BQ3-BQ4). Maturity status around Peak Height Velocity (PHV) was determined according to their %AH and grouping as Pre-PHV (<88%), Circa PHV (88%-96%), Post-PHV (> 96%). CP & FP were measured using a visual analogue scale (1-5). Chi-Square and Odds Ratio test were used to analyze the RAE. ANOVAs were run to explore whether RAE influences the %AH, and if both variables are influencing the assessment of CP & FP. Correlation analysis were carried out between %AH and chronological age.

Results: RAE was observed in all the different age categories analyzed (all $ps < .05$). A positive correlation between AH% and chronological age was observed in all the age groups analyzed (U11-U15; $p < .05$ $r = (.347-.476)$, with exception of U16. Regarding the coaches' assessment of performance, CP & FP were not influenced by RAE in none of the age groups. %AH did not influence CP nor FP in any age group, except for the U14 group, with a positive correlation with CP ($r = .402^{**}$) and FP ($r = .398^{**}$).

Conclusions: The RAE is present in the elite academies. Chronologically older players seem to start their maturational development earlier, especially when they are near to the PHV. The chronological age and maturity status of the players, only seem to influence the coaches' assessment of CP & FP in the U14 group, just in the period very close to the PHV. Continuous monitoring of the players' maturity status will facilitate the adaptation in training.

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Developing a performance analysis practitioner development pathway in Gaelic games: A case study.

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Background/aim: Performance analysis (PA) is integral to the preparation of elite Gaelic Games (GG) teams and is increasingly evident at sub-elite level. By 2016 GG administrators were concerned about unregulated, often volunteer-led PA practice with GG teams. A survey of GG coaches (1) suggested shortfalls in PA practices which were not in line with a holistic model of player development. These findings precipitated an extensive action research project, conducted in partnership with GG. We sought to co-design, deliver, and evaluate a credible accreditation model which could serve as a tool to demonstrate standards of practice; facilitate engagement in a community of practice; support practitioner development.

Methods: The overarching method for the study was the Participatory Action Research and Action Learning (PALAR) framework (2). This included a survey (46 analysts), an interview study (11 analysts), and the content analysis of participant feedback from multiple educational events to support critical reflection and program evaluation.

Results: A Practitioner Development Pathway (PDP) was established with 3 components that were developed iteratively.

- 1) Accreditation: 236 analysts accredited in a 4 Level Quality Assured Accreditation process;
- 2) Education: 4 annual Community of Practice events, 14 "Introduction to PA in GG" courses delivered, a GDPR Guide and a GG PA Guide for Practice developed;
- 3) Evaluation: Interview data showed that; analysts felt the PDP had delivered its outcomes; analysts are hugely resourceful and committed to learning; recognition and validation of their role is very important; practitioners see value in reflecting on their philosophy, purpose, and practice. In a 2021 survey 65% of respondents agree / strongly agree that being a GAA accredited analyst is recognised as something valuable among the wider GG community, while 85% agree / strongly agree that the PDP has helped them to become connected with the wider GG PA community.

Conclusions: Our evidence suggests that the PDP provided much needed recognition for analysts, networking and educational opportunities, and increased awareness of professional practice. The perceived success of this program supports the application of the PALAR framework and values to guide engaged research of this nature in sport.

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Evaluation of virtual reality to identify visuo-motor deficit in previously concussed rugby players.

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Background/aim: Previously concussed athletes are at greater risk of suffering another concussion or injury after being cleared by a physician to return to sport. These athletes often continue to display balance control and visuomotor impairments (1). Visuomotor impairments during locomotion have been recently evaluated in a collision avoidance task between 2 athletes (2). Previously concussed athletes demonstrate inappropriate avoidance behaviors and increased motor variability. Despite being closely related to daily situations, this protocol requires athletes to visit the lab and it is not easy to perform follow-up evaluations. One major limitation for re-testing athletes is that the protocol requires a mutual avoidance, which corresponds to a multi-participants evaluation rather than an individual assessment. In this context, virtual reality (VR) seems to be an essential tool (portable, repeatable). Therefore, we aim at evaluating the ability of a VR task to reveal visuomotor deficits that persist after a recovery of a concussion in a collision avoidance task.

Methods: We aim to recruit 20 rugby players who have recently sustained a concussion and have returned to play, and 20 rugby players who have not sustained a concussion in the last 2 years. Athletes will be immersed in VR and asked to avoid a collision with a virtual pedestrian using a joystick. This pedestrian will not react to the participant, walking in a straight line at a constant speed of 1.33m/s, crossing participants' path at a 90° angle. We will manipulate the collision risk across trials to evaluate those in which a change in path or speed is performed. In total, participants will perform 136 trials. We will focus both on the kinematics of participants' trajectory (avoidance behavior) as well as on their gaze activity using an eye tracker integrated in the VR headset (gaze allocation, fixation properties).

Results: We expect to provide a reliable tool to evaluate persistent effects of a previous concussion, showing that previously concussed athletes display visuomotor impairments, with greater variability in timing of trajectory adaptations.

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The feasibility, safety, and efficacy of garment-integrated blood flow restriction training.

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Background/aim: Objectives: Explore the feasibility of lower-limb garment-integrated BFR-training.

Design: Observational study. Setting: Human performance laboratory.

Methods: Participants: Healthy males with no experience of BFR-training.

Main outcome measures: Feasibility was determined by a priori thresholds for recruitment, adherence, and data collection. Safety was determined by measuring BFR tourniquet pressure and the incidence of side effects. Efficacy was determined by measuring body anthropometry and knee isokinetic dynamometry. Feasibility and safety outcomes were reported descriptively or as a proportion with 95% confidence intervals (95% CI), with mean change, 95% CIs, and effect sizes for efficacy outcomes.

Results: Twelve participants (mean age 24.8 years [6.5]) were successfully recruited; 11 completed the study. 134/136 sessions were completed (adherence=98.5%) and 100% of data were collected. There was one event of excessive pain during exercise (0.7%, 95% CI 0.0%, 4.0%), two events of excessive pain post-exercise (1.5%, 95% CI 0.4%, 5.5%), and one event of persistent paraesthesia post-exercise (0.7%, 95% CI 0.0%, 4.0%). Mean maximal BFR tourniquet pressure was <200 mmHg. We observed an increase in knee extension peak torque (mean change 12.4 Nm), but no notable changes in body anthropometry.

Conclusions: Lower-limb garment-integrated BFR-training is feasible, has no signal of important harm, and could be used independently.

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The locomotive demands of elite soccer assistant referees across different competitions.

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Background/aim: There have been 288 studies on elite soccer referees since 1990. However, there have only been 20 studies on assistant referees (ARs) since 2002. Moreover, few studies have described the locomotive demands placed on ARs across different competitions which result in differences in total distance covered for players (1). The present study aimed to examine the locomotive demands placed on ARs across four different elite competitions.

Methods: The AR's included in the present study officiated in FIFA, UEFA (EUR), Premier League (PL), English Football league (EFL) and Domestic cups (DC). Match data from 5 ARs were recorded during 352 games in the 2019/20 and 2020/21 seasons. The AR's were fitted with a StatSports system (StatSports, Ireland) for continuous recording during games. Devices were set up to record time spent moving at different speeds and distances covered (2). Statistical analysis was completed using a Linear Mixed method with main effects of season and competition. Ethical clearance was received from Liverpool John Moores University.

Results: There were no differences in total distance covered by AR's between seasons and between the four competitions; EUR: 2019/20: 5131 vs 2020/21:5365m, PL: 5239 vs 5267m, EFL: 5155 vs 5449m and DC: 4919vs 5185m nor was there a season*competition interaction ($F(3,311) = 0.313$; $p=0.816$). There were no significant differences in absolute high-speed distances covered by AR's between seasons and between the four competitions; EUR: 96.0 vs 139.0m, PL: 114.5 vs 118.2m, EFL: 105.7 vs 143.7m and DC: 87.9 vs 127.0m nor was there a season*competition interaction ($F(3,311)= 1.146$; $p=0.331$). There were no significant differences in maximum speeds achieved by AR's between seasons and between competitions; EUR: 7.2 vs 7.3 km.h⁻¹, PL: 7.3 vs 7.2 km.h⁻¹, EFL: 7.3 vs 7.2 km.h⁻¹ and DC: 6.8 vs 7.1 km.h⁻¹ nor was there a season*competition interaction ($F(3,311)= 0.714$; $p=0.544$).

Conclusions: The main findings of this study were that there were no differences in total and absolute high-speed distances and maximum speed achieved by AR's across four different elite competitions over 2 consecutive seasons.

The comparison of blood lactate and heart rate values after FIFA tests of referees in Cyprus.

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Background/aim: This study covers the measurement of lactic acid accumulated in the body and heart rate right after the 40 x 75 run, which is the F.I.F.A. Athletic Interval Test protocol for the football referees affiliated with the Central Committee of the Cyprus Turkish Football Federation.

Methods: After completing the mandatory F.I.F.A. Athletic Interval Test (1) to determine the endurance values of 43 football referees from 17 Super Leagues, 5 categories A, 9 categories B, and 12 categories C were measured with portable pulse meters attached to the body throughout the test for heart rate beats and blood lactate values (2) were measured right after via portable lactate analyzer. SPSS 24.0 program was employed to analyze the data. The data were analyzed with Kolmogorov-Smirnov and Shapiro-Wilk tests, and parametric tests were used in this study. Pearson Correlation was employed to determine the relationship between the heart rate and lactic acid values.

Results: It is revealed that the lactic acid (mmol/l) and heart rate beats (beat/min) values obtained from the referees have a normal distribution. According to the simple linear regression analysis, there was a significant relationship between heart rate beats and lactic acid values; no significant relationship was identified between the classification of the referees and the beats of heart rate values. Also, there was no significant relationship between the classification of the referees and the lactic acid values. According to the results of ANOVA, there was no significant difference between the referees' lactic acid and heart rate values with regard to the classification of the referees.

Conclusions: A significant increase in lactic acid and heart rate values of the football referees was observed during the test. There was a weak significant correlation between the heart rate beats and lactic acid values of all referees in the study. There was no significant difference between lactic acid and heart rate values among the classification groups of the referees.

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CSR in German professional football – relevance, perception and expectations from fans' perspective.

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Background/aim: The 36 clubs of the German 1st and 2nd Bundesliga decided to be the first of the major professional football leagues to include a mandatory sustainability guideline in their licensing regulations from the season 2023/24. Besides (possible) honorable convictions of the clubs, the implementation of sustainability criteria and the integration of socially, ecologically and economically sustainable projects is pursued for strategic and instrumental reasons (1). For that the CSR perceptions from the perspective of the biggest stakeholders, the fans of German professional soccer, is necessary but largely unexplored.

Methods: For data collection a highly structured online questionnaire was placed in German fan fora in September 2020. In accordance with the theoretical framework, the questionnaire covers items on a) general consumer behaviour, b) fan identification and loyalty, c) relevance and perception of CSR commitment in professional football and d) socio-demographic information.

Results: The first results (N=324) show that fans consider the responsible treatment of young players (MW=4.5; SD=0.84) and the promotion of children and young people (4.47; SD=0.77) to be the most important CSR fields of action of German professional football clubs (measured with five-point Likert scales). Furthermore, the perception of CSR depends on the club and the league. There is a significant medium link between the perceived commitment and team loyalty (team identification). The lack of knowledge about the associations' CSR reports and the perceived inadequacy of information indicate a desire for improved sustainability reporting. Team identification functions as a predictor of the fans' CSR information status and their willingness to make a personal contribution.

Conclusions: The study shows that professional clubs not only differ in the implementation of CSR measures, but also in the perception of fans and the possible influence on their behaviour. For successful strategic stakeholder management in the future, the most promising fields of action, deficits and interrelationships identified must be taken into account.

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Health benefits of recreational football in premenopausal women: A systematic review.

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Background/aim: The impact of recreational football on the fitness levels and overall health of previously untrained women has been studied extensively. However, there has been no systematic review that focused on a narrower range of ages that focuses on premenopausal women specifically. Therefore, the purpose of this review was to explore and summarize the effects of recreational football on metabolic, cardiovascular, and bone health among premenopausal women

Methods: The following online databases were used for a computerized literature search: PubMed, SPORTDiscus, Scopus, Medline, and Web of Science. The search was carried out until April 18, 2022. The keywords for the search included: ("recreational football" OR "recreational soccer") AND ("premenopausal women" OR "women"). The initial search identified 212 studies. After eliminating duplicate studies, 150 studies were attained for the title and abstract reading. After analyzing studies based on title and abstract reading, 14 articles with full text were assessed for eligibility. Four articles out of 14 were excluded since the studies did not meet the sample requirement and were not recreational football studies.

Results: All included studies were conducted as randomized controlled trials with premenopausal women. The subjects commonly received recreational football in the form of small-sided games played for 1 hour twice or three times a week, in a variety of different intervention lengths regarding the study design. The results of the reviewed studies indicated that participating in recreational football led to a significant increase in muscle mass, lean body mass, aerobic capacity, bone mineral content and density, and high-density lipoprotein, and a significant decrease in fat mass, resting and submaximal exercise heart rate, blood lactate level during walking, total cholesterol and triglyceride, and systolic and diastolic blood pressures.

Conclusions: Although recreational football is not among the popular exercise types included in the studies about premenopausal women, this review emphasizes the health benefits of recreational football for this population.

Geographical predictors of early talent identification in Dutch youth soccer.

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Background/aim: Multiple personal and environmental factors impact the likelihood of becoming a professional soccer player. For example, the birthplace effect implies that socio-geographical variables – such as community size and density – positively impact the development of talent (2). Recently, variables, such as urbanity, were found to mediate the relationship between population size and attaining professional level (1). However, these studies examined the birthplace effect for attaining senior professional level. Therefore, this study investigated the effect of geographical variables on the likelihood of being recruited for a professional soccer Academy.

Methods: All 12-year-olds players involved in a professional Academy between 2015 and 2020 were included (n = 2963). For these players, the place of early development was determined as the first amateur youth soccer club. Based on the club's location, we computed the total number of recruited players per municipality, which served as the outcome measure. For each municipality, we then collected the following predictors: number of proximal professional and top amateur clubs, total number of youth players and inhabitants, number of physical activity opportunities and mobility levels in a municipality. To test the relationships between these predictors and the number of recruited players per municipality, linear regression and relative importance analysis were performed.

Results: Similar to previous studies, the model explained 9% of the variance in total number of recruited players per municipality. The outcome was best predicted by the number of proximal top amateur clubs. In addition, the proximity of professional clubs, the municipality's physical activities opportunities and number of sport accommodations all had a positive impact on the recruitment of talented players.

Conclusions: Successful recruitment in an Academy from a municipality was best explained by the proximity of top amateur clubs. Although our model explained a limited portion of the variance in scouting process, it is interesting to find that growing up in the vicinity of many top amateur clubs increases the chance of recruitment at age 12.

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Study of each club's efforts to realize the philosophy of the WE League: Focus on the coaching staff.

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Background/aim: In Japan, the first professional women's soccer league was started in September 2021. The league is called "the Women Empowerment League ("WE League)". The WE League is the first Japanese sports organization to require the promotion of women in its entry criteria and has its original items such as "at least one female coach must be included in the coaching staff" on the field. However, some clubs have not achieved the entry criteria, and there is only one female manager out of eleven, so there are some points that should be improved in order for women to play an active role as coaches. From the above, the purpose of this study is to clarify the efforts that clubs have taken in organizing their coaching staff and the associated issues when entering the WE League, and to clarify the characteristics of clubs where female coaches are active.

Methods: A semi-structured interview was conducted with three selected clubs. The interview data were analyzed using SCAT (Steps for Coding and Theorization). 1)

Results: Six characteristics of clubs where female coaches are active were clarified.: (1) The awareness of the gender equality and diversity of their coaching staff, (2) The clubs are developing and strengthening female coaches in their own clubs, (3) The awareness of the benefits of employing female coaches, (4) Some factors prevent the clubs from employing female coaches, (5) The clubs are finding solutions to (4), and (6) The clubs are conscious of the need for a work-life balance system for coaches and are preparing an environment in which female coaches can continue their careers.

Conclusions: The results of this study are expected to be useful for the WE club and clubs that intend to enter the league in the future. However, since these are only the perspectives of the clubs, it is necessary to focus on female coaches who actually work in the field to clarify the similarities and differences between the opinions of the clubs and the field.

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A comparison of tactical behaviors according to the match outcome in Spanish LaLiga football teams.

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Background/aim: Recent studies have revealed the association of specific technical-tactical indicators with match outcome in professional football (1). However, the emergence of tracking data allows evaluating more complex variables related to the teams' tactical sequences (2). The aim of this study was to compare the tactical behaviours during the teams' offensive and defensive sequences according to the match outcome in Spanish LaLiga.

Methods: A total of eight variables related to the teams' tactical sequences were examined during 380 matches of the 2021/2020 season of the Spanish LaLiga. These variables were captured using the Tracab tracking system used by Mediacoach. The data was analyzed using repeated measures ANOVA to compare the tactical behaviors of teams when they won, tied or lost the match.

Results: Offensively, teams registered fewer number of positional attacks (67.9 ± 12.9 vs 72.3 ± 14.1 vs 74.3 ± 11.4 ; $p < 0.001$) and offensive set pieces (9.8 ± 1.7 vs 10.5 ± 2.2 vs 10.9 ± 2.2 ; $p < 0.01$), as well as more counterattacks (11.3 ± 2.2 vs 10.5 ± 2.0 vs 9.7 ± 2.1 ; $p < 0.001$) when they won, in comparison with when they tied and lost, respectively. Defensively, teams registered more defensive set pieces (11.3 ± 2.6 vs 10.4 ± 1.9 vs 9.6 ± 1.9 ; $P < 0.001$) and low-block defensive sequences (11.4 ± 3.7 vs 10.6 ± 4.0 vs 9.1 ± 3.1 ; $p < 0.05$) when they won the match than when they tied or lost. In addition, teams had fewer high-block sequences (59.7 ± 5.3 vs 60.1 ± 6.1 vs 62.6 ± 5.2 $p < 0.05$) when they won the match than when they tied or lost.

Conclusions: These findings indicate that Spanish LaLiga teams adapt their offensive and defensive playing styles depending on the match outcome.

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Analysis of penetration plays into the opponent's defensive organization in soccer attacks.

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Background/aim: It has been reported that it is effective to penetrate the opponent's defensive organization when attacking and to create an unmarked situation from the opponent's defense where there are no opposing defenders within a 5-m radius of the ball carrier and in the shooting path in order to obtain scoring opportunities in soccer (Suzuki et al., 2019). This study aimed to identify effective plays to create an unmarked situation when penetrating an opponent's defensive organization.

Methods: 40 matches in FIFA World Cup 2018 group stage were analyzed. Notational analysis was conducted for each match on attacking plays that penetrated the opponent's defensive organization. A total of 25 items were measured, mainly items related to players who made passes into the defensive organization and players who received passes within the defensive organization. If the player receiving the pass in the defensive organization was unmarked, it was considered a success; otherwise, it was considered a failure. Statistical analysis was performed by an independent samples t-test and χ^2 test.

Results: The occurrence rates of the number of passes "0" before the ball is passed to the passer, the number of touches by the passer "1 touch", and the opponent's defensive organization situation "imbalance" in the success case was higher than in the failure case, indicating that the quick penetration into the defensive organization after winning the ball is the most effective way to create an unmarked situation. Furthermore, the occurrence rates of "underlap" and "overlap" off-the-ball movements, "lateral/backward" entry points into the defensive organization, and "unmarked" at the start of a move were higher in the case of success than in the case of failure, indicating that movements to overtake the player who made passes into the defensive organization from outside the defensive organization are effective.

Conclusions: From the above, plays that are effective in creating an unmarked situation within the opponent's defensive organization include a play in which a player quickly breaks into the opponent's defensive organization after winning the ball and a play in which a player receives a pass from outside the opponent's defensive organization in a move that overtakes the passer.

Effects of player roles in creating different landscapes for shared affordances SSCGs.

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Background/aim: In line with the ecological dynamics perspective, tactical behaviours of players and teams result from information exchanges that emerge among players, based on their action capabilities (physical, technical, and tactical). Players and teams constantly interact to form synergies and create information, making decisions and organizing actions, according to collective possibilities for action of the team, known as affordances. Ecological dynamics views competitive performance behaviours in sports teams as emerging from the sharing of available affordances. The aim of the present study was to examine how team composition of players with different roles constrains individual and collective tactical behaviours, and ball possession effectiveness, during competitive 3 vs 3 small-sided and conditioned games (SSCGs) in youth soccer players.

Methods: Fifteen male players (under 15 yrs, mean age 13.2 ± 1.03 years, mean years of practice: 4.2 ± 1.10 years) from the same club participated in this study. For analysis purposes, on advice from the coaching staff, participants were categorised according to their main team performance role, resulting in sub-samples of 5 defenders (centre-backs = 2 and full-backs = 3), 7 midfielders (central midfielders = 3 and wide midfielders = 4) and 3 attackers (forwards). In order to assess participant tactical behaviours, a notational analysis system was created with four categories: i) team behaviours, ii) individual players' offensive actions, iii) individual players' defensive actions, and iv), ball possession effectiveness.

Results: Analysis of players' offensive actions revealed that the team composed only of midfielders revealed a higher frequency of diagonal and vertical passes in relation to the attackers' team. In offensive individual actions, the attackers' team revealed more dribbles in relation to the teams of defenders and midfielders. Analysis of ball possession effectiveness revealed that the team of defenders achieved higher values of shots on goal compared to the team of midfielders.

Conclusions: Our findings suggested how the main playing role of a performer may constrain and promote different emergent collective behaviours and individual actions in 3 vs 3 SSCGs. Due to differences in performance context, players with different playing roles seem to exploit affordances and perform differently in competitive conditions. Due to differences in performance context, players with different playing roles seem to exploit affordances and perform differently in competitive conditions.

Qualitative case study of leadership behavior of professional football coach Ivica Osim.

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Background/aim: Transformational leaders seek to change behavior by appealing to emotions, inspiring and providing beliefs and values to help followers maximize their potential, and perform beyond expectations. Previous research has shown that Transformational leadership (TFL) behavior by coaches not only improves players' performance, but also has positive effects on psychological and behavioral aspects. However, as most research has been conducted among youth players with low skill levels, research with elite-level players is needed to deepen our understanding of the effectiveness of TFL behavior. Additionally, while research on TFL behaviors has been conducted based on the coach's perspective, few studies have examined it qualitatively from the player's perspective. This study aimed to qualitatively investigate the TFL behavior of professional football coaches from the players' perspective.

Methods: Participants were two former professional soccer players who had been coached by Ivica Osim for more than three seasons at a professional soccer club. Interviews were conducted in a semi-structured format based on previous research that qualitatively examined coaches' TFL behavior. Interview questions were designed to allow participants to investigate how they perceived their coaches' TFL behavior. Additionally, follow-up questions were used to obtain a detailed description regarding the leadership described by the participants. Using the Differentiated Transformational Leadership Inventory (DTLI) as the analytical framework, the interview data were analyzed deductively, coding them into six categories.

Results: Deductive categorization of the coach's behavior based on the DTLI resulted in a number of comments relating to intellectual stimulation, high performance expectations, inspirational motivation, and fostering acceptance of group goals. These four factors accounted for approximately 80% of the interview data obtained from the two participants, highlighting them as important aspects of TFL behavior.

Conclusions: In terms of inspirational motivation, an element of TFL, coach expressed an implicit vision of an effective team, rather than an explicit vision of winning or ranking. In terms of high performance expectations, and fostering acceptance of group goals, coach more concerned about whether players took risks and challenged themselves or played with commitment for the team, rather than whether they scored goals or made other plays that led directly to victory. The comments regarding intellectual stimulation revealed that coach expressed to players that it is only by acting autonomously that they can grow, and that this requires them to deviate appropriately, guided by their own sense of responsibility, and not be bound by existing rules.

Technical, tactical and physical demands of diverse positions with formation changes.

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Background/aim: Due to the frequent position changes during the game¹), the performance required of each player on technical, tactical and physical demands is diverse. A method has been developed that can identify formation changes during a match²), and in the future it will be necessary to evaluate players according to the changed positions. Physical fitness training for soccer has been also conducted includes technical and tactical elements, and in order to clarify training issues, it is important to understand the technical and tactical characteristics of each position in detail. The purpose was to summarize the types of positions in soccer and the technical, tactics, and physical demands, and to clarify position requirements in formation changes.

Methods: The subjects were four licensed coaches who have produced professional players. After collecting information on recent soccer tactical systems from references, I interviewed about position characteristics and necessary technical, tactical, and physical demands. Verbalized information was aggregated using the KJ method.

Results: 17 positions were defined from 7 basic systems used in major tournaments, and it was assumed that two positions could be combined mainly on the offensive side due to position changes in offense and defense. Technical, tactical and physical demands for each position of players. In particular, in order to change positions, pressing from the front line, ball possession, duel defense, transition and running distance are commonly required in many positions.

Conclusions: The sprint distance and speed required differ depending on the position, and it was presented that physical diversity that can withstand position changes is necessary. In particular, Winger and fullback are active in changing positions to the center of the pitch or to the front line during the game. In addition, it is thought that forward players need distance covered and acceleration/deceleration more because of more pressing in attacking third.

Similarity of player load patterns between positions and matches in elite soccer.

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Background/aim: Tri-axial accelerometers are highly responsive motion sensors that record acceleration of body movement in three dimensions. The present study wanted to combine tri-axial accelerometer and time-motion analysis to obtain knowledge concerning player load during match play. Our primary aim was to explore the development of player load throughout match time (i.e., the pattern) using moving 5-min windows in an elite soccer team, and our secondary aim to compare player load patterns between different positions within the same team.

Methods: The dataset included domestic home matches ($n = 34$) over three seasons for a Norwegian Elite League team. To construct an analysis capturing the immediate, dynamic nature of a match for all players, mean values were calculated over consecutive (i.e., moving) 5-min periods for player load, as well as time-motion variables (total distance, accelerations, decelerations, sprint distance, high-intensity running distance) for comparison. Data for each variable were averaged within positions in each match, converted to z-scores, and averaged across all matches, yielding one time series for each variable for each position.

Results: Overall, we observed a distinct pattern in player load throughout match time, which was also present in the majority of individual matches. The results show distinct player load patterns with three “high-load periods” in each half of the match, separated by “lower-load periods”, in most of the matches. Cross-correlation analyses support the visual evidence, with correlations ranging 0.88 – 0.97 ($p < .001$) in all position pairs. In contrast, no specific patterns were discernible for total distance, accelerations, decelerations, sprint distance, and high-intensity running distance.

Conclusions: The main finding was the distinct player load pattern with three “high-load periods” in each half, separated by “lower-load periods”. The player load patterns were relatively similar between positions and occurred at approximately the same time points during the majority of matches. In contrast, no specific patterns were discernible in total distance, accelerations, decelerations, sprint distance and high-intensity running distance. These novel findings can be discussed with two points of departure: the team’s pacing strategy from a physical viewpoint and from a perspective based on interpersonal coordination between player positions.

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Validation of the Dutch Acute Recovery and Stress Scale and the Short Recovery and Stress Scale.

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Background/aim: In sports, validated instruments are needed to monitor recovery and stress processes in athletes. (1) Recent proposals for monitoring tools include the Acute Recovery and Stress Scale (ARSS) and the Short Recovery and Stress Scale (SRSS). (2) These questionnaires were designed to assess the multidimensional aspects of recovery and stress on a daily basis. Initial research indicated good reliability and validity of the instruments in the German and English cohorts. In this study, we aimed to extend the psychometric properties by incorporating the recovery-stress state of athletes into one confirmatory factor analysis (CFA), and replicating the earlier procedure among Dutch and Belgian athletes to determine the structural validity. (2) We followed the Consensus-based Standards for the selection of Health Measurement Instruments criteria.

Methods: Six translators translated the ARSS and SRSS in a parallel back-translation procedure, after which we determined their structural validity with multiple CFA models (i.e., first-order, bifactor, and higher-order) and by replicating the CFA models used in earlier studies, (2) internal consistency with Cronbach's alpha, and construct validity through correlations between the ARSS and SRSS and the Recovery-Stress Questionnaire for Athletes (RESTQ-Sport).

Results: The Dutch version showed a sufficient model fit for the eight scales of the ARSS with the higher-order recovery-stress approach (root mean square error of approximation (RMSEA) = .09, comparative fit index (CFI) = .82, Tucker-Lewis Index (TLI) = .80, and standardized root mean square residual (SRMR) = .10), a good model fit for the replicated analysis (RMSEA = .07, CFI = .93, TLI = .91, SRMR = .06), and satisfactory internal consistency ($\alpha = .75 - .87$). The correlations within and between the ARSS and SRSS, as well as between the ARSS/SRSS and the RESTQ-Sport ($r = .31 - .77$ for the ARSS, $r = .28 - .63$ for the SRSS) also supported construct validity.

Conclusions: These combined findings support the use of the Dutch ARSS and SRSS to assess recovery and stress in sports-related research and practice. However, scale validation is an ongoing process; thus, future studies could extend the psychometric properties further by increasing the model fit by testing different models in other populations.

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The peak and the distribution of maximal demands during official match in U19 elite soccer players.

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Background/aim: The most demanding passages of match-play (MDP) and the distribution of match-activities relative to maximum-intensities during official match were investigated in top-class football. However, few information for MDP and none for the distribution of match-activities are still available for youth football. The present study aimed to determine these issues in youth football.

Methods: Twenty-four (n=24) U19 elite male players competing in European youth championship were monitored during 32 official matches (186 individual-samples). Maximum relative ($m \cdot \min^{-1}$) total distance (TD), high-speed running (HSRD), very high-speed running (VHSRD), sprint, acceleration and deceleration distances were calculated across different durations (1-5, 10, 15, 90-min) using a rolling method. Maximum-intensities (1-minpeak) were used as the reference value to determine the distribution of relative intensity across the whole-match demands (90-minavg). Time and distance higher than 90-minavg (>90-minavg) were also calculated.

Results: MDP showed large to very-large [effect-size (ES): 1.43/4.85] differences between 1-minpeak vs all durations for each parameter. The relative ($m \cdot \min^{-1}$) 1-minpeak than 90-minavg was about +64% for TD, +321% for HSRD, +678% for VHSRD, +1641% for sprint, +822% for acceleration and +638% for deceleration. The total distance covered >90-minavg than 90-minavg was ~63.6(5.2)% for TD, ~83.4(3.4)% for HSRD, ~98.2(1.9)% for VHSRD, ~100(0.0)% for sprint, ~100(0.0)% for acceleration and ~100.0(0.00)% for deceleration. The relative distance >90-minavg was large (ES: 1.81; CI: 1.22 to 2.39) for TD and very large (ES: 2.67 to 5.36) for VHSRD, sprint, acceleration and deceleration.

Conclusions: The MDP and the locomotor intensity >90-minavg could be considered for maximizing performance in elite youth football players.

Monitoring kicking intensity in kicking sports. Necessary or collecting stats for stats sake?

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Background/aim: Monitoring of athlete's locomotor activities and accelerometer-based outputs (total distance, high-speed running distance, sprint distance and the number of accelerations and decelerations) has become common practice within football codes (soccer, rugby, AFL and Gaelic football) to monitor the physical outputs of athletes in training and match scenarios. In conjunction with these metrics, understanding outputs for kicking may provide a more holistic approach to athlete load monitoring for sports that incorporate kicking actions. Further, it might inform skill development programs by providing the number of kicks performed by each leg and kick intensity for different drills used by coaches. Aim: Using current research to investigate if it is necessary to monitor kicking metrics within training and match scenarios.

Methods: Foot-mounted inertial measurement units (FIMUs) are used to monitor technical actions in football. FIMUs have reported technical metrics such as foot usage (left/right), kicking/release velocity (speed of the lower limb as it strikes the ball), and release index (impulse measure of releases: release frequency * release speed) which are referred to as kicking intensity and possession statistics.

Results: Kicking intensity differed between different training drills and training sessions (1,2). Small-sided games and possession drills evoked more ball touches and releases per minute than match play (1). Technical (Mean±SD: 6.1±7.2) and tactical (10.0±10.5) drills such as shooting and finishing drills consisted of the highest number of high-speed releases whereas small-sided games (1.4±1.6) and possession (0.3±0.9) drills displayed the lowest number of high-speed releases (1,2). It may be that kicking intensity places itself within a continuum with physical exposure where the two sit at opposite ends of this continuum but meet in the middle as physical-technical metrics. This part of the continuum may be reserved for metrics that include a physical and technical factor such as release velocity or release index. The data also highlights differences between drills in terms of kicking volumes and intensity which has implications for load management and skill development.

Conclusions: The monitoring of the physical exposure and kicking intensity continuum is a relatively new concept thus, investigations need to be performed to gain a better understanding of what effect kicking actions have on athlete development, match preparation, neuromuscular fatigue and risk of injury.

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Relationship between internal and external load in professional soccer players.

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Background/aim: Internal and external loads are frequently used to monitor training load during a soccer season. The rate of perceived exertion (RPE) is a valid and non-invasive indicator of internal training load, while the global position system (GPS) permits quantifying training and matching activities of each player (external load). Previous studies tested the comparison between RPE and GPS in small-sided games (1) or investigated physical and perceived soccer demands by playing position (2). The present study aimed to examine external and internal training load within one week of the competitive season.

Methods: Internal and external load data for 22 professional male soccer players (26.3±3.9 years) were obtained over two competitive matches and four training sessions. External training and match load were assessed using a 10-Hz GPS unit (Apex, StatSports, Northern Ireland). Additionally, internal training load RPE was individually obtained 30 minutes after training and match days using the Borg scale. The analysis of variance (ANOVA) tested the variation of GPS variables and RPE across one week.

Results: RPE and GPS outputs were largely (distance 24-39 km.h⁻¹: r=0.565; maximum velocity: r=0.568) or very largely related (total distance: r=0.810; distance 14-18 km.h⁻¹: r=0.726; Distance 18-24 km.h⁻¹: r=0.769; Distance high-speed running > 18 km.h⁻¹: r=0.771; the number of decelerations: r=0.765). As expected, variation across the week was noted for RPE (F=28.267; p<0.001; ES-r=0.586). In general, except for MD+1, similar fluctuations were found for GPS outputs.

Conclusions: Although substantial intra-individual variability was found, the current study highlights RPE as a valuable tool to quantify load among professional soccer players within a competitive season since it was related with GPS variables. Future studies should confirm the current results across a long period of the competitive season and also examine intra-individual variability on soccer load.

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An evaluation of the development of Jones fractures in terms of The dynamic factors.

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Background/aim: A Jones fracture is defined as a stress fracture of the proximal metaphyseal and diaphyseal part of the 5th metatarsal bone caused by sports activities. Jones fracture occurs more frequently in sports requiring cutting motions, stepping motion, kicking motion for football. The objective of this study was to simulate the development of Jones fractures based on the dynamic factors acting on the 5thMB when moving and prevent recurrence.

Methods: A total of 4 adult male football players were measured for football kicking movement using a 3D motion analyzing device, after which the results were analyzed by SIMM 6.0, calculating the ground reaction force (GRF) z component for each movement. In addition, the finite element models of the 5th metatarsal bone were created based on the CT data of an identical subject whose movement was measured. The loading conditions were the maximum GRF value after the foot contact the ground for each movement was provided as the 5th metatarsal distal head arbitrary point. The load position was set with reference to the same direction as the z axis; an inclined direction of 30° to the z axis; and an inclined direction of 45° to the z axis. The Finite Element Method was used for analysis, and a bone fracture analysis was conducted by Mechanical Finder 7.0.

Results: For loads at an inclined direction of 30° to the z axis, and an inclined direction of 45° to the z axis, the fracture lines were observed in the proximal metaphyseal-diaphyseal junction of the 5th metatarsal bone.

Conclusions: In order to prevent Jones fractures from occurring in the pivoting leg during kicking movement in football, it was revealed that the most important factor is to make the player to acquire the movements that will not place an outer load on the foot. Should a fracture occur, to prevent recurrence, careful consideration should be taken regarding outer loading during movement at the time of rehabilitation.

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Factors, prevalence, pain and function: hip and knee osteoarthritis in the active male footballer.

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Background/aim: The present literature often discusses and details osteoarthritis (OA) in retired professional male football players. However, there is no evidence base detailing the prevalence of OA of knees and/or hips in the active professional male footballer. This study assists in shedding some initial light on this cohort and these conditions.

Methods: Active professional male footballers were recruited from Fédération Internationale des Associations de Footballeurs Professionnel's (FIFPRO) members.

A total of 101 footballers consented to answer questionnaires and be examined by their team doctors in order to establish whether they have knee or hip OA. The questions included several injuries and surgery to these joints. This study aimed to establish a possible association between these types of medical-related issues and the development of OA in the active professional male footballer. Also, if OA can be clinically recognised in the knee and/or hip.

Results: This study found that 53% of the cohort examined and reported by the team physicians for the presence of clinical OA, the knee represented 9% of this cohort and the hip 8%. Knee injuries and surgery represented 54% while hip injuries and surgery represented 31%. There was no significant association between the development of OA in the active professional male footballer after injury or surgery to the knee or hip. Their function was also not significantly affected in these joints after injury or surgery in the active professional male footballer.

Conclusions: The development of knee or hip OA after injury or surgery in the active professional male footballer does not affect the athlete's function.

Quality not quantity: using a heading coaching framework to reduce heading burden.

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Background/aim: With increasing concerns that repetitive ball-head impacts are associated with long-term issues with brain health, there is a need to explore risk reduction strategies. A number of football associations around the world have implemented heading guidelines which primarily focus on reducing heading quantity through heading restrictions and bans. Perhaps a shift in focus to heading quality through coaching frameworks would provide a better solution to reduce the burden of heading as well as increasing buy-in from players and other football stakeholders. The aim of the study was to explore strategies that could be incorporated into coaching frameworks to reduce the burden of heading in players of all ages and skill levels.

Methods: For this narrative review, a four-step search strategy was implemented to locate any data-based studies which reported on heading frequency as well as head impact magnitude, heading-related injury risk, cognitive outcomes and/or heading technique proficiency.

Results: In total 62 papers were located with equivocal evidence to support a 'safe' number of headers per week or a 'safe' age of first exposure to heading. Evidence suggests that focusing on performance and heading quality overlaps with many of the strategies to reduce heading burden such as teaching heading technique, with many of the components of heading being able to be taught without any ball-head impacts. Using lower pressure match and training balls, removing unnecessary heading drills which do not translate to game play and increasing neuromuscular control of the neck muscles.

Conclusions: Switching the focus away from heading guidelines which primarily advocate for heading restrictions and bans and towards heading coaching frameworks which support players and coaches to focus on heading quality and technical proficiency may assist in reducing heading burden while at the same time increasing player and coach buy-in.

An attempt to quantify the difficulty in a goalkeeper's defensive response to a cross ball.

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Methods: Our research group used data from the 2010 FIFA World Cup held in South Africa to construct a regression equation that quantifies difficulties in a goalkeeper's shot blocking (Hirashima et al., 2014). Using that regression equation, we evaluated goalkeepers who participated in the 2014 and 2018 World Cups and presented the results from Rennes 2017 and Melbourne 2019. Subsequently, this study used logistic regression analysis to identify factors that influence the success or failure of goalkeepers' defenses against crosses. Then, sample data were obtained from 550 scenes (134 successful and 416 unsuccessful) of a defending goalkeeper's crossing during the 48 qualifying league matches of the 2018 FIFA World Cup held in Russia.

Results: Results showed that the main factors influencing the success or failure of a goalkeeper's defense to crosses were set play or open play, presence of defenders in front of the crosser, presence of defenders in contact with the crosser, presence of changes in the trajectory of the cross by other players, the number of opposing players within five meters of the arrival point of the cross, the number of friendly players within five meters of the arrival point of the cross, the number of friendly players between the arrival point of the cross and both posts, the distance from the goal to the sending point of the cross, the distance from the goal to the arrival point of the cross, the distance from the goal to the last line of defense, and the crossing speed.

Conclusions: Therefore, a future task is to construct a regression equation to quantify the degree of difficulty in dealing with crosses on the basis of the 11 factors extracted in this study. The fulfillment of this task will enable the development of an objective index for evaluating goalkeepers' ability to defend against crosses.

Technical key performance indicators and transfer fees in the second division of the Bundesliga.

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Background/aim: With rising transfer fees, an inflated market and clubs in the minor leagues of professional football being at the forefront of insolvency proceedings, quantitative decision-making in the transfer market is key to tactful club management (1-2). Although a few studies have looked at the first-division level, limited studies have looked at the second-division level in football. Therefore, the aim of the current study was to determine if differences in the main key performance indicators between defenders, midfielders and strikers in the second division of the German Bundesliga and if relationships exist between these key performance indicators and the transfer fees that were paid for these players.

Methods: Data of 123 transfers of four seasons (2015-2016 to 2019/2020) within the 2nd German Bundesliga were extracted from transfermarkt.de and whoscored.com. Data on age, height, position, minutes played, appearances, transfer fees, tackles, interceptions, assists and goals were captured from the databases. Differences between defenders, midfielders and attackers were analysed with a Kruskal Wallis test, while a posthoc Dun's test was performed when a significant difference was found. Relationships between the different key performance indicators (tackles, interceptions, assists and goals) and transfer fees were analysed with a Spearman's Rho correlation.

Results: No differences in age, minutes played, appearances and transfer fees were found between defenders, midfielders and strikers. However, defenders and strikers were overall taller than midfielders ($p < 0.05$). Defenders' estimated transfer fees displayed a negative association with tackles ($r_s = -0.41$, $p = 0.03$), but no association with interceptions ($r_s = 0.06$, $p = 0.76$). Midfielders' estimated transfer fees showed no association with tackles ($r_s = 0.17$, $p = 0.24$), but a positive association with assists ($r_s = 0.44$, $p = 0.01$). Strikers' estimated transfer fees showed no association with goals ($r_s = 0.22$, $p = 0.16$) or assists ($r_s = 0.15$, $p = 0.34$).

Conclusions: The number of tackles made by defenders negatively impacts transfer fees, while assists positively affect transfer fees in midfielders. Interestingly neither assists nor goals impacted the transfer fees of attackers in the second division of the Bundesliga. Future research needs to determine which other KPA influences transfer fees in second-division level football.

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Association between 2D:4D ratios, sprint and cumulative workloads in elite youth soccer players.

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Background/aim: The aim of this study was two-fold: (i) to estimate the correlation between 2D:4D, maximal oxygen uptake (VO₂max), body fat percentage (BF%), maximum heart rate (HRmax), change of direction (COD), and accumulated acute and chronic workload variables; (ii) to verify if the length of the second digit divided by fourth digit (2D:4D) can explain fitness variables and accumulated training load.

Methods: Twenty elite young football players (age: 13.26 ± 0.19 years; height: 165.8 ± 11.67 cm; body mass: 50.70 ± 7.56 kg; VO₂max, 48.22 ± 2.29 ml.kg⁻¹.min⁻¹) participated in the present study. Anthropometric and body composition variables (e.g., height, body mass, sitting height, age, BF%, body mass index, right and left finger 2D:4D ratios) and HRmax were measured. Training load was monitored by the rating perceived exertion during the 26 weeks. The following fitness tests were also conducted: intermittent fitness test 30–15 for VO₂max, 5-0-5 test for COD, and 10 and 30-meter for sprint ability.

Results: There were associations between HRmax and VO₂max, between 2D and 4D lengths and Left and Right hand ratios. Also in AW with Right and Left 4D. The CW and de ACWR with the Right 4D. There were other associations between physical test variables and workload variables. No significant correlations were observed between right and left finger 2D:4D ratios and the results obtained in the selected fitness tests. Similarly, right and left finger 2D:4D ratios did not show a significant correlation with BF%, VO₂max, and HRmax (all p > 0.05).

Conclusions: Under-14 soccer players with low right and left-hand 2D:4D ratios did not perform better in the selected fitness tests used to assess VO₂max, COD, or sprint ability. However, it cannot be ruled out that the absence of statistically significant results may be related to the small sample size and the maturational heterogeneity of the participants.

Competition and training demands in elite women's rugby sevens: Bridging the gap.

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Background/aim: Research in women's rugby sevens (WR7s) has traditionally quantified normative physiological and/or GPS match-play movement demand values in isolation, with minimal consideration of the contextual, individual, or situational factors within the match, tournament, or training which could influence these values.

A greater understanding of the influence of these types of factors is needed to provide coaches with a clearer framework to make decisions about the most beneficial impact, inform the specificity of training, monitor internal and external load, support developmental pathways, and identify factors which may differentiate international and domestic level athletes. This presentation is an exploration into the characterization and comparison of women's rugby sevens. Consideration was given to player level (e.g., international, domestic), player position (e.g., forward, back, speed edge), tournament level (e.g., international, domestic), contextual factors (e.g., team rank, margin of result, day number, half of play etc.) match-play movement demands via Global Positioning Systems (GPS; e.g., High speed run, max velocity), cognitive perceptual factors (mental effort, self-confidence, ratings of perceived exertion), and physiological measures (e.g. HR) when performing in a novel elite dual-level tournament.

Methods: Fifty-four rugby sevens players; twenty-one international-level (5 speed edges, 8 backs, 8 forwards), and thirty-three domestic-level (10 speed edges, 11 backs, 12 forwards) wore GPS devices, HR monitors, and filled out cognitive perceptual measures while playing in and training for an elite dual-level tournament covering 2 seasons.

Results: Significant differences exist between and within playing level, player position, contextual factors, cognitive perceptual measures, and training sessions.

Conclusions: Results from this research identify key points of difference in match-play movement demands in multiple factors of women's rugby sevens.

Coaches and performance staff can use this information to; 1. Prepare and simulate scenarios in training which they know will elicit higher match-play movement demands in actual competition at this level. 2. Monitor and predict player loads, return to play protocols, and maximising recovery strategies. 3. Support developmental pathways and help to identify factors which may differentiate international and domestic level athletes.

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Effects of location and result in running and accelerometry variables in Professional Women Soccer.

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Background/aim: The aims of this study were to compare external match load between home and away matches as well as the result of the match (win, draw and loss). The secondary aim was to quantify external training load that preceded the next match taking into account both match location and result.

Methods: Ten elite women soccer players participated in the study (age 24.6±2.3 years). Seven home and seven away matches occurred in which four wins, three draws and seven losses occurred. The following global positioning system (GPS) metrics were analysed: duration, total distance, high-speed running distance (HSR, ≥15 km/h), number of accelerations (ACC) and decelerations (DEC), average speed and player load.

Results: There were no significant differences between match results and match locations. Regarding comparisons of training data preceding different match results, only duration and player load did not differ while HSR, number of ACC and DEC showed to be higher when the next match was a loss ($p < 0.05$, moderate to very large effect). Regarding comparisons of training data preceding different match locations, only duration, total distance and player load did not differ while HSR, average speed, number of ACC and DEC of all zones showed to be higher when the next match was at home ($p < 0.05$, moderate to very large effect).

Conclusions: This study showed that match result and location did not have a significant effect on GPS metrics exhibited during match-day. However, training data seems to influence the contextual factors of the next match which should be considered when planning training sessions.

Quantifying acceleration intensity in rugby union: The importance of considering initial speed.

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Background/aim: Quantifying high intensity accelerations in Rugby Union is critical to understanding the physical demand of the game. How the initial speed of an acceleration and player position effects the recorded acceleration profile has not been investigated in Rugby Union match-play. The aim of the current study was to compare an acceleration magnitude threshold to an acceleration intensity threshold to investigate the effect of initial speed and player position on the recorded acceleration profile.

Methods: Accelerations were quantified based on their intensity by considering acceleration magnitude and initial speed in unison. Raw global positioning system match-play data was collected from 52 elite male Rugby Union players over two seasons. Players were grouped by position. Two acceleration threshold methods were developed to compare an acceleration magnitude-based threshold ($3.66 \text{ m}\cdot\text{s}^{-2}$) to an acceleration intensity-based threshold. A regression was normalised to represent an intensity of 50% maximal acceleration magnitude across all initial speeds for the acceleration intensity-based threshold. A one-way ANOVA and a Tukey post hoc analysis was completed to assess the effect of the initial speed grouping and player position on the relative error.

Results: Initial speed and player position had a significant effect ($p < 0.001$) on the change in acceleration profile between the acceleration threshold methods. The difference found between the acceleration threshold methods suggests that high intensity accelerations initiated from a moving start are not well described by an acceleration magnitude threshold. This leads to a misrepresentation of the recorded acceleration demand and an underestimation of inter-positional differences.

Conclusions: An acceleration intensity approach enables the practitioner to make more specific distinctions and develop a deeper understanding of the overall, positional, and individual acceleration profile of match-play. This can aid in the optimisation of player preparation for overall match-play demand.

Determination of the anxiety–related SLC6A4 gene promoter “S” and “L” alleles in football players.

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Background/aim: The psychological characteristics of the athlete affect his athletic performance. Among them, the anxiety level of the athlete is especially important.

Serotonin is an important neurotransmitter that acts in the central and peripheral nervous systems. Serotonin transporter protein, which ensures that serotonin is taken back from the synaptic gap where it is secreted, is produced by the SLC6A4 gene located on chromosome 17. In the L/S polymorphism of the SLC6A4 gene, the L allele increases the transcriptional efficiency while the S allele has the opposite effect (1). The aim of this study was to determine the distribution of the "S" and "L" alleles of the promoter region of the SLC6A4 gene in professional Turkish male football players.

Methods: 69 male football players (age = 22 ± 3 years) and 92 sedentary individuals (age = 24 ± 2 years) control group participated in our research. DNA isolation was performed from the buccal epithelial cells of the individuals participating in the study. The SLC6A4 L/S polymorphisms were genotyped using conventional PCR. In the statistical analysis of the results obtained, χ^2 (chi-square) analysis was performed using the SPSS 25.0 program. A value of $p < 0.05$ was accepted as statistically significant.

Results: The respective percentage of the football players (n=69), SLC6A4 LL, LS and SS genotypes were 23.2%, 47.8% and 29.0%. The allelic counts were 47.1% for L and 52.9% for the S alleles of SLC6A4. The respective percentage of the control group (n=92), SLC6A4 LL, LS and SS genotypes were 6.5%, 34.8% and 58.7%. The allelic counts were 23.9% for L and 76.1% for the S alleles of SLC6A4. In the χ^2 analysis, a statistically significant difference was found between the genotype ($p = 0.002$) and allele frequencies ($p < 0.001$) in the athlete and control groups.

Conclusions: In our study, the LS genotype and S allele were found to be higher in football players. Studies to date have associated some personality traits associated with anxiety, hostility, and depression with the S allele. Athletes carrying the anxiety-related S allele should be given mental support to positively strengthen their performance.

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Analysis of goal scoring patterns in the 2022 UEFA Women European Soccer Championship.

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Background/aim: Even though women's football is growing dramatically, there are very few studies that have focused on the analysis of goal scoring patterns (1). For this reason, in the present research we analyzed relevant contextual variables related to the creation of plays that ended in a goal in the 2022 UEFA Women European Soccer Championship. Accordingly, two main objectives were proposed: to describe the incidence of scoring first on the match results and to determine the relationship between contextual variables related to goal scoring patterns.

Methods: A qualitative methodology was used to analyze the goals during the 2022 UEFA Women European Soccer Championship. An ad hoc observation instrument was used to categorize the goals through the Wyscout video and data platform (www.wyscout.com). Descriptive (frequency and average) and inferential (Chi-square test) analyses were performed considering the next variables: location of the passing and scoring players; type of ball disposal, number of contacts, contact surface, shooting distance; level of opposition to the scorer and location of the ball in the goal).

Results: Descriptive analysis the goals were performed, including the influence of scoring first on the match result. Differences were observed between the zone of the field where the player shot and the rest of the contextual variables: location of the passing player; type of ball disposal, number of contacts, contact surface, shooting distance; level of opposition to the scorer and location of the ball within the goal.

Conclusions: Our results allow expanding the weak knowledge on this topic in women football. As far as we know, many of the analyzed variables have not been previously studied and they can serve as a reference for future research. Better knowledge of goal scoring patterns in women's football may let coaches and players be aware of the importance of certain offensive- defensive aspects directly related to the goal, and could be useful in the design of individual and collective training drills.

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Comparison of external load in small-sided games and competition in Japanese football players.

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Background/aim: Football coaches and sports scientists need to control the training load applied to each player to maximize individual adaptations and improve performance (1). However, there is insufficient information regarding the physical demands on Japanese football players. Therefore, the aim of this study was to compare external load in different small-sided games (SSGs) and official matches (OM) in Japanese football players.

Methods: Sixteen male football players were monitored with global positioning systems (GPS; SPI-Pro X2, GPSports; 15Hz) during 4vs.4 (30 m × 20 m, 75 m² · player-1), 7vs.7 (68 m × 43 m, 209 m² · player-1), and 11vs.11 (105 m × 68 m, 324 m² · player-1) SSGs and OM. The total distance covered (TD), the distance of high-speed running (HSRD; 15-18 km · h⁻¹), very high-speed running (VHSRD; 18-24 km · h⁻¹), and sprint (SPD; >24 km · h⁻¹) were collected. The high-intensity accelerations and decelerations efforts (HIE) was defined based on the number of accelerations and decelerations (>2.5 m · s⁻²). These variables were normalized by relative value (m · min⁻¹ and number · min⁻¹). Moreover, the maximum velocity (MaxV; km · h⁻¹) was also collected.

Results: The SPD increased with pitch size (11vs.11 > OM > 7vs.7 > 4vs.4). On the other hand, the HIE decreased with pitch size (4vs.4 > 7vs.7 > 11vs.11 > OM). The TD and HSRD were difference with pitch size in the following (6vs.6 > 11vs.11 > 4vs.4 > OM). Whereas the VHSRD was difference with pitch size in the following (11vs.11 > 7vs.7 > OM > 4vs.4). Moreover, the MaxV during OM was faster than that of 4vs.4 and 7vs.7. Percentage differences of the MaxV, when compared with the competition were as follows: -55% (4vs.4), -22% (7vs.7), and -3% (11vs.11).

Conclusions: Our results suggested that a larger pitch size is required to increase the locomotor demands, especially for high-speed running. In SSGs with low density per player, coaches should consider high-speed running or sprinting supplementations using specific rules during SSGs, individualized positional drills, and/or running-based exercises to prepare the players. However, football coaches and sports scientists should also consider an essential element of football (e.g., accelerations and decelerations) when running speed is low.

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Analyzing the effects of reduced field sizes on tactical behaviour in 11 versus 11 football practice.

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Background/aim: One major problem in football practice is defining the scaling of the field size for the intended practice task design. To increase the frequency of actions under high pressure in training, practitioners tend to design training environments with reduced pitch dimensions (Owen et al., 2014). On the other side, the emergence of collective behavior depends on the ambient information that is available in the learning environment. To facilitate the skill transfer from training to the actual game, there is a need to investigate if the interpersonal layout given in training represents the affordances of the performance environment (Sullivan et al., 2021). The present study analyzes how collective behaviors change when the area per player is reduced.

Methods: 22 male soccer players of a 5th division club in Germany were separated into two teams and competed for an 11 versus 11 in four different field conditions. Thereby the area per player changed across conditions from formal field 324m² (FF324), to medium field 218m² (MF218), to half field 162m² (HF162), and small field 101m², (SF101). Area per player was played and examined. Each condition size was played with eleven players per team. Each team played five attacks per condition (a total of 40 attacks). The two teams performed 40 trials in a crossover study design. Players' positional data were computed using a local positioning system and processed to calculate measures of inter-team distance, team length and width (offensive, defensive), total convex hull, team spread (offensive, defensive), dyadic distance (offensive, defensive), distance to the nearest opponent (offensive, defensive), mean pressure received and mean pressure exerted.

Conclusions: The data shows, that when downscaling the field sizes in football, the interpersonal distances are just like the total convex hull compresses. Moreover, large dimensional changes lead to different game properties on a physical and tactical level. Future studies should focus on the potential of representative fields in practice tasks, as this might allow players to get better attuned to the ambient informational properties that specify the actions in the actual performance environment.

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Observational analysis of situations and tasks in grassroots football.

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Background/aim: The contributions of Motor Praxeology to the study and knowledge of cooperation-opposition sports are a reality. In the last decade the works whose object of study is the Motor Action have proliferated. The information about the elements that make up sports (space, time, interaction, gestures and regulations) allows the design of effective tasks. We consider it appropriate to develop a specific line of research to analyse tactical behaviour in sports initiation in football. The objectives were to identify the motor actions involved in the sports initiation of football taking into account its structural complexity and to validate an evaluation test from the observational methodology.

Methods: The analysis of the training tasks was carried out through observational methodology, and by developing an ad hoc observation instrument. For this purpose, observational designs of a nomothetic nature were applied, which allowed the study of monitoring units of multidimensional behaviours. Lince Plus software (Soto et al., 2019) was used and both a descriptive and a sequential analysis of delays were conducted. Two study groups have been defined with an intentional sampling technique. An intentional sampling is oriented to the selection of those units and dimensions that best guarantee the quantity (saturation) and the quality (richness) of the information. A sample of 28 athletes aged between 10 and 11 who play football at the Club Gran Rosario - GEK, Santa Fé, Argentina. Each group was subdivided into two teams of 7 vs. 7 (each one with a goalkeeper). These groups were filmed once a month, for three months. The playing field used for youth football had to conform to the dimensions regulated by Rosario Football League (Argentina).

Results: An analysis through CHAID decision trees was performed. Decision trees are a statistical technique for segmentation, data reduction, variable filtering, category fusion, etc., allowing the identification of interactions through Chi-squared tests.

Conclusions: The elaboration of an ad hoc observation instrument has allowed us to record motor behaviour of a collective nature and carry out a quantitative and qualitative analysis.

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The relationships between team momentum and collective organization in football.

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Background/aim: This study aimed to qualitatively characterize the typologies of collective organizations associated with experiences of positive momentum (M+) and negative momentum (M-), as well as the dynamics of these typologies according to changes from M+ to M- and vice versa.

Methods: Four expert football coaches watched sequences of two international-level football matches during which a team first took a large lead in the score (M+) then was caught up (M-), while its opponent experienced the opposite scenario. During the viewing of the videos, semi-structured interviews led these experts to identify specific collective organization indicators associated with M+ and M-. Qualitative data were then coded and categorized by this paper's first two authors who are themselves football experts.

Results: Macroscopic level: The team block (i.e., all the lines – defense, middle, attack – of a team) was most often forward during M+ and backward during M-. Positions ahead of team blocks were more frequent during remontada M+ than during initial M+.

Mesoscopic level: During M-, team blocks were stretched and the behaviors of some of their players were disconnected from those of their teammates. During M+, team blocks were compact and individual behaviors were strongly connected with collective actions.

Microscopic level: M+ was associated with short distances between the ball carrier and the defender closest to him and by without-the-ball offensive and defensive runs directed towards the opposite goal. Offensive and defensive runs towards the goal to attack were more frequent during remontada M+ than during initial M+. During M-, the distances between the ball carrier and the closest defender were large, especially during demontada M-.

Conclusions: Patterns of collective organization that were identified are consistent with those observed when teams pursue offensive or defensive aims (1). They also confirm, at a collective level, the relationships that were observed between momentum and dyadic motor synchronization in sport (2). Research on the dynamics of collective patterns associated with momentum experiences is to be continued in light of the dynamical systems theory.

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Effects of limiting players' verbal communication during football small-sided games in youth players.

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Background/aim: Successful performance depends on players' verbal and nonverbal communication with teammates and opponents to engage in goal-directed behaviors according to spatial-temporal relations. Accordingly, some studies have investigated how the emphasis or inhibition of spaces of play, limits of the field or even the color vests changed the interpersonal relations between teammates and opponents (1, 2). Nevertheless, no study has examined how limiting players' verbal communication affects their performance in small games (SSG), and therefore this was investigated in this study.

Methods: Sixteen youth players (U16) participated in four SSG: i) Gk+6v6+Gk without restrictions (6v6 CTR); ii) Gk+6v6+Gk with restrictions of communication (6v6 MUTE); iii) Gk+8vs8+Gk without restrictions (8v8 CTR); and iv) Gk+8v8+Gk with restrictions of communication (8v8 MUTE). The playing area and length/width ratio were kept constant between conditions. GPS devices (WIMU ProTM; Realtrack Systems, Almeria, Spain) were used to record the physical and tactical performance of the players.

Results: No statistically significant differences between conditions were found for the 6vs6 game format. Significant effects have identified all conditions and the 8vs8 MUTE. Higher playing areas were found for the 8vs8 MUTE when compared to 8vs8 CTR ($X^2 = 518$, $p < 0.001$), 6vs6 CTR ($p < 0.001$) and to 6vs6 MUTE ($p < 0.001$). Lower total distance covered ($F = 5.0$, $p = 0.003$) and sprinting distance ($X^2 = 10.8$, $p = 0.013$) were found during the 8vs8 MUTE than 6vs6 MUTE and 8vs8 CTR. In turn, the higher walking distance was found for the 8vs8 MUTE compared to 8vs8 CTR ($F = 2.95$, $p = 0.047$).

Conclusions: Overall, the limited communication of players affected their collective coordination and promoted greater dispersion in larger formats, which seems to impair the external load. In practical terms, coaches can use the 8vs8 mute condition to reduce external load and promote positional adaptability.

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Characteristics of motor cognitive ability of young aged 14-18 years-old.

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Background/aim: Cognitive training deals with the attention, decision-making, and short-term memory. These are important abilities in team sports and in sports where reaction time and motor skills play a key role. The purpose of the study was twofold: 1. to assess motor cognitive abilities among young football players and compare these abilities in tests with and without the ball, and 2. to investigate the motor cognitive abilities differences between young football players and non-training.

Methods: The study included 24 boys from a Polish football club in the first division. The study group attends football training 4 days a week. The study was conducted using the Skill Court device. The test subject moves around a specially prepared area (5x6m) according to instructions displayed on the device's monitor. The device allows the evaluation of perception, reaction, speed of action, acceleration, deceleration, and change of direction. The subjects performed a total of four tests: 50m random run without the ball (50m run) and with a ball (50m run the ball), random star-run without a ball (star), and with the ball (star ball). The score of the test was the test execution time in seconds.

Results: The study shows that in the first "50m run" test, the athletes obtained times of 23.38 ± 2.20 s, while in the "50m run the ball" test, the times were significantly longer at 33.38 ± 3.19 s. In the "star" test, the test group achieved times of 19.29 ± 1.27 s, while the same test with the "star ball" was performed at 25.47 ± 2.63 s. Test times with and without the ball were correlated with each other for both tests. Correlation results showed that there was essentially no correlation between the test with the ball and the test without the ball ($|r| < 0.3$). The analysis also shows that the football group achieved better times than the non-training youth.

Conclusions: The lack of correlation between trials with and without the ball may indicate an influence of technique on the times obtained in motor cognitive tests. The technique is closely related to coordination, which affects reaction speed, agility, and change of direction. In addition, the group of football players showed better times than the control group so it can be assumed that football training has a positive effect on the formation of motor cognitive ability.

Bone mineral quality in U10, U12, U14 and U16 youth football players during a competitive season.

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Background/aim: The childhood and adolescence stages are key for the acquisition of bone mineral content, which can positively influence and prevent osteoporosis, as 26% of an adult's bone mineral content is acquired at this stage (1). Previous studies have shown the positive effect of football training on BMC and BMD in children of a certain age (2). Aim of this research was to analyze the effects of playing football on BMC and BMD in young football players at different stages of growth during a competitive season.

Methods: 60 football children divided into four groups according to their category (U10, U12, U14, U16). It was analyzed in three phases of the season; beginning, middle and end of the season. BMC and BMD were assessed using standardized procedures (Dxa). A Two-way mixed ANOVA was used.

Results: The BMC of the whole body and both legs increased at the third period of the season compared to the first and second period in all categories ($P < 0.01$). Higher values were found in the BMC of the whole body, left arm, trunk, left leg and right leg in the U14 and U16 players in the three periods analyzed compared to the U10, U12 players ($P < 0.01$). Increase in whole body BMD at the third measurement compared to the first and second period in all categories ($P < 0.01$). Higher BMD in the whole body of U16 players in the three periods of the season with respect to the other categories ($P < 0.01$).

Conclusions: After 9 months of football training, improvements in bone mineral quality and body composition were observed in all categories, with the U16 players showing the most notable improvements. However, in the case of 10- and 12-year-old players, a longer period (9 months) is necessary to observe significant improvements with respect to 14- and 16-year-old players who show improvements at 4 and 9 months of training.

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Reference values of stiffness in soccer players. Modulating effect of age and demarcation.

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Background/aim: Jumping, sprinting and changes of direction are the most frequent actions in soccer. Optimal performance in these actions is associated to an adequate level of stiffness, defined as the relationship between the force applied to a tissue and the displacement exerted (1). Stiffness of the lower limb is required to absorb ground reaction forces, as well as to store and reuse elastic energy. Higher stiffness values are related to improved sprinting, greater acceleration, higher efficiencies in movements involving changes of direction and greater jump height in rapid stretch-shortening cycle activities. Conversely, excessive levels of stiffness can lead to bone injuries (stress fractures and osteoarthritis) (2). On the other hand, it has been suggested that too low values of stiffness may link to excessive range of movement in joints leading to soft tissue injuries. Current research aims to characterize the reference values of stiffness in young soccer players according to age and demarcation as well as to analyze their relationship with performance and injury risk.

Methods: Male soccer players ranging from 14 to 18 years old filled a survey to categorize the injuries suffered in the last 6 months. Stiffness was calculated using a validated inertial system (IMU) during countermovement jump (CMJ), Stiffness Test and calculating flight height, contact time, reactivity index and rate of force development.

Conclusions: Our results will describe the reference values of stiffness in soccer players, its relation with performance and injuries incidence, and its modulation by age and soccer specific demarcation.

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Distribution of ACE I/D and AGT rs699 polymorphisms in Turkish male football players.

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Background/aim: The Renin-Angiotensin System plays an important role in the control and regulation of blood pressure in the human body. The AGT gene rs699 polymorphism causes the cytosine-thymine (T>C) transition. This amino acid change is associated with an increase in circulating AGT concentration. ACE contains a polymorphism due to an insertion (I) or a deletion (D) of a 287 bp Alu sequence in intron 16. The I/D polymorphism is associated with circulating and tissue ACE levels (1). The aim of this study is to examine the differences between genotype and allele distributions of ACE I/D and AGT rs699 polymorphisms in Turkish male football players.

Methods: 78 male football players (age = 20 ± 2 years) and 130 sedentary individuals (age = 24 ± 4 years) control group participated in our research. DNA isolation was performed from the buccal epithelial cells of the individuals participating in the study. Real Time PCR was used for genotyping of the AGT rs699 polymorphism and the ACE I/D polymorphisms were genotyped using conventional PCR. In the statistical analysis of the results obtained, χ^2 (chi-square) analysis was performed using the SPSS 25.0 program. A value of $p < 0.05$ was accepted as statistically significant.

Results: The respective percentage of the football players (n=78), ACE II, ID and DD genotypes were 28.2%, 34.6% and 37.2%. For the AGT genotype, the respective frequencies were 30.8%, 50.0% and 19.2% for the CC, CT and TT genotypes. The respective percentage of the control group (n=105), ACE II, ID and DD genotypes were 28.6%, 38.1% and 33.3%. For the AGT genotype, the respective frequencies were 32.4%, 51.4% and 16.2% for the CC, CT and TT genotypes. In the χ^2 analysis, no statistically significant difference was found between ACE and AGT the genotype and allelic frequencies in the footballers and control groups.

Conclusions: Our results were in agreement with the previous reports, indicating the presence of ACE D and AGT C allele in football players. We suggest that ACE and AGT genotypes are important biomarkers for genetic counseling for the individuals who are prone to be successful football players.

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The relationship between visual reaction time and balance skills in CTFF (A2) league footballers.

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Background/aim: This study aimed to measure football players' balance and the reaction speed of their hands and feet. And this study also aimed to determine the relationship between the balance and reaction speed of the hands and feet of football players.

Methods: 38 players from the A2 League of Cyprus Turkish Football Federation (CTFF) participated in this study. With Flamingo Balance Test, their statical balance (1) and Star Excursion Test and Multiple Single Foot Leap tests, their dynamic balances (2) were measured. With Blazepod flash reflex lights, their hands and legs' visual reaction time was measured. SPSS 24.0 software was used to analyze the data.

Results: Failure number of the Flamingo Balance Test is 4.16 ± 1.89 ; right foot star test result is 87.817 ± 10.73 (cm); left foot star test result is 86.659 ± 10.36 (cm), one leg leap with right foot is 19.24 ± 9.32 , one leg leap with left foot is 10.63 ± 8.93 , average of total strike of hand reaction is 29.58 ± 5.52 , average speed of hand reaction is 883.55 ± 91.83 , total number of strike of foot reaction is 29.76 ± 3.78 , average speed of foot reaction is 816.68 ± 4.22 , total number of strike of right foot reaction is 28.29 ± 4.22 , average speed of right foot reaction is 978.63 ± 119.86 , total number of strike of left foot reaction is 26.18 ± 3.90 , and average speed of left foot reaction is 986.44 ± 217.36 .

Conclusions: The right foot jumping score average points is higher than the left foot jumping score. The right foot's average reaction strike score is higher than the left foot. In the left footed players, there was a significant negative relationship between right foot strike number and right foot reaction speed. In the right footed players, there was a significant negative relationship between left-foot strike number and left foot reaction speed. In the right footed players, there was a significant positive relationship between right foot leap level and right foot reaction speed. In the left footed players, there was a significant negative relationship between right foot leap level and right foot strike number.

Player and Staff Perceptions of Mental Health Support Within Elite Women's Football in England.

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Background/aim: Elite female footballers in England report an elevated prevalence of depression, anxiety, and disordered eating symptoms relative to elite female footballers in other countries (1). Importantly, 86% of elite female footballers in England report wanting psychological support during their football career, but only 50% have access to support and only 28% use available psychological support (1). Consequently, research is needed to explore the barriers to accessing and utilizing psychological support in this population. The aim of this qualitative study was to explore player and staff perceptions of the mental health support currently offered in elite women's football in England.

Methods: Semi-structured interviews were conducted with N=30 participants (players [n=21], coaches [n=3], chaplains [n=2], sport scientists [n=2], and sport psychologists [n=2]) who represented the top two tiers of women's football in England (Women's Super League and Women's Championship) during the 2020-2021 competitive season (mean interview duration=72 min/interview; totalling >36 hours of data). Reflexive thematic analysis was used to analyse the data.

Results: All participants voiced the critical need for improved mental health support in elite women's football. Participants described a culture of reluctance towards using mental health support due to (1) perceived stigma from coaches (2) limited resources and support options (e.g., the only support offered is the sport psychologist for the men's team), and (3) feelings of uncertainty around the authenticity of support; many participants felt the current support felt like a "tick box". Participants highlighted several recommendations for improving mental health support; for example, they suggested that clubs should provide players with the option to work with a psychologist not affiliated with the team or club.

Conclusions: This is the first study to explore player and staff perceptions regarding mental health support in women's football. Coaches, staff, and stakeholders play an important role in regulating the accessibility and efficacy of mental health support for elite female footballers and therefore should be targeted by interventions that are designed to support player mental health. This is an important finding because current mental health interventions primarily focus on intervening solely at the individual player level.

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Anticipating injuries and health problems in elite soccer players using Dynamic Complexity

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Background/aim: Injuries and health problems of soccer players may appear abruptly and are often unexpected. However, hypotheses from complex systems theory suggest that these events can be preceded by certain Early Warning Signals (EWSs) (1). We tested whether injuries and health problems can be anticipated with a specific type of EWS, that is, an increase in dynamic complexity (DC) (2).

Methods: Over two competitive seasons, we collected psychological and physiological self-reports (i.e., self-efficacy, motivation, mood, rating of own performance, enjoyment, and recovery) and data from heart rate sensors on every training and match day from 14 youth soccer players. We recorded time-loss injuries daily and players filled in the Sports Trauma Research Center Questionnaire on Health Problems (OSTRC-H2) once a week. We then calculated the DC of the self-reports and sensor data in a seven-day window to test for increased variability and complexity over time before injuries and health problems.

Results: Players experienced 5.6 injuries and 8.4 health problems on average across two seasons (range=1-18 and range=2-26, respectively). Results showed that increases in DC could often anticipate the occurrence of injuries and health problems. In 55% and 37% of the players DC increased up to five days before injuries and health problems, respectively (SD=39% and SD=25%, Min=0% and Min=0%, Max=100% and Max=83%).

Conclusions: Results of this study suggest that EWSs can be used for real-time anticipation of injuries and health problems in daily soccer practice. Future research should test for the robustness of these results within and between individuals and perform sensitivity and specificity tests. In addition, finding out how warning signals can be communicated to soccer players and staff is an interesting avenue.

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The 5Cs as a behavioural analysis and intervention method in youth football.

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Background/aim: Psychological skills training (PST) in football has been called football's next frontier. While stakeholders generally acknowledge the importance of psychology, anyone implementing a PST in a football club must acknowledge various obstacles in their path. They include cost, lack of knowledge, coach and player perceptions and lack of commitment from management. Building on Harwood's 5Cs for positive youth development in football we constructed and tested a method that would empower coaches. The goal was to make PST accessible to coaches and players, so it would become part of their daily routine with the goal of enhancing competitive performance.

Methods: The 5Cs are Commitment, Communication, Concentration, Control and Confidence. We gathered nine expert football coaches to build job descriptions according to positions to enhance role clarity. Through a workshop and one versus one interviews, they were asked to attribute a C to each description. The resulting job descriptions were used to build a tagging manual. Working with the U15 and U17 teams of a professional top league club, we analysed individual player behaviors from video recordings of all their games during a four-month period. During that time an intervention took place, based on the 5Cs, involving classroom sessions for players and coaches, online parent sessions and on-field training sessions directed by coaches.

Conclusions: Results indicate that PST in football should focus on the coach as the central figure in its delivery. Player development should include role clarity framed through on-field behaviours. Merging performance enhancement with positive youth development will combine the different needs of stakeholders (clubs, parents).

Applying performance analysis in soccer: Understanding all aspects relating to game outcome.

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It is widely known that contemporary soccer is a multi-billion-euro industry and that gaining a competitive advantage over rival teams can be significantly financially beneficial, indicating that the stakes for all stakeholders (players, coaches, management) within a team or club are high. Performance analysis is therefore important, in order to get a better understanding of the outcomes of games. As game outcome are often the basis for many decisions within a team or club, related to training, but also aspects as testing and monitoring, it is important to (better) understand game outcome in soccer. There are many factors that influence game outcome, which can be summarized from the positivist paradigm as the performance of team and its opponent. Within the positivist paradigm, the factor chance is however not accounted for. Chance in sports refers to as something uncontrollable and unforeseeable, not intended and not caused by skill or tactics, and although it is widely regarded that game outcome in soccer is influenced by chance. This indicates that the factor chance should be considered in soccer, nevertheless, the number of studies on this topic is currently limited. This may be because the concept of chance may be perceived as rather abstract, and may be deemed unmeasurable. With the (still) emerging possibilities of technology, the need to extract useful information and relate it to performance in our beautiful game becomes ever increasing. This creates an uneven situation, in which performance game be meticulously analyzed, while chance is disregarded. This may lead to wrong decisions, as either good or bad game outcomes, possibly as a result of chance, evoke emotions that increase the bias that is connected to performance judgements. Increased understanding of game outcome in soccer may lead to a more holistic approach on decision-making by stakeholders, leading to more 'correct' decision and less disruptions of fruitful processes within teams. In this study, a model will be presented, depicting the relation between game.

Injury forecasting for return-to-play decisions in football: data-driven approaches and alternatives.

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Background/aim: Decision-making processes for return to play after injuries require forecasting the potential outcome (e.g., re-injury risk). In football, (re-)injury risk is influenced by a combination of physical, mental, and contextual factors. To predict reinjury risk, highly complex and flexible data-driven methods are a natural preference. For a data-driven prediction model, it is essential to generalise to new data. However, in real-world injury forecasting, sparse datasets, imbalanced data points (i.e., with injury vs. without injury) limit performance of trained models especially on unseen data. On the other hand, subjective human reasoning based on experience alone has the appeal of functioning in complex situations with scarce specific precedents. Psychological heuristics, as a potential hub for data and experience-driven approaches, emphasise the potential for gains in forecasting by deliberately reducing model complexity (1). Therefore, this work aims to demonstrate the limited generalisability of data-driven models based on sparse precedents. The challenge is exemplified by predicting acute, non-contact, and time-loss (ANCTL) injuries in football. Furthermore, an alternative to forecasting football injuries and re-injuries was suggested.

Methods: A dataset including 76 professional outfield players' screening (e.g., body composition), monitoring (e.g., session RPE), and injury information during a season was used to fit Histogram-based Gradient Boosting Classification Tree (HGBDT). The feature with the greatest importance was selected to fit linear regression (LR). Recall score and ROC area-under-the-curve (ROC-AUC) were used to evaluate model performance.

Results: The LR model presented high bias (low accuracy on training sets). The HGBDT model with all features showed low bias but high variance (on test sets, recall score: 0.08 to 0.31 and ROC-AUC: 0.48 to 0.63).

Conclusions: This study provided a proof of concept that purely data-driven approaches usually fail to predict ANCTL injuries in football, reflected by underfitting or overfitting. Integrating experience-based human reasoning into a "hybrid-intelligence" approach could help decision making with few specific precedents (1). Moreover, heuristics may enable leveraging the benefits of adapting model complexity to the available dataset. Such adapted approaches may be expected to lead to more accurate forecasts and reliable decisions than those effortful data-driven strategies.

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Coach experiences of formal coach education developed by national governing bodies: Systematic review

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Background: The education and training of coaches is considered central to maintaining and improving the quality of sporting provision. Formal coach education is accessed by thousands of coaches each year. However, there is still considerable evidence which suggests that coaches do not prefer formal coach education and feel it plays only a minor role in their development. One possible reason for this, suggested by many researchers, is the lack of consideration of the coaches' perspective in the design of current programmes, which has led to the current initial criticism of NGB programmes regarding the course content and the way they are delivered.

Purpose: The purpose of this study was to systematically review the existing empirical evidence about how coaches experience formal coach education programmes developed by NGBs. **Methods:** A systematic review was conducted. Based on the ENTREQ guidelines, A comprehensive search was performed in six electronic databases using key words related to coach experience, coach education and national governing bodies. The inclusion criteria were: coach, coach trainee, coach learner; formal coach education courses developed by NGBs; peer-reviewed articles in English published between 2000 and 2021; qualitative methods studies. Tong et al's (2012) COREQ checklist was used to undertake an article quality assessment. Thematic analysis was used to analyse data from the included articles.

Results: 15 studies met the study's inclusion criteria. Analysis showed three main themes influenced coaches' course experience: (1) coach educator pedagogy (2) learning design, and (3) course content. More specifically, coaches' experience depended heavily on (a) whether the educator used pedagogical approaches which include interactive elements and (b) whether educators had good interpersonal skills. In addition, the course content can be demonstrated and applied in practical-based workshops with sufficient time as well as coaches were provided with support by educators to help and facilitate their reflective practice, were both desired by the coaches. Finally, there was uneasiness around failing to meet coaches' expectations of course content and any disconnect between course content and coaches' actual practice of coaching.

Conclusions: The review provides a detailed understanding of what coaches perceive they want and need from NGB coach education courses. These findings provide insight to inform how future NGB's designers and educators could think about what coaches want and need from these experiences.

The impact of the new stoppage time algorithm on the timing of goals in FIFA world cup.

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Background/aim: The purpose of this study is to explore the influence of goal times after the new stoppage time algorithm.

Methods: The timing of goals scored in the group stage of the 2022 and 2018 FIFA World Cup was used for analysis. Goal time is divided between the first and second halves and every 15 minutes. The difference in the time distribution of goals was tested using a Chi-square test with a significance level set at $p < 0.05$.

Results: A total of 120 goals were scored in the group stage, 35.8% of which came in the first half and 64.2% in the second half in 2022 FIFA World Cup group stage and a total of 122 goals were scored in the group stage, 38.5% of which came in the first half and 61.5% in the second half in 2018 FIFA World Cup group stage. There is no difference between the first and second halves ($\chi^2 = 0.188$, $p > 0.05$) of the two World Cups in terms of goal time, nor was there a difference in time to goal per 15 minutes ($\chi^2 = 2.468$, $p > 0.05$). In the 15-minute period, the greatest variation in the number of goals was seen from 61-75 minutes (2022 World Cup: 26.3% VS 2018 World Cup 16.4%).

Conclusions: With the new stoppage time algorithm, there was no significant change in goal time, but there was a trend towards more goals in 61-75 minutes. Practitioners need to grasp the features of the new compensatory time algorithm and rationalise their athletes' physical allocation and tactical strategies.

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Cognitive functions of football players undergoing intense intermittent exercise.

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Background/aim: Research has demonstrated that physiological responses to acute exercise elicit significant changes in cognitive functions (1). Moreover, studies based on Yerkes and Dodson's inverted-U theory have reported that moderate-intensity exercise induces optimal cognitive performance, whereas high-intensity exercise results in poor cognitive performance (2). However, knowledge based on a football-specific research design is necessary to apply these findings to football. Based on the above considerations, we examined the inverted-U-shaped relationship between intermittent exercise intensity and cognitive functions using the Pass-Choice Reaction Task, a standardized test assessing the speed and accuracy of information processing in football, and the Stroop-Test II.

Methods: Male football players (N = 13, Mean ± SD: age = 20.2 ± 0.94 yrs) in Japanese university football clubs participated in the study. They conducted Pass-Choice Reaction Task and Stroop-Test II after exercising at different intensities (No-exercise control test: CT; Moderate Intensity Exercise; MI, High-intensity exercise: HI). One MI load set consisted of 50% of the maximum anaerobic power (watt) for 5 seconds and 10% for 25 seconds, a total of 30 seconds. One HI load set consisted of 80% max anaerobic power for 5 seconds and 10% anaerobic power for 25 seconds, a total of 30 seconds. The participants consecutively performed ten sets of MI and HI as one term of each and conducted three terms with a one-minute rest between terms. The Pass-Choice Reaction Task measured Reaction times when participants decided whether to pass the ball to the right, the left, or a central player in response to slides of game situations. The Stroop-Test II evaluated their attention function.

Results: The Pass-Choice Reaction Task demonstrated that RTs of MI and HI were significantly faster than CT. However, there were no significant differences between MI and HI. The Stroop Test results demonstrated that the correct response number increased significantly in MI and HI than in CT. However, there were no significant differences between MI and HI. These results suggest that intermittent exercise might improve information processing and attention functions. However, the results did not show that exercise intensity and cognitive function have an inverted-U relationship.

Conclusions: Intermittent exercise simulating a Football match suggested moderate-intensity exercise promoted selective attention functions and shortened RT. However, there was no difference between moderate and high-intensity exercise.

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Body composition, physical, technical and tactical performance of Chinese youth male footballers.

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Background/aim: Identifying youth football talent is complex and is related to maturity, technical skills, game performance, and many other factors. A holistic approach to talent identification is needed to better understand the development and performance of young football players (1). We examined age-related differences in the characteristics of football players aged 9-15 years in terms of body composition, physical performance, and technical and tactical skills. It was hypothesized that body composition, physical performance, technical and tactical skills would differ between 9, 11, 13, 15 years old.

Methods: Recruiting about 300 young athletes from the top four teams of the U9, U11, U13, and U15 youth football competitions in Shanghai. These athletes were tested in the areas of individual physiology and technical football skills. The tests included height, weight, chest circumference, waist circumference, skeletal muscle, body fat percentage, 15 m sprint, 30 m sprint, 20-meter shuttle run, standing long jump, seated forward bend, dribbling speed, passing accuracy 20 m, and juggling ability. Descriptive statistics are presented as means, standard deviations and frequencies. ANOVA was used to compare means across the four age-cohorts and Bonferroni's test for post-hoc multiple comparisons. All statistical analyses were performed using IBM SPSS Statistics v.28, with the significance level set at 5%.

Results: 15-year-old football players were significantly ($p < 0.001$) taller, heavier, and more mature than 13-, 11-, and 9-year-olds. Similar results were found in physical performance, with 15-year-olds performing better ($p < 0.001$), but no statistically significant differences were observed in the seated forward bend test ($p > 0.05$). In the technical skills test, 15-year-olds performed better than the other three age groups ($p < 0.01$). Players from 9 to 15 years of age improved in all technical tests except for shot accuracy.

Conclusions: 15-year-old players are better in body composition and physical performance than younger ones, which is related to growth maturity and training time. The tactical skills of youth football players did not differ across age groups.

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Maturation, playing time and coaches assessment of maturity status in elite football academies.

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Background/aim: Nowadays, physical variables are known to very relevant in soccer (1). Indeed, talent identification in youth soccer is influenced by the players' physical attributes and their maturational status, since an advanced maturation has been linked to higher performance (2). The main objective of our study was to explore whether maturity status influences the playing time (PT) and the coaches' assessment of maturity status (MS).

Methods: The sample was composed by 345 male players (Mage=14.34 ± 1.12) from different Spanish elite academies. Within each age group category (U13-U16), players were classified according to their maturational status (Early, Normal or Late). Their temporal distance to Peak Height Velocity (PHV) was also estimated. T-Student tests were used to determine if the maturity status influences the percentage of playing time. Correlation analysis were also carried out to explore the relationship between the PHV and coaches' assessment of maturity status (MS).

Results: Interestingly, no late-maturing player were found in the different age groups of the elite soccer academies analyzed. Maturity status and playing time did not show relationship in the U15 and U16 categories, in contrast early maturers enjoyed more playing time in the youngest groups (U13, p=.069; U14, p<.05). Interestingly about the relationship between PHV and MS; while no correlation was found in the older group (U16, r= .051), a small correlation was found in U15 (r= .210*) and moderate correlations were found in U13 (r=.586**) and U14 (r=.530**).

Conclusions: Maturity status seems to bias talent selection, since late-maturing players were not present in the elite soccer academies analyzed. Moreover, maturity status showed a relevant influence in the playing time of the younger players (U13 & U14), an influence which tended to disappear after the PHV period (U15 & U16). Interestingly, the coach's perception of players maturity was also more effective in younger players before their PHV period.

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The peak height velocity age and physical performance in youth girl soccer players.

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Background/aim: Individual maturity and sex differences must be considered to provide optimal training programs for youth athletes who were going through a growth spurt. This study aimed at investigating the relationship between peak height velocity age (PHVA) and physical performance.

Methods: Thirty-two junior high school girls (Height: 157.4±4.4 cm, Weight: 47.5±5.5 kg, Age: 13.9±0.9 years) participated in this study. Height, sitting height, and weight were measured as physical parameters. They performed 6 events performance tests (10 m sprint, 40 m sprint, standing long jump, 3 steps jump, Yo-Yo-test, and kicking ball distance). PHVA was calculated using the formula of Mirwald et al. (1). Years from PHV predicted from anthropometric data was used as a maturity indicator.

Results: The mean value of PHVA was 8.93±0.61 years. All participants in this study were post-PHV. There was a significant correlation between the performance of the standing long jump, 3 steps jump, kicking ball distance, and PHV. As increases in stature components and muscle area have been reported after PHV (2), jumping and kicking performances likely improved as lower limb muscle strength improved. Meanwhile, there was no correlation with 10 m sprint, 40 m sprint, Yo-Yo-test, and PHV.

Conclusions: Jumping and kicking performance continued to improve after PHV, reflecting differences in muscle mass growth timing. Previous studies have reported increased knee abduction moments and increased risk of anterior cruciate ligament injury during and after PHV in girls. Therefore, it is very important to understand that different individuals perform differently depending on their physical maturity level, even after PHV, and trainers and coaches should train according to the physical maturity level of the individual in girl soccer players.

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Relative age influences player's physical performance and its assessment by coaches.

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Background/aim: The Relative Age Effect (RAE), favours players born at the beginning of the chronological year, showing a better physical fitness (Peña-González et al., 2020). This factor interferes in the processes of talent identification, where elite football academies tend to show a pronounced RAE presence. Our study analyzes the relationship between the RAE and one relevant physical ability in football (explosive strength), and explore the relationship between RAE, quantitative objective results from jumping ability and the coaches' subjective perception of physical performance within players already selected by elite football academies.

Methods: 541 male players (U11-U19) from different Spanish elite academies were classified according to each age group category (U12, U14, U16 and U19) and birth quartile (BQ1-BQ4). Explosive strength was measured by Squat Jump (SJ, cm), Countermovement Jump (CMJ, cm), and 20-meter run (20m, seconds) were objectively evaluated. The coaches' subjective perception of player's physical fitness (CP) was assessed using a visual analogue scale (1-5 pts). Chi-Square test and Odds Ratio were used to explore the birth asymmetries (RAE). ANOVAs were used to determine if the RAE modulates the different component of explosive strength and CP. Finally, correlation analysis was carried out between the SJ, CMJ and 20m and the CP.

Results: RAE is present in elite academies ($p=.000$; OR = 7.86 between BQ1/BQ4). An inverse RAE was found in explosive strength in the U12 group, with BQ4 players jumping higher in SJ and running faster in 20 m than BQ2 players ($p<.05$). However, in U15 the RAE effect was found, showing that BQ2 players jumped higher in SJ than their BQ4 counterparts ($p<.05$). Moderate correlations were observed between explosive strength abilities and CP in most of the age categories.

Conclusions: The RAE is very accentuated in the Spanish elite football academies. However, at the physical fitness level, no dissimilarities were found between players born in different year quarters. The coaches' subjective perception on physical fitness performance is closely related with the real objective values of explosive strength, giving greater credibility to the observation by coaches in the selection processes at a conditional level.

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Relative age effect in youth football: a longitudinal investigation in a portuguese academy.

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Background/aim: Young football players are exposed to several morphological transformations resulting from different growth rates that interfere with individual and collective performance (1,2). The relative age effect (RAE) states that in a grouping of players by age categories, the older players are at an advantage because of their relative superior development (physical, e.g.) compared to their younger colleagues (1). The aim of this study was to investigate the RAE in a football academy according to the different age categories and the competitive level.

Methods: Data from 2696 young players (5 to 19 years old) from a Portuguese football academy from 2010 to 2023 seasons were analyzed. The sample was divided into 7 age groups (each age group contains 2 chronological years) and grouped by 3 competitive levels: Beginners (U5 - U11), Development (U12 - U15) and Performance (U16 - U19). Birth quarters were categorized (2) following the chronological order into Q1 (Jan to Mar), Q2 (Apr to Jun), Q3 (Jul to Sep) and Q4 (Oct to Dec). Descriptive statistics were calculated and chi-square test was used to verify the significant differences ($p < 0.05$).

Results: The results showed higher relative frequency in Q1 (26.1%) and Q2 (29.4%) relative to Q3 (21.4%) and Q4 (23%). An association was found between birth quartile and age subcategory ($p < 0.05$). In quartile by subcategory, it was verified that in 6 of the 7 subcategories the relative frequency was higher in Q2 and Q1, excepting the U5-U7 subcategory. For the competitive framework, no significant differences were found ($p > 0.05$). However, the Q2 registered a higher percentage in Beginners (28.4%) Development (30.7%) and Performance (29%) compared to the remaining years Q1 (23.2%, 26.9%, 28.7%), Q3 (24.2%, 19.7%, 20.4%) and Q4 (24.3%, 22.7%, 22%).

Conclusions: The results show possible relations between birth quartile, subcategories, and competition. It was concluded that the higher the subcategory and competitive framework, the greater the presence of RAE. Competitive models that mitigate the effects of advantages may benefit player development.

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Partners

