UNIVERSITY OF LIMERICK
OLLSCOIL LUIMNIGH

Sport and Human Performance Research Centre

NATIONAL SPORT AND HUMAN PERFORMANCE CONFERENCE

29th September, 2023

University of Limerick, Limerick, Ireland

BOOK OF ABSTRACTS

ul.ie/shprc/nshpconference2023

NATIONAL SPORT AND HUMAN PERFORMANCE CONFERENCE 2023

Welcoming Address

On behalf of the Department of Physical Education and Sport Sciences (PESS) and the Sport and Human Performance Research Centre, we would like to warmly welcome you to the inaugural National Sport and Human Performance Conference hosted this year at the University of Limerick on Friday 29th September 2023.

The conference is an important outcome of the establishment of the Sport and Human Performance Research Centre (SHPRC) which is a UL priority Research Centre. The SHPRC's mission is to advance interdisciplinary research in sport and human performance at the University of Limerick, to inform national and international best practice, and through the creation of national and international collaborative networks, to achieve global recognition for the quality of its research outputs and graduate students.

The SHPRC is dedicated to innovative, interdisciplinary, applied translational research in sport and human performance. Established in 2021 and launched by Lord Sebastian Coe (President of World Athletics) in October 2022, the SHPRC has a management team of 7 academic faculty and a technical officer, and currently has 68 members (26 full; 26 affiliate; 13 researcher (including two post-doctoral researchers); 2 industry and 1 community). It is a virtual centre, homed within the PESS building in UL but with extensive national and international collaborations and with six core themes:

- Athletics Sport Science
- Rugby Sport Science
- Esports Science
- Weight Category Sport Science
- Endurance Sport Science
- Coaching Science (emerging theme)

Key research metrics from 2017 (date of the SHPRC's inception) include: 657 publications (195 top 10% of journals, 88 top 10% most cited publications); 49% international collaboration, 21 PhD graduates, and research funding awards of €8.11 million.

The conference will bring together postgraduate research students from across the Higher Education Institutions (HEIs) of Ireland, coaches, applied scientists / practitioners, national governing bodies (NGB's) and academics interested in advancing multidisciplinary and interdisciplinary translational research in sport and human performance.

This one-day conference aims to:

- Advance knowledge and inform professional best practice in Sport and Human Performance
- Support early career researchers and practitioners engaged in Sport and Human Performance research
- Encourage collaboration and knowledge exchange across researchers, NGB's and applied scientists clustering expertise around key research disciplines or themes
- Develop national and international networks / strategic partnerships related to Sport and Human Performance

This conference aims to provide a home for the discussion and dissemination of sport and human performance related research nationally, a chance to talk and network, form friendships, and research collaborations. It will provide an opportunity for emerging research topics to flourish and facilitate SHPRC and our other related research groups across Ireland to work together. The conference programme today includes 16 oral presentations, 35 poster presentations by delegates across 14 national HEI's; 7 international HEI's and 12 National Governing Bodies/Institutes of Sport (mentioned on page 6), engaged in a range of applied practices or undertaking research for professional / structured doctorate awards, traditional PhD, MPhil and MSc awards under the 6 conference research themes.

We also have presentations under emerging themes including coaching science as well as practical workshops related to cutting edge Sport and Human Performance technologies. There will be best poster and oral presentation awards during the closing address. More importantly, it is our hope that our informal tone will provide presenters with freedom to engage in frank, productive and stimulating conversations across the oral, poster and workshop sessions.

We are delighted to welcome this year's distinguished keynote speakers, Prof Rod McLoughlin (Medical Director, IRFU) who will speak to the challenges of applying an evidence-based medicine and science approach in an elite environment and Prof Sharon Madigan (Head of Performance Nutrition, Sport Ireland) who will speak on the topic of Sports nutrition – science vs pseudoscience.

Finally, we would like to thank all of the organising committee for the considerable work that has been put into the organisation of this conference well in advance of today – it was a fantastic team effort!

We hope you enjoy the conference.

Dr Mark Lyons
Conference Chair

Prof Ian Kenny
Co-Director, SHPRC

Prof Giles Warrington
Co-Director, SHPRC

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NATIONAL SPORT AND HUMAN PERFORMANCE CONFERENCE PROGRAMME

'Evidence-based Approaches to Sport and Human Performance'

Time	Event	Location
08h00	**Registration & Coffee**	PESS Foyer
09h00	**Conference Opening Address** – Prof Giles Warrington	PG053
09h15	**Keynote Address 1 - Prof Rod McLoughlin (Medical Director, IRFU)** 'The challenges of applying an evidence-based medicine and science approach in an elite environment'	PG053
10h00	**Oral Presentations - Session 1** 1. **Eddie McGuinness** - Exploring how sprint distance and split times impact maximum sprinting speed in ladies Gaelic football 2. **Eoghan Myers** - What do elite rowing coxswains say during races? 3. **Karol Dillon** - Profiling the different types of laterality in high-performance male and female Gaelic footballers 4. **Declan O'Rahilly** - The reliability of the cube reader LFD to measure salivary cortisol and salivary immunoglobulin-A in inter- county hurling players	PG053
11h00	**Coffee**	PESS Foyer
11h30	**Oral Presentations - Session 2** 1. **Kevin Murray** - An examination of bilateral skill proficiency and frequency of pass in selected and non-selected youth academy Gaelic footballers 2. **Chris Leckey** - Machine learning for non-contact injury risk prediction in the lower extremities of elite male Rugby Union players 3. **Kevin Smith** - An evaluation of the Irish Rugby Football Union Coach Education Framework and its impact on the coach-athlete dyad in adolescent rugby union 4. **Steven Golovkine** - The influence of the menstrual cycle on the performance of female cyclists: a functional multilevel modelling approach	PG053

CONFERENCE PROGRAMME CONTINUED

Time	Event	Location
12h30	**Lunch** **Technical Workshops**	PESS Foyer & PG053
13h00	**Poster Presentations**	PG053
13h45	**Oral Presentations - Session 3** 1. **Conor Shannon** - Conditioning in Gaelic games: The effectiveness of three running prescription modalities on aerobic capacity and performance-related variables in elite U20 inter-county hurlers 2. **Niall O'Mahony** - An exploration of high-performance team sport coaches practice activities across a season: A mixed methods case study approach 3. **Peter Shaw** - Levels of burnout in 14-year-old Irish multi-sport athletes 4. **Ryan Gaffney** - Determinants of match outcomes in elite level hurling	PG053
14h45	**Keynote Address 2 - Prof Sharon Madigan (Head of Performance Nutrition, Sport Ireland)** 'Sports Nutrition – Science vs Pseudoscience'	PG053
15h30	**Oral Presentations - Session 4** 1. **Phil Kearney** - The association between season length at age 14 and athlete retention at ages 16 and 19 in endurance events in track and field 2. **Norma Bargary** - Applications and innovations in functional data analysis for sport and exercise biomechanics 3. **Maeve Mannion** – The menstrual cycle and female athletes participating and competing in weight category sports: A narrative review 4. **Toni Rossiter** - The effect of long-haul transmeridian travel on cognitive performance on Olympic team support staff 5. **Fionn Fitzgerald** - The eyes don't have it: Coach's eye is not a valid method of estimating biological maturation	PG053
16h45	**Presentation Awards** Best Oral Presentation Award *Presented by Prof Giles Warrington (Co-Director of SHPRC)* Best Poster Presentation Award *Presented by Prof Ian Kenny (Co-Director of SHPRC)*	PG053
16h55	**Closing Address** – Dr Mark Lyons	PG053

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NATIONAL SPORT AND HUMAN PERFORMANCE CONFERENCE PROGRAMME

KEYNOTE SPEAKERS

Prof Rod McLoughlin (MB, MRCGP, DCH, MSC, FSEM, FSEM(UK))

Prof McLoughlin graduated from UCD in 1984 went on to complete his General Practice training in 1990 followed by studying Sport & Exercise Medicine at the Royal London Hospital. Returning to Ireland in 1991, he set up practice as a Sports & Exercise Medicine Physician at O'Neill's Sports Medicine, based at Dublin City University and UCD.

In 2006, he was appointed Medical Officer to the Olympic Council of Ireland and subsequently appointed as Medical Director at the Irish Institute of Sport, combining both roles for the Beijing, London and Rio Olympics until 2016. He has previously lectured on the Diploma in Sports Management and BSc Sport & Exercise Management programmes at UCD and was a Board Member and Treasurer Faculty of Sports & Exercise Medicine, RCSI and RCPI. He was recently appointed as an Adjunct Professor at the University of Limerick.

Professor McLoughlin is currently the Director of Medical Service at the Irish Rugby Football Union having joined in 2013 and is chairperson of EPCR Medical committee. His keynote address will examine 'The challenges of applying an evidence-based medicine and science approach in an elite environment'.

Prof Sharon Madigan RD, BSc, MSc, PhD, SENr, FFSEM (Hon)

Prof Madigan is currently the Head of Performance Sport at the Irish Institute of Sport. She has significant experience as a clinical dietitian and in respiratory medicine. She has a PhD in Nutrition Education. She is responsible for delivery and coordination of nutrition services for elite Irish athletes across a range of Olympic and Paralympic sports.

She has worked across team sports, individual sports, weight category sports. A strong focus of her position within Institute of Sport is the engagement in high performance research. Sharon's main research interest's focus on the interaction between diet and health and diet and sports performance and this has led to strong working relationships with a range of partners. She is currently involved in co-supervision of a number of research projects including energy and other nutrient deficiencies and relationships with injury, illness, bone health and performance; Vitamin D and athletic performance; Vitamin D and COPD; Gut health and sports performance; sleep, recovery and nutrition in elite sport and female health and performance. She has delivered nutrition support to athletes over five Olympic cycles and other major championships such as European, World and EU championships. She was the assistant camp manager for the Tokyo 2021 Olympic Games. She has recently been appointed as Lead Scientist for Paris 2024. Prof Madigan's keynote address will examine 'Sports Nutrition– Science vs Pseudoscience'.

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NATIONAL SPORT AND HUMAN PERFORMANCE CONFERENCE

'Evidence-based Approaches to Sport and Human Performance'

Research being conducted across 14 national HEI's in collaboration with 7 international HEI's and 12 National Governing Bodies / Institutes of sport will be represented across this one day conference.

Irish HEI's

University of Limerick
Technological University of the Shannon (Athlone)
Munster Technological University (Cork and Kerry)
South East Technological University (Carlow, Waterford)
Institute of Technology, Blanchardstown
Marino Institute of Education, Dublin
Ulster University
Dublin City University
Trinity College Dublin
University of Galway
University College Dublin

International HEI's

University of Bath
Leeds Beckett University
University of Lincoln
Manchester Metropolitan University
University of Wolverhampton
College of William and Mary, Virginia
Northumbria University

NGB's & Institutes

Connacht GAA
Kerry GAA
Clare GAA
Cork GAA
Irish Rugby Football Union
Lero
Athletics Ireland
Sport Ireland Institute
Cycling Ireland
Movement & Skill Acquisition Ireland
Sport Institute Northern Ireland
Irish Horseracing Regulatory Board

Coaching Science

A case study examining the relationship between training load, sleep and illness in an elite swimmer

Cahill, R. & Exley, K.

School of Allied Health, University of Limerick.

Background:
There is a wealth of literature examining the relationship between training load (TL) and injury but little examining illness and its impact on sleep. An no-of-1 study offered opportunity to overcome limitations which may have prevented such research to date. Therefore, the primary aim of this study was to identify the relationship between sleep duration, TL, and illness in an elite swimmer. Investigating the interpretability of load monitoring strategies at an individual level was a secondary aim.

Research Methods:
Retrospective qualitative analysis of prospectively collected cohort data was conducted on one male swimmer over an 89-week period. Session rate of perceived exertion (sRPE) and session duration were collected and from these data, TL was calculated. All TL data (pool, S&C, racing, cross training) were combined to calculate total TL. TL was used to calculate Exponentially Weighted Moving Average Acute/Chronic Work Ratio (EWMA ACWR). The Athlete reported "bedtime" and "wake-time" which was converted to Total Sleep Time (TST) via an application. Incidences of illness were reported by the medical and coaching staff biweekly.

Main Findings
An inverse relationship between sleep duration and TL was observed, with scheduling hypothesised as the most likely cause. Occasions where decreasing load occurred in conjunction with decreasing sleep aligned with episodes of illness and competition. Therefore, the swimmer slept less during periods of low load when either ill or in competition environments. Over the two-year period, just one-third of the episodes of illness arose following spikes in EWMA above the "sweet spot" (0.8-1.3) (Gabbett, 2016). EWMA was not considered a predictor of illness, while session rate of perceived exertion (sRPE) provided more insight into athlete's risk of illness or quality of sleep.

Coach / Practitioner Implications
By examining the relationship between sleep, load and illness in a high-performance swimmer, insight was gained into how practitioners can monitor these variables, interpret meaningful findings in large volumes of data and consequently advance recovery. Such insight will help advance sport and human performance by highlighting the numerous areas where physiotherapists and other coaching staff can provide support.

References
Adam, K. et al. (1977*). J. R. Coll. Physicians Lond*, (11), 376-388.
Barry, L. et al. (2021). *Phys Ther in Sport*, (48), 154-168.
Biggins, M. et al. (2020). *The Phys and Sports Med*, 49(4), 429-437.
Gabbett, T. (2016). *Br J Sports Med*, 50(5), 273-280.

Profiling the physical conditioning attributes of young male Gaelic football players: From adolescence to adulthood

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Introduction
Given the importance of physical conditioning for young Gaelic football players, as evidenced by differences reported in muscular strength, power and aerobic function when comparing playing standards [1], studies profiling these attributes remain remarkably few. As such, the provision of a more comprehensive body of results characterising a wider range of players, would elicit valuable diagnostic information for practitioners. Therefore, this study assessed the anthropometry and physical conditioning attributes of young male national level Gaelic football players, comparing possible differences according to (i) age categories (under-14 to under-21) and (ii) positions within age categories.

Method
In total, 3885 assessments were undertaken in 2663 players across a 10-year period (2013 to 2023). Assessments included anthropometry and body composition (stature, body mass, sum of 3 skinfolds), flexibility (sit and reach test), muscular power (countermovement jump and standing long jump), running speed (over 5 and 20 m), muscular endurance (maximum push up test) and aerobic capacity (yo-yo intermittent recovery test level 1 [YYIRT1]).

Results
Significant development was demonstrated across the age categories for anthropometry (e.g., height [cm] U-14 [171.1±7.2]; U-21 [180.8±6.3]), muscular power (e.g., Standing long jump [cm] U-14 [188.9±19.1]; U-21 [219.4±21.0]), running speed (e.g., 5 m running speed [s] U-14 [3.36±0.13]; U-20 [3.20±0.09]), running momentum (e.g., 20 m momentum [$kg \cdot ms^{-1}$] U-14 [352.3±45.0]; U-20 [498.1±51.5]), muscular endurance (push-ups [*n*] U-14 [18.2±10.0]; U-21 [37.8±13.2]), flexibility (sit and reach U-14 [17.8±6.3];U-21 [24.0±6.1]) and aerobic capacity (YYIRT1 [m] U-14 [1189.6±388.7]; U-21 [1691.8±337.1]) ($p<0.05$). When comparing the playing positions, goalkeepers and midfielders generally tended to be significantly taller and heavier than backs and forwards, respectively ($p<0.05$). Additionally, midfielders tended to display significantly superior aerobic conditioning when compared with other positions, while goalkeepers typically displayed significantly lower aerobic capabilities than outfield positions ($p<0.05$).

Conclusions
In Gaelic football, a wide range of physical conditioning attributes are ancillary to player development, resilience to psychophysiological demands/injury and the capacity for high performance. The present findings offer comparative data of Gaelic football players from different annual-age categories (i.e., under-14 to under-21) which are further classified according to positions.

Practical Applications
Practitioners may utilise this data to inform player identification processes, assess individual players' strengths and weaknesses, characterise position-specific benchmarks and monitor physiological adaptations in the transition from adolescence to adulthood.

References
Mooney, T., et al. (2019) *J Aust Strength Cond*, 27(05), 14-24.

Profiling the different types of laterality in high-performance male and female Gaelic footballers

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Introduction
Laterality studies in soccer (Carey et al., 2009; Marcori et al., 2021) and basketball (Giovanini et al., 2020; Stöckel & Vater, 2014) have tended to focus on overall patterns of dominant and non-dominant limb use. However, laterality is a more complex construct than often perceived and player profiles should not be reduced to binary answers. This study investigated the diversity of laterality profiles within high performance men's and women's Gaelic football.

Methods
Video footage for teams was acquired through freely available television recordings and YouTube streams of games played between 2017 and 2021. All skill executions (hand pass, kick pass, hop, and solo) during 121 games (76 male, 45 female) were coded using Nacsport. Participants including male and female (n = 83, 51) adult, high performance Gaelic Football players who had executed at least 10 kick passes, 13 solos, 21 handpasses, and 22 hops. These players were then classified as being bilateral (40-60% dominant side use), partially bilateral (bilateral in one, two, or three skills), unilateral (predominantly one sided for the hand or foot, or both, mixed handed (hand dominance depended on the skill), mixed footed (foot dominance depended on the skill), or cross lateral (contralateral upper and lower limb dominance).

Results
Chi Squared test of independence showed a significant difference in the laterality profiles of male and female players ($\chi^2 = 11.0$, $p = .004$). Specifically, unilaterality was far more prominent in females (females: 72%, males: 41%). No player was bilateral for all four skills. Partial bilaterality was seen in more males (27.7%) than females (10.4%). Cross laterality was more common in males (28.9%) than females (16.7%). Mixed sidedness was more common in males than females for skills involving the feet ($\chi^2 = 13.8$, $p < .001$), but not for the hands ($\chi^2 = 2.6$, $p = .267$). Mann Whitney U tests revealed that right sided players were more asymmetrical than left sided individuals across the four skills ($p < 0.05$).

Discussion
The results show that laterality is far more nuanced than previous research on sportspeople has described. Gender differences in bilaterality, mixed sidedness, and cross laterality, suggest avenues for further research and applied practice. Practical implications include the need to evaluate player laterality on a skill by skill basis, and, particularly for coaches of female players, a need to reflect on opportunities to accelerate bilateral skill development.

References:
Carey, D. P. et al. (2009). *Cortex*, *45*(5), 650-661.
Giovanini, B. et al. 2020). *Psychol Sport Exerc*, *51*, 101785.
Marcori, A. J. et al. (2021). *J Mot. Behav*., *54*(3), 382-390.
Stöckel, T., & Vater, C. (2014). *Hum. Mov. Sci*, *38*, 143-

The eyes don't have it: Coach's eye is not a valid method of estimating biological maturation

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[5]University of Bath, Department for Health

Introduction
In Gaelic football, coaches tend to select players on subjective assessments, which are often biased toward players advanced in biological maturation (Fitzgerald et al., 2023). A typical assumption found in talent identification literature is that different coaches, given the same athletes and circumstances, will identify the same subset of athletes as "talented". This study investigated (i) the accuracy of the coaches' eye as a method to estimate players as early, on-time and late maturing and to explore (ii) the inter-coach agreement on the assessment of talent in a group of athletes.

Methods
Biological maturity was estimated based upon the Khamis-Roche method of percentage of predicted adult height (%PAH) for 247 male adolescent Gaelic footballers (U14-U16; $m_{age} \pm SD$ = 15.1±0.8 years) (Khamis & Roche, 1994). Two coaches were recruited from each of the nine squads (N=18) to provide an estimation of their own players' biological maturation by coaches' eye, rating of each player's current ability, long-term potential and selection of their top 5 and bottom 5 players. Inter-rater reliability was calculated using weighted kappa (K).

Results
Agreement between coaches' estimation of biological maturity and %PAH (k=0.17) was quite poor, supporting the contention that eyeballing players' maturation status may be inaccurate. Coaches' agreement on estimation of maturity (k=0.33), and rating of current ability (k=0.39) was fair, whereas agreement on future potential (0.41) and top and bottom players (k=0.55) was moderate.

Conclusion
These findings suggest that coaches' eye may be an inaccurate method of estimating maturation. In addition, this current research suggests, in isolation, there is poor inter-coach agreement in the identification of talented athletes and indicates that the "coach's eye" is subjective and variable.

References
Fitzgerald, F., Campbell, M., Kearney, P. E., & Cumming, S. (2023). As apples to oranges: The independent effects of relative age and biological maturity on player selection in Irish Gaelic football academies (*in review*)
Khamis, H. J., & Roche, A. F. (1994). *Paediatr*, 94 (4) (Pt 1): 504–507.

Determinants of match outcomes in elite level hurling

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Introduction
Despite the popularity of the GAA Hurling Championships, factors contributing to successful outcomes has gained limited recognition. Although studies have explored the frequency occurrence of Hurling skills (Gilmore, 2008) and attacking profiles in elite Hurling (Clear et al.,2017), further research is needed to gain greater clarity on significant factors related to team outcomes alongside pitch locations of possessions, turnovers, puckouts and scoring success. This study aims to advance coaching expertise and the sporting profession through observing the vast footage available to understand the role of performance indicators on match outcomes.

Method
Footage of top tier hurling games (n=29) from the 2019 All Ireland hurling championship were analysed. To advance data reliability, operational definitions of indicators were agreed with an expert panel of inter county coaches. Match footage was imported to Nacsport Scout plus (Analysis pro., Wales) and a tagging template was designed to record the frequency of indicators. An interrater reliability test was conducted resulting in a Kappa statistic of 0.604 ($p<.0.001$) To compare the impact of key performance indicators on match outcomes, a Wilcoxon signed ranks test was conducted.

Results
Results found several variables significantly ($p<.0.05$) associated with scoring opportunities and match outcomes including goals, points, total scores, shots from play and conversion rate. Short passes, fouls and tackle count were also significantly associated with successful match outcomes. The highest number of scores from play (14.7%) originated from location L6 (Left side of the pitch between 21m and 45m from goal). This is interesting as it was expected that the centre forward position, would be the location of most points scored from play. Pitch location C6 (Centre of the pitch between 21m and 45m from goal) recorded the highest shot success rate from play with a score of 82.8%. Further analysis on turnover count proved significantly greater for winning ($M=40.0$, $SD=7.0$) than losing teams ($M=37.5$, $SD=7.3$; $p=0.034$) with the majority (27.1%) resulting from poor strikes. Analysis of productivity confirms that winning teams ($M=4.1$, $SD=0.5$) were able to generate more shots during games than losing teams ($M=3.0$, $SD=0.7$; $p<0.001$). The importance of puckouts was recognised with long puckouts won by opposition identified as a key factor associated with match outcomes.

Conclusions
This is the first study in Hurling to use a pitch descriptor to highlight the location of shots, puckouts, turnovers, possessions, and fouls. The findings demonstrated the role of specific match variables and aspects of play in terms of match outcomes in elite level Hurling.

Practical Applications
These findings may be utilised to advance the expertise of coaches who can design their training sessions using evidence-based research. Coaches should aim to improve their team's productivity by focusing on winning turnovers and working possession into location C6 when attempting to score. An area for further investigation is to explore the success of attacks when teams build play from the back and deliver a pass to their forwards from their middle third compared to their defensive third.

References
Gilmore, J. H. (2008). *Intl J Perform Anal Sport*, 8(1), 68-75.
Clear, C., Hughes, M. & Martin, D., (2017). *Intl J Perform Anal Sport*, 17(3), 319-333.

Efficacy of the dynamic strength index as a diagnostic tool in a team setting

Hughes, W.[1], Healy, R.[1], Lyons, M.[2], Higginbotham, C.[3], Lane, A.[1] & Beattie, K.[1]

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Introduction

The dynamic strength index (DSI) is an assessment of the ratio between ballistic peak force (i.e., explosive-strength), produced during the countermovement jump (CMJ), and maximal peak force (i.e., maximal-strength) during the isometric mid-thigh pull (IMTP). It has previously been recommended focusing on explosive-strength when the ratio is low (< 0.60) and maximal-strength development when the ratio is high (> 0.80) (Sheppard et al., 2011). However, the DSI is a ratio between the strength capabilities and, thus, does not consider the relative strength capacity of an athlete (McMahon et al., 2017). Consequently, it may not be appropriate to compare athletes within a team setting based on DSI scores alone. This study examined the efficacy of the DSI as a diagnostic tool by comparing the strength capabilities of athletes against performance benchmarks using T-scores.

Methods

Ninety female Gaelic football players (age; 25.3 ± 6.3 years, stature; 1.67 ± 0.06 m, mass; 66.5 ± 8.4 kg) participated in this study. Strength characteristics were assessed through the IMTP and CMJ. DSI was calculated by dividing CMJ propulsion peak force by IMTP peak force. A T-Score is an alternative form of standardised score that is calculated by multiplying a Z-Score by 10 and adding 50. It may provide a more intuitive value for athletes and practitioners, given that it is scaled from 0-100 with a score of 50 equalling the mean. T-Scores for the individual components of the DSI were subsequently calculated and categorised into the following performance bands; extremely poor ≤20; very poor 20-30; poor 30-40; below average 40-45; average 45-55; above average 55-60; good 60-70; very good 70-80; extremely good ≥80. Three groups representing low, moderate, and high DSI values were formed. Groups A (n = 13) & C (n = 14) were determined using a median split and removing data within ± 1 SD of the median. Group B (n = 16) was determined by selecting the data within ± 0.25 SD of the median. The individual components of the DSI were subsequently compared to the performance benchmarks.

Results

Mean DSI and CMJ height for the group was 0.81 ± 0.14 and 24.9 ± 4.7 cm, respectively. A very large negative correlation was observed between IMTP peak force and DSI (r = -0.81). A moderate correlation between CMJ peak force and DSI (r = 0.32) was observed. Results are presented in Table 1.

Table 1. IMTP and CMJ peak force, and CMJ height values with corresponding T-scores for groups presenting with low (Group A), moderate (Group B), and high (Group C) DSI scores

	DSI Score	IMTP (N·kg^{-1})	T-Score	CMJ (N·kg^{-1})	T-Score	CMJ (cm)	T-Score
Group A	0.61	36.4	65	22.2	47	25.2	51
Group B	0.79	28.1	49	22.2	47	24.4	49
Group C	1.03	23.4	39	24.0	55	25.4	51

Conclusions & Practical Applications

DSI may be efficacious regarding its use as a diagnostic tool for comparing an athlete's specific strength capabilities in a team setting, however, IMTP peak force appears to be a stronger predictor of DSI score. T-scores for each group corresponded to the DSI score interpretation. Interestingly, DSI could not distinguish athletes' CMJ height, indicating its limitation in assessing CMJ performance. This is not surprising given the importance of jump strategy for overall performance during the CMJ.

References

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McMahon, J. J., et al. (2017) *Sports*, 5(4), 72;
Sheppard, J. M., et al. (2011) *J Aus Strength Cond*, 19(2).

Methods matter! Analysis of load-velocity profiling in swimming

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Introduction

Load-Velocity (L-V) profiling is a popular method of assessing an athlete's physical performance. This can help identify an athlete's strengths and weaknesses; monitor performance; and guide the prescription of individualised training interventions. Recently, profiling has been applied to swimming performance (Gonjo et al. 2020). The aim of this study was to assess whether L-V profiling outcomes differ across a range of distance measurement windows.

Methods

Thirty-seven elite swimmers, 26 males (age 20.8 ± 3.7 years; height 1.85 ± 0.07 m; mass 80.7 ± 7.3 kg) and 11 females (age 20.8 ± 3.4 years; height 1.74 ± 0.05 m; mass 67.6 ± 6.2 kg), completed 3 front crawl sprints over 10 m while attached to a portable resistance device (1080 Sprint). The resistance was incrementally increased throughout trials 1-3 (males: 1, 5, & 9 kg; females: 1, 3, & 5 kg). The fastest average velocity over 3-, 4-, and 5-m was determined, representing 3 distance measurement windows. The values of load and velocity were plotted, and their relationship expressed as a linear regression line. The intercept between the axes identified the maximum theoretical velocity (V_0) and maximum theoretical load (L_0). The coefficient of determination (R^2) was also calculated. As the data formed part of a 6-month longitudinal study, with multiple testing sessions, a repeated measures ANOVA was used to assess the difference between each distance measurement window. Statistical significance was accepted at $p < 0.05$.

Results

V_0 and L_0 were significantly different across the distance measurement window ($p < 0.05$) for both male and female swimmers. Post hoc permutations (Table 1) suggested the L-V outcomes differed between distances and gender.

Table 1. Descriptive statistics (Mean ± SD) for L-V outcomes for male (n = 62) and female (n = 30) swimmers

	V_0 (m/s)		L_0 (kg)		R^2	
	Male	Female	Male	Female	Male	Female
3-Meters	1.90 ± 0.07†	1.69 ± 0.09*†	29.2 ± 5.1*†	18.7 ± 2.6†	0.99 ± 0.01	0.99 ± 0.01
4-Meters	1.89 ± 0.07 $^{\Delta}$	1.68 ± 0.09	28.3 ± 5.1 $^{\Delta}$	18.5 ± 2.6 $^{\Delta}$	0.99 ± 0.01	0.99 ± 0.01
5-Meters	1.89 ± 0.07	1.68 ± 0.09	27.5 ± 5.1	18.0 ± 2.6	0.99 ± 0.01	0.99 ± 0.02

Post-hoc Bonferroni $p < 0.05$: *3 vs 4 m; †3 vs 5 m; $^{\Delta}$4 vs 5 m

Conclusions & Practical Applications

Samozino et al. (2022) stressed the importance of methodological rigour to produce reliable L-V outputs. Within a swimming context, the results of this study report that while the linearity of the L-V profile does not differ across the distance measurement window, caution should be taken when interpreting the outcome variables, as these were found to be statistically different. Initial indications suggest that a 5 m distance window may be most appropriate, with further research warranted to confirm this assessment. Practitioners should consider the analysis method when comparing the L-V profile outcomes between studies.

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Exploring how sprint distance and split times impact maximum sprinting speed in ladies Gaelic Football

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Introduction
Maximum Sprinting Speed (MSS) is an important physical quality in Ladies Gaelic football (Duggan et al., 2022). Top speed is typically measured via timing gates using split times measured over a variety of distances (Haugen and Buchheit, 2016). The purpose of the current study was to determine the differences in MSS estimates using a range of splits in female Gaelic football players.

Method
Sixty-two (20 elite and 42 sub-elite) female Gaelic football players participated in the study. Data were collected on a synthetic indoor running track and monitored using nine dual-beam timing gates placed at 5 m intervals over 40 m. Descriptive statistics were produced for the four different distance and split combinations and mean differences were calculated between each method. A repeated measures analysis of variance (RMANOVA) test was conducted to determine whether statistically significant ($p < 0.05$) differences existed between estimates of MSS derived from different split (5 or 10 m) and/or distances (30 or 40 m). The two-way random model intraclass correlation coefficient (ICC) with 95% CI and coefficient of variation expressed as a percentage (CV%) were used to determine the inter-trial reliability of estimated MSS.

Results
The RMANOVA showed that all of the variables were significantly different ($p < 0.05$). The fastest mean MSS from both trials was attained over 40 m monitored in 5 m splits, followed by 30 m via 5 m splits, 40 m in 5 m splits and 30 m in 10 m splits. All methods showed excellent agreement between trials 1 and 2 with ICCs (range: 0.97 – 0.98) and CV% (range: 1.0 to 1.2%) (Table 1).

Table 1. Mean (± SD), ICCs, and CV% for each MSS estimation method

	Mean ± SD	Trial 1	Trial 2	ICC [95% CI]	CV% [95% CI]
MSS from 5 m splits over 40m ($m \cdot s^{-1}$)	7.22 ± 0.48	7.22 ± 0.48	7.22 ± 0.49	0.97 [0.95; 0.98]	1.2 [1.0; 1.4]
MSS from 5 m splits over 30m ($m \cdot s^{-1}$)	7.19 ± 0.46	7.18 ± 0.46	7.20 ± 0.47	0.97 [0.95; 0.98]	1.1 [1.0; 1.4]
MSS from 10 m splits over 40m ($m \cdot s^{-1}$)	7.16 ± 0.47	7.16 ± 0.47	7.16 ± 0.48	0.98 [0.96; 0.99]	1.0 [0.9; 1.3]
MSS from 10 m splits over 30 m ($m \cdot s^{-1}$)	7.14 ± 0.46	7.14 ± 0.46	7.15 ± 0.47	0.97 [0.96; 0.98]	1.0 [0.9; 1.3]

MSS: Maximum sprinting speed, I*CC:* Intraclass correlation coefficient, *CI:* Confidence interval, *CV%:* Coefficient of variation percentage

Conclusions
The use of different distances and splits yields statistically significant differences in the MSS values derived. All estimation methods show excellent between-trial reliability for MSS.

Practical applications
Considering that practitioners may be limited by the distance available to complete sprint testing, using a 30 m sprint with 5 m splits will yield higher MSS compared to 10 m splits over 40 m. The highest MSS was achieved in 5 m splits over 40 m.

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Where did they go? Player progression in Gaelic Athletic Association talent academies

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Background
While talent development systems are commonplace (Rothwell et al., 2022), there is limited information regarding the pathways taken by youth players through to senior level (Calvin, 2017; Herrebrøden & Bjørndal, 2022). This project benchmarked the effectiveness of player identification at Under 14 (the start of the pathway) within Clare and Tipperary GAA, by tracing the progression of players through to later representative levels.

Methods
A large consultation with Programme and Year Books collectors across the country, in conjunction with access to both county and national GAA player archive. These sources were utilised to identify individuals who had competed at Under 14 intercounty hurling tournaments between 1985 & 2016 (Clare, n = 700) or 2006 & 2011 (Tipperary, n = 120).

Results
Withing Clare GAA, 58% of U14s progressed to play at minor level for the county and 29% played at U21 level. 74.8% of Clare U14 players went to represent their club at adult level; 9.6% were selected to a senior intercounty panel, while 4.6% played 5+ years at senior intercounty level. The Tipperary data were restricted to intercounty representation; 28.3% of players were selected to a minor panel and 18.3% made an U21 panel. 6.3% of players were selected to a senior panel and 5% played 10+ senior championship games.

Discussion
Player progression at underage showed marked differences between the counties. The low number of players who have a senior intercounty career from U14 development squads should encourage reflection amongst coaches and administrators overseeing these squads as to their optimal use of resources.

Future research
Future research will involve a survey of current inter-county players to examine their route to high performance sport, including the roles played by school teams and participation in other sports on the development journey.

Practical application
This research will help in framing the various routes present in Gaelic games academies, the relationships between these routes and transitions to senior teams. This could potentially influence the purpose of talent academies and the need for a congruent system within clubs focusing on player development over underage success. This research may also shine light on the need for a more robust talent identification system, with a much more holistic development model. Shifting the focus from the selection of players at U14 level to a potentially more encompassing model, as this has not correlated to successful transition to senior teams.

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An examination of bilateral skill proficiency and frequency of pass in selected and non-selected youth academy Gaelic footballers

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Introduction
An athlete's bilateral competence can be described as the ability to produce a movement solution that doesn't suffer a performance decrement when utilising a non-dominant limb when performing a sports-specific skill (Stöckel & Weigelt, 2012). Bilateral skill proficiency and frequency of use in competitive performance is a significant attribute for players in team ball sports due to their ability to shoot, tackle, or clear the ball more efficiently and effectively than players who rely more heavily on their dominant limb (Stöckel & Carey, 2016). The purpose of this research was to examine differences in bilateral skill proficiency and frequency of use between selected and non-selected Under 17 male inter-county academy Gaelic footballers.

Method
Participants were youth academy Gaelic football players (N = 82, Mean age = 15.54 years, SD = .27) were retrospectively grouped as selected (n = 19) and non-selected (n = 63) for their representative inter-county squad pre-competition. A discrete skills test evaluated bilateral hand pass and kick pass proficiency for dominant hand pass (DHP), non-dominant hand pass (NDHP), dominant kick pass (DKP), and non-dominant kick pass (NDKP). Within-academy matches (N = 8) were video recorded and subsequently analysed via SportsCode ™ for in-game bilateral passing proficiency and frequency (N = 3109).

Results
Selected players demonstrated greater levels of proficiency in the discrete skills test in both NDKP (p = .001) and NDHP (p = .007) than their non-selected counterparts. Selected players were also more proficient when using the NDHP (p = .002) in match play, while inversely non-selected players used the DHP (p = .037) significantly more than selected players in match play. Binary logistic regression was conducted to assess and identify which of the measured variables from the bilateral skills test and match play analysis were the strongest predictors of selection to the U17 county squad. The strongest predictors of selection to the inter-county squad appeared to be the NDKP and NDHP in the discrete skills test, in addition to successful DKP and NDHP in match play (p < .05), with 89% of players correctly classified.

Conclusions
This research highlights the advantages of bilateral proficiency in achieving selection to an inter-county squad, and also serves to provide valuable data that may inform Gaelic football academy and club coaches regarding the importance of bilateral proficiency for both player development and future selection to inter-county squads. Furthermore, a normative data repository has now been established that may inform young players aspiring to be selected to academy-level teams regarding future selection.

Practical Applications
These findings provide strong support for coaches at academy and club level to design training practices that can promote bilateral proficiency and frequency of use. Furthermore, session design that promotes a range of bilateral focused situations, while developing the spatial and tactical skills that players require, could contribute to their future development and maximise their opportunity for future selection to an inter-county squad.

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What do elite rowing coxswains say during races?

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Introduction
A coxswain (or cox) steers a rowing boat and provides a mix of technical, tactical and psychological information (or calls) during training and racing. Despite their critical contribution to rowing performance, minimal research has investigated coxes in any context (Gabana et al, 2015). With the intention of informing cox education and future research, the aim of this study is to explore what elite coxes say during rowing races.

Methods
Videos of elite senior coxes in competition were sourced from YouTube (search term: cox* recording world OR henley OR olympic* OR homes OR euro* -junior). Exclusion criteria included poor quality audio or incomplete recordings. Only one video per cox was analysed, with the most recent recording used. Videos that met the inclusion criteria were analysed using thematic analysis (Braun & Clarke 2013). Trustworthiness was established by three authors independently reviewing two random samples. From this a coding framework was established from which the primary analyst coded all videos. Finally, the data were compiled and reviewed by all three authors (Braun & Clarke, 2013).

Results
Eight videos met the inclusion criteria including three from World Championships, one from a World Cup, two from Henley semi-finals and three from Henley finals. The main themes that emerged were technical cues, psychological cues and tactical and environmental cues (Table 1). As the races progressed, technical cues decrease in frequency and psychological cues increase. Technical cues primarily had an internal focus of attention. Psychological cues mainly consisted of praise, general encouragement, and preparation for future calls. Tactical and environmental cues were largely references to the boat's position and the race plan. 66% of cues also conveyed information about timing or rhythm through tone of voice. Coxes had an average of 32 calls per minute. Considerable individual differences were observed in the frequency and content of calls.

Table 1. Frequency of calls within three main thematic categories at various sections in a race (% of total calls)

	Technical cues	Psychological cues	Tactical & Environmental cues
First 500 m	46	33	22
Middle	42	36	22
Final 500 m	41	39	21
Overall	40	38	21

Conclusions
Mapping the information provided by coxes during rowing races provides a stimulus for coxes, their team-mates and coaches to reflect. In particular, coxing scripts may be fine-tuned by considering the content, timing and consistency of cues.

Practical Applications
This was the first study to explore what elite coxes say during racing. The findings have the potential to guide future research, ultimately informing an evidence-based approach to cox education.

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An exploration of high-performance team sport coaches practice activities across a season: A mixed methods case study approach

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Introduction
The coaching environment is the primary teaching and learning medium for the development of players' technical and tactical skills (Ford et al., 2010). However, there is limited understanding of the specific practice structures and pedagogies coaches use across a full season in a range of contexts (Cope et al., 2017; Kinnerk et al., 2019), and the accompanying rationale that guides their practice (Roca & Ford, 2020). A mixed methods case study approach was used to investigate the session design and associated decision making of high-performance Gaelic football coaches.

Method
Two high performance Gaelic football coaches participated in a season long study. Sessions (n = 52) were analysed for the proportion of time spent in and sequencing of training form activities, playing form activities, pedagogical discussions and transitions. Semi-structured interviews were used to explore beyond the *what* and *how* of coaching to examine the underlying rationale that guides practice across a season.

Results
Both coaches spent the greatest amount of time in playing form activity (45% each) while conditioned games, full sided games and fitness were the three most used activities. Coaches predominantly used non-linear sequencing where the initial activity post warm up was a playing form activity 68% and 73% of the time for the senior coach and youth coach respectively. Interview data revealed that the coaches optimised learning by primarily engaging in problem solving through highly representative activities which were supported by social interaction and dialogue. The coaches also rationalised the need to occasionally deviate from playing form activities when required.

Conclusions
This longitudinal mixed methods research provides a nuanced understanding of coaches' practice in a high-performance team sports context which, until now, has received little attention in the literature. The specific findings can help high performance team sports coaches to reflect upon how to select and sequence practice activities to maximise player learning within their own context.

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Levels of burnout in 14-year-old Irish multi-sport athletes

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Introduction

For teenage athletes, playing multiple sports at a high level is demanding. Managing these demands places youth athletes at risk of burnout: a psychological syndrome characterized by emotional and physical exhaustion, sport devaluation and a reduced sense of accomplishment (Eklund & DeFreese, 2020). This study investigated (i) the levels of burnout reported by a sample of multi-sport athletes from an Irish secondary school, and (ii) whether individuals reporting concerning levels of burnout were playing a greater number of sports, more months per year in their primary sport, and had fewer months off all organized sport per year than their peers.

Method

179 14-year-old multi-sport athletes completed a survey on their sport participation (e.g., number of sports played, months active per year). Burnout was assessed using the Athlete Burnout Questionnaire (Raedeke & Smith, 2009). Within this sample, Cronbach's Alpha indicated good internal consistency for the subscales of Reduced Sense of Accomplishment (RA; $\alpha = 0.719$), Sport Devaluation (SD; $\alpha = 0.761$) and Emotional and Physical Exhaustion (EPE; $\alpha = 0.854$). A score of 3 ("sometimes") or higher delineated a concerning level of burnout (Raedeke & Smith, 2009; Eklund & DeFreese, 2020). Mann Whitney U tests were used to examine between group differences.

Results

A concerning score for EPE was reported by 22.9% of 14-year-olds surveyed; for RA and SD the proportions were 14.5% and 8.4% respectively. Players who were rated as "Of Concern" in relation to EPE, RA or SD showed no difference in number of sports played, number of months in the primary sport, or months off sport per year, compared to their peers who were within the normal range (all ps > 0.05; Table 1).

Table 1. Association of sport participation characteristics and burnout levels

		RA		SD		EPE	
	Burnout Score	***Mdn (IQR)***	***p***	***Mdn (IQR)***	***p***	***Mdn (IQR)***	***p***
Number of Sports Played	Normal	3.0 (2)	.336	3.0 (2)	.931	3.0 (2)	.079
	Of Concern	3.0 (2)		3.0 (2)		3.5 (2)	
Months Playing Primary Sport	Normal	11.0 (3)	.233	11.0 (3)	.089	11.0 (3)	.499
	Of Concern	11.0 (3)		9.0 (4)		11.0 (3)	
Months off all organized sport	Normal	0.0 (2)	.982	0.0 (1)	.223	0.0 (1)	.456
	Of Concern	0.0 (1)		0.5 (2)		0.0 (2)	

Conclusions

A substantial proportion of 14-year-old multi-sport athletes reported concerning levels of emotional and physical exhaustion relative to normative samples (Raedeke & Smith, 2009). As the number of sports played and months engaged in sport did not discriminate between individuals with a concerning burnout profile and those without, future research should consider training quality and interpersonal relationships as well as the contribution of non-sporting factors (e.g., school, home, environment, etc).

Practical Applications

Further research is needed on awareness and mechanisms of burnout in multisport athletes.

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Language-based pedagogies for half-time communications in adult sport

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Introduction
The half-time talk (HTT) constitutes a vital aspect of a coach's performance strategy. It represents a complex and pivotal time (Mouchet & Duffy 2020) where the dynamic interaction between coaches and athletes relies on consistency in communication based on practiced routines. The absence of substantial research into in-game coaching is a shortcoming and little has been done to identify coaching practices in the competitive domain despite the International Council for Coaching Excellence's (ICCE) identification of in-competition behaviours as an important element of a coach's core functions. A recent study by Smith and Sherwin (2022) on coach and player perceptions of half-time in elite rugby union outlined a coach-facilitated collaborative environment was perceived to be the most effective half-time strategy. The aim of this research was to establish what coaches say and how they deliver their messages by analysing the content of the coach-athlete interactions during half time.

Method
This qualitative research focussed on four male coaches in three different sports (Field Hockey, Gaelic Football and Rugby Union) and conducted a linguistic analysis to establish the potential meaning of the interactions. One to two HTTs of each of the four coaches are analysed with six talks considered for the purpose of this analysis. The initial review of the HTTs involved a thematic analysis (Braun & Clarke, 2006) to identify patterns and typical strategies used by the coaches. A discourse analytical framework provides in-depth interpretations of the strategies employed, focusing on how the coach attempts to address the specific need and goals relating to the first half performance. Specifically we look at how the coach manipulates language and other semiotic devices to enact management of expectations for performance in the second half. A turn-by-turn analysis of coach: athlete interactions considers elements including delivery, sequence, timing, turn-taking (Van Dijk 1997: 71) to understand how coaches attempt to facilitate leadership and direction for the team after the break.

Results
Coaches rely on questioning to highlight problems and elicit player-generated solutions. Open-ended questions are used to elicit player collaboration on decision-making, followed by coach echoing expectations in final direction. Questioning is also employed to highlight opportunities, in particular asking challenging questions to motivate and encourage intensity. Coaches tend to use directive language by emphasising opportunities that will be created by desired behaviour and putting a positive spin on the past leading to expected future behaviour.

Conclusions and Practical Applications
This work can be considered the beginning of a synthesis of in-game coaching talk toward establishing an evidence-based framework for coaches to reference, when adapting the above strategies in their own talks as needed for each game.

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Endurance Sport Science

Training-related factors that differentiate between the recently injured, injury-resistant and never injured runner – A retrospective study

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Introduction
Several risk factors have been proposed to relate to the high prevalence rates of running-related injuries (RRIs), such as previous injury, and various training practices. One particular practice which appears to be common amongst runners is training with pain or a "niggle". However, little research has investigated the training practices of the never injured runner (NI), and runners who may have acquired injury resistance (AIR).

Methods
An online survey captured details of training practices and previous injury history from a population of 246 recreational male and female runners. Training practices were compared between three insightful groups, which were determined based on previous injury history; recently injured (RI): RRI 3-12 months ago; AIR: RRI 1-2 years ago; NI: no RRI history.

Results
Half of all participants (50%) reported to have sustained an RRI in the preceding 3-12 months, with the knee (22%) and calf (20%) most commonly affected. A greater percentage of RI runners reported to do hill runs, and change gradient on a frequent basis. NI runners reported to run an average of 10km per week, with slower training speeds than RI runners. Twice as many RI runners reported to run with a niggle (43%) compared to NI runners (21%).

Conclusion
RI runners appear to demonstrate riskier training practices compared to AIR and NI runners, indicating the need for training modifications in RRI management and return to participation. Running with a niggle seems to be a common practice amongst RI runners, but more research is required to determine the prospective contribution of niggles to RRIs.

Practical Applications
Runners who are experiencing a niggle should train with caution, especially if they have a recent history of injury. Other training practices which may be risky include incline training, higher training loads and greater training speeds.

The association between foot strike angle at initial contact and calf-complex injuries among recreational runners

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Introduction
Clinicians, coaches and runners alike have long been interested in factors associated with running related injuries (RRIs), with a view to decreasing the high incidence and associated burden. Among the factors most frequently speculated to be associated with RRIs is foot strike (FS) angle at initial contact, as it is assumed that high forces at this time point may dictate loading of biological tissues. However, evidence is mixed, and it may be necessary to investigate the association between FS and *specific* RRIs, given that different foot strike patterns have resulted in different distribution of loading within the lower limb (Hashizume and Yanagiya, 2017). Calf-complex RRIs are one of the most common RRIs, but prospective research investigating foot strike and calf-complex injury remains limited, with studies yielding mixed results (Hein *et al.* 2014; Lagas *et al.* 2010; Altman and Davis 2016; Hollander et al. 2021). This research aims to identify if FS angle can predict calf-complex injury in recreational runners.

Method
Healthy recreational runners were recruited to attend a baseline session. Their running kinematics were captured via 3D motion analysis whilst running on a treadmill at a self-selected pace. FS angle was calculated using foot flexion angle at initial contact. Participants trained as normal and RRIs were tracked for one year. Only participants whose first injury was to the calf-complex were classified as injured. A binary logistic regression was performed, with calf-complex injury as the dependent variable and FS angle as the independent variable.

Results
Of the 225 runners tracked for injury for one year, 31 (14%) runners experienced a calf-complex injury, whilst 108 remained uninjured. Logistic regression was used to analyse the relationship between foot flexion angle at initial contact and calf-complex injury. The logistic regression model was not significant (Tabel 1).

Table 1. The association between foot strike angle at initial contact and calf-complex injury

Variable	Uninjured Mean ± SD	Injured Mean ± SD	Sig.	OR	95% CI for OR (Lower)	95% CI for OR (Upper)
Foot flexion at initial contact (°)	14.9 ± 7.6	14.7 ± 7.4	0.8	1.00	0.96	1.03

SD= standard deviation, Sig= significance, OR.= odds ratio, CI.= confidence interval.

Conclusions
FS angle at initial contact was not associated with calf-complex injuries, in line with some previous research (Lagas et al., 2010). However, due to the conflicting findings of other studies and small sample sizes in this and previous research (Hein *et al.* 2014; Altman and Davis 2016; Hollander et al. 2021), more research is warranted before reaching definitive conclusions.

Practical Applications
Clinicians, coaches and runners should practice caution when assuming an association between RRIs and FS angle.

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The influence of the menstrual cycle on the performance of female cyclists: a functional multilevel modelling approach

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Introduction
Menstrual cycles affect women's health and wellness. Female sex hormones, and especially, oestradiol and progesterone, fluctuate along the menstrual cycle. These hormones affect multiple parameters on women ranging from adverse symptoms, such as fatigue or sleep disturbance along menstrual cycle phases (Pierson et al., 2021), to many beneficial cardiovascular, muscular, and metabolic parameters (Meignié et al., 2021). Performance-based research in women sport science is still scarce regarding the influence of menstrual cycle phases (Meignié et al, 2021). Cycling is interesting to analyse the influence of hormonal fluctuation onto female performance. Performance can be measured using Mean Maximal Power (MMP) curve.

Method
Power output data were recorded at 1Hz by personal power meter. An MMP curve was derived from every individual training. Eight high-level female cyclists, with natural cycles, volunteered to participate in the study. We asked the cyclists to inform us of the start and end of their period, and we estimated the day of ovulation for each cycle. Their menstrual cycles were divided into three phases: the menstruation, the follicular, and the luteal phase. A functional linear mixed model has been proposed to assess whether performance differs between phases of the menstrual cycle and how performance varies over the cycle based on the athletes, training intensities and types of the bike.

Results
The test statistic computed on the observed data is smaller than the 95%-quantile of the distribution of the test statistics computed on the bootstrap samples for all phases comparison. There is no evidence of a difference between the phases considering their mean MMP curves. The decomposition of the variance highlights the importance of accounting for the different sources of variability as most of the overall variability is induced by the different observations (49.8%). The second most important source of variability is induced by the athletes (22%). It appears that the different phases induce zero variation of power output.

Conclusions
We found no evidence of a difference in the mean MMP curves for the different phases. The variability in the data is not influenced by the different phases and is mostly due to the difference between the athletes and the randomness of the repeated observations. We have however not proven that there is no variation between phases, we have failed to find evidence of variation between phases. The athletes are thus likely to achieve their peak performance in each phase.

Practical Applications
These results may be helpful for coaches who use these curves for training planning or the comprehension of their athletes. It may also help the athletes to refine team strategies and enhance in-race decision making.

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2D cycling kinematics for paralympic triathletes pre & post wind tunnel positional optimisation

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Introduction

Drag equates to 90% of the total resistance opposing motion in cyclists such as time trialists (Malizia, 2021; Grappe, et al., 1997). Accordingly aerodynamic testing is used to optimise positions in minimising drag. However, little research has been conducted on elite tandem cycling and no research investigating the transferability of wind tunnel optimisation to real world cycling across any discipline. This paper presents a method and preliminary results of tracking 2D cycling kinematics from a sagittal plane using a customised marker-set, which accounts for pelvic rotation and spinal curvature.

Methods

Two male elite Triathletes were recruited to measure cycling kinematics pre and post aerodynamic optimisation. Using retroreflective markers, analysis was carried out across a series of crank revolutions at anaerobic threshold. Three-minute efforts were performed at this workload and captures were recorded at 2:30 for 30seconds. All kinematic values are compared to a standing anatomical zero calibration shot.

Results

Positional changes from pre to post for P1 indicates a pelvic tilt difference of -23^{o}, hip flexion of -20^{o}, knee flexion of 7.0^{o}, ankle of -3^{o}, helmet of -42^{o}, lower spine of 28^{o}, mid spine of -6^{o}, upper spine of -3^{o}and a spine radius of 0cm. Positional changes for P2 indicates a pelvic tilt difference of -7^{o}, hip flexion of -7^{o}, knee flexion of 4^{o}, ankle angle of 0^{0} helmet of 2^{o}, lower spine of 2^{o}, mid spine of -6^{o}, upper spine of -13^{o} and a spine radius of 18cm.

Table 1. Mean values for kinematic variables pre and post wind tunnel position optimisation

	Pelvis Tilt (°)	Hip Flexion (°)	Knee Flexion (°)	Ankle (°)	Helmet (°)	Lower Spine (°)	Mid Spine (°)	Upper Spine (°)	Spine Radius (cm)
P1 Pre	32.6 ± 1.9	68.2 ± 15.6	58.8 ± 24.4	7.8 ± 7.1	140.7 ± 1.5	28.8 ± 2.7	16.0 ± 2.7	3.5 ± 3.1	48.2 ± 2.5
P1 Post	9.5 ± 2.0*	47.4 ± 16.8*	65.8 ± 26.0	4.9 ± 5.3	99.1 ± 0.9*	56.8 ± 2.5*	10.0 ± 3.8*	0.52 ± 4.7*	48.1 ± 3.0
P2 Pre	38.0 ± 4.5	75.5 ± 17.8	61.7 ± 24.3	8.2 ± 8.0	-1.4 ± 4.0	14.9 ± 4.0	-0.8 ± 3.5	30.0 ± 4.2	50.2 ± 2.5
P2 Post	30.9 ± 3.4*	68.5 ± 17.7	65.2 ± 25.6	8.2 ± 6.9	0.2 ± 1.9*	16.7 ± 4.1	-6.5 ± 5.7*	16.8 ± 5.9*	68.3± 5.6*

* P > 0.05 between the pre and post mean

Conclusion

Aerodynamic position optimisation is individual however, assessing kinematic changes provides an opportunity to establish each athlete's optimised position and can be used as a reference point when comparing kinematics in competition. In addition, kinematic values can be used by Physiotherapists in screening for increased risk of injury which could be attributable to the compromised positions of cyclist.

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A 2D video-based method to estimate sagittal plane pelvis orientation in cycling

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Introduction
The gold standard for measuring cycling positioning uses marker-based motion capture and inverse kinematics. Vicon uses multiple infrared cameras to track the positioning of markers on the body, and biomechanical inverse kinematics calculations are used to compute 3D joint angles. However, marker-based motion capture is time-consuming (setup, data collection and post-processing) and due to the fixed capture volume, cannot capture moving cyclists. Accurate tracking of the sagittal orientation of the pelvis requires tracking at least two fixed positions but this is complicated by the soft tissue covering the pelvis. In the absence of a meaningful measure of the pelvis orientation, the hip joint angle is frequently erroneously computed as the angle between lines from the knee to the hip and from the hip to the shoulder. There is the need for an efficient method to estimate pelvis orientation in 2D for cycling positional evaluation.

Methods
Following institutional ethical approval and informed consent, two male trained cyclists were recruited for cycling positional evaluations. The cyclists sat in four different positions (upright, mid, TT and superman) on a Monark cycle ergometer, reflective markers were placed at key points of the body. For ground truth data collection, a six-camera Vicon nexus system was used. The cadence was approximately 80 and the power output approximately 150W.

Preliminary Results
Across the four positions recorded the mean difference between the Vicon method and the 2D pelvic cluster was -1.4^{o} with a strong correlation of R^2= 0.97.

Table 1. Kinematic mean values for varied cycling positions using different analysis programs

Description	**Up/Straight** (^{o})	**Mid** (^{o})	**TT** (^{o})	**Superman** (^{o})
MATLAB P1	13.9	18.3	29.5	34
Vicon P1	13.7	20.8	31.3	40.2
Error P1	**0.2**	**-2.5**	**-1.8**	**-6.2**
MATLAB P2	12.2	20.1	24.1	35.2
Vicon P2	12.3	19.9	24.4	35.9
Error P2	**-0.1**	**0.2**	**-0.3**	**-0.7**

Conclusions
The pelvic cluster concept proved to have a high correlation with Vicon. With reduced set up time and significant cost effectiveness of adopting this adapted 2D method the practical applications have a wide application to many sporting backgrounds. In addition to the favourable practicalities the cluster concept is portable and can be used for moving captures. This method addresses the current issues of measuring 2D pelvis kinematics by disregarding sites such as ASIS that have large artificial noise and adopting a cluster of markers to form a rigid body on the pelvis. Further research will evaluate the pelvic cluster validation across a larger cohort of trained cyclists.

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Low back pain management in an international female rower: A 35 week case study

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Background

This case study describes low back pain (LBP) management using an integrated model of biomechanics, training load monitoring, biopsychosocial factors and strength and conditioning (S&C). A 27-year-old female international rower with a 6-month history of LBP presented to a physiotherapist. Feedback was her low back feels "achy and weak", is aggravated by rowing, sitting, coughing and is worst on rising, but eases by "moving". The rower was not on medication. Informed consent was obtained. The rower had hip hypomobility, posterior pelvic tilt from mid-range during squatting, and poor motor control during the catch/finish phase. MRI revealed moderate to severe loss of joint space at L5-S1 with mild to moderate disk bulging causing moderate to severe stenosis.

Description of Intervention

The physiotherapy intervention (week 1-15) incorporated a daily monitoring tool using a Microsoft Excel sheet which comprised of a numeric pain rating scale (NPRS) (Childs, 2005), training load monitoring, sleep, fatigue, and mood scale. Prescription included motor control exercises to improve pelvic positioning during squatting/rowing, static stretching of the hips/hamstrings and a gradual increase in cross-training/rowing volume in training zone 1 (<2mM blood lactate). On week 11, the rower was discharged to an accredited S&C coach. Feedback was the rower needed to increase lower body (LB) strength, trunk endurance/strength and hip range of motion with a gradual return to zone 3 (>4mM blood lactate). S&C was performed twice per week. Week 11-20 focused on improving hip hinging/squatting strength endurance, and trunk endurance (Nugent et al., 2020). Week 21-34 focused on LB and trunk strength.

Main Findings

On week 12, the rower reached their pre-injury weekly training volume (440 mins or 85km). On week 21, they competed for the first time that season. On week 35, the rower won the national single scull championships, and was pain free. Table 1 provides an overview.

Table 1: Training Volumes and biopsychosocial factors across 35 weeks

Weeks	NPRS (0-10)	Sleep (0-5)	Fatigue (0-5)	Mood (0-10)	Rowing volume (mins)	Cross-training volume (mins)	Zone1 training volume (mins)	Zone2 training volume (mins)	Zone3 training volume (mins)
1-5	4±1	2±0	2±0	7±1	57±37	243±42	300±14	0±0	0±0
6-10	3±0*	2±0*	3±0*	7±1*	247±152*	95±78*	342±120*	0±0*	0±0*
11-15	2±1	2±0	2±0	8±0	435±9	106±25	541±28	0±0	2±4
16-20					393±75	41±27	434± 50	4±1	23±3
21-25					403±47	53±19	456±60	10±4	34±11
26-30					472±32	30±48	502±65	6±2	31±7
31-35					386±97	14±31	400±101	11±1	43±28

*= athlete was ill during week 7

Practitioner Implications

LBP management involves the multifaceted integration of biomechanics, training load, biopsychosocial factors (sleep, etc.), and S&C (Wilson et al., 2021). NPRS is a useful tool in monitoring pain responses during rehabilitation.

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The effect of a low or high carbohydrate meal prior to exercise on markers of bone remodelling in endurance athletes.

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Introduction
Low carbohydrate dietary practices have become increasingly popular and prevalent due to proposed benefits for the endurance phenotype (Heikura et al., 2018). However, it is important to consider how such practices, in particular pre-exercise feeding, can influence bone remodelling which is the coordinated process of bone resorption followed by formation. Recent evidence suggests that consuming a high carbohydrate (HCHO) diet across a single training day supresses bone resorption to a greater extent than an energy matched low carbohydrate (LCHO) diet (Hammond et al., 2019). This study aimed to determine the influence of feeding an isocaloric, protein (PRO) matched HCHO meal or LCHO meal prior to a standardised bout of exercise on β-CTX and P1NP which are markers of bone resorption and formation, respectively. Given the available evidence it was hypothesized that a HCHO meal would lead to a greater suppression of β-CTX in the post exercise period in comparison to the LCHO meal. As P1NP is generally less responsive to the effects of both feeding and exercise it was hypothesized that the difference between conditions for this marker would be minimal.

Method
In a crossover study design, 9 male endurance runners completed two bouts of treadmill running at a speed equivalent to 70% $\dot{V}O_{2max}$ for 2 hours having consumed either a HCHO (1.5 g·kg^{-1}BM CHO, 0.4 g·kg^{-1}BM PRO and 0.1 g·kg^{-1}BM fat) or LCHO (0.2 g·kg^{-1}BM CHO, 0·4 g.kg^{-1}BM PRO and 0.7 g·kg^{-1}BM fat) meal prior to exercise. Blood samples were collected at baseline, pre-exercise, immediately post exercise, 1h, 2h, 3h and 4h post exercise for the determination of β-CTX and P1NP.

Results
There was no significant difference between conditions for β-CTX or P1NP concentration at baseline. There was a significant main effect of time (p < 0.001) for β-CTX with characteristic decreases in response to feeding of both HCHO (-33.45 ± 5.12%) and LCHO (-22.75 ± 9.34) and increases in response to endurance exercise. However, there was no effect for dietary condition or interaction effect. There was a significant main effect of time (p < 0.001) and the interaction (p = 0.008) of time and condition for P1NP. There was a transient increase in the post exercise period which returns to baseline by 4 h. At 2 h and 4 h post exercise, P1NP was higher in the HCHO condition compared to the LCHO condition.

Conclusions
Feeding of either a HCHO or LCHO meal induces a similar decrease in β-CTX during the pre-exercise feeding window and increase following a subsequent bout of endurance exercise. A HCHO meal pre-exercise leads to a greater P1NP response at 2h and 4h post exercise which may have implications for long term bone metabolism.

Practical Applications
HCHO feeding in advance of exercise may positively influence bone turnover via an increase in bone formation. This in combination with findings regarding the modulation of CHO feeding during exercise (Sale et al., 2015) and the feeding of CHO and protein post exercise (Townsend et al., 2017) encourage the consumption of CHO around exercise to support bone remodelling and maintain bone mass.

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Conditioning in Gaelic games: The effectiveness of three running prescription modalities on aerobic capacity and performance-related variables in elite U20 inter-county hurlers

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Introduction

The match-play demands of hurling have been well-established, however, previous research has failed to investigate the effects of commonly used conditioning training protocols on performance (Duggan et al., 2022). Therefore, the purpose of this research was to examine the effects of three commonly used methods of high-intensity interval training (HIIT) on measures of aerobic, speed and jump performance in elite inter-county U20 hurlers.

Method

Male u20 intercounty hurlers (*n* = 32; age = 19.1 ± 0.8 years; height = 180.2 ± 4.2 cm; body mass = 80.2 ± 8.6 kg) were randomly assigned to one of three intervention groups: sub-maximal continuous maximal aerobic speed (MAS; *n* = 10), MAS + anaerobic speed reserve% (ASR; *n* = 11) and %Vmax (SIT; *n* = 11). The training intervention lasted 6 weeks, with a 3-session/week frequency. Pre- and post-intervention, participants completed a test battery including a 1200m time trial for the calculation of MAS (m/s), drop jump for the calculation of the reactive strength index (RSI), 10m sprint time (s) and countermovement jump (CMJ) (cm).

Results

Over the course of the 6-week study, the overall athletic profile of the squad (*n* = 32) improved favourably, with a large effect on MAS and CMJ performance (d = 0.95, d = 1.06), a medium effect on RSI (d = 0.58) and a small effect on 10m sprint performance (d = 0.23), as assessed by Cohen's *d* observed, independent of training group. The between-group analysis with ANCOVA revealed that there were no significant differences between any of the three intervention groups for any outcome measure ($p > 0.05$). The within-group analysis revealed significant improvements in the MAS group for MAS (m/s) and CMJ (cm) performance ($p < 0.05$), the ASR group reported significant improvements for MAS (m/s), 10m sprint time (s), CMJ (cm) and RSI ($p < 0.05$), and the SIT group reported significant improvements in MAS (m/s) and RSI scores ($p < 0.05$), respectively.

Table 1. Likelihood of a meaningful change in performance pre-post intervention, independent of training group, as assessed using the SWC and Cohen's d.

Variable	TE	$SWC_{0.2}$	Effect Rating	$SWC_{0.5}$	Effect Rating	Cohen's d	Effect Rating
MAS	0.08	0.04	Marginal	0.10	Good	0.95	Large
CMJ	0.79	0.082	Good	2.04	Good	1.06	Large
RSI	0.17	0.05	Marginal	0.12	Marginal	0.58	Medium
10m sprint	0.03	0.01	Marginal	0.02	Ok	0.23	Small

Conclusions

The study reports that the three HIIT modalities used in this intervention can be pragmatic options for practitioners during the in-season phase of training in GAA contexts. All three interventions were equally effective at enhancing MAS, CMJ, and maintaining speed/power.

Practical Applications

Practitioners should consider the demands of match-play when prescribing conditioning, with the findings of this study offering three efficacious methods of prescribing in-season conditioning, thus increasing training variability and reducing monotony, allowing for the targeted development of a range of physical qualities concurrently (Guridi Lopategui et al. 2020).

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Measurement / Assessment in Sport Science

Longitudinal functional data analysis with applications in biomechanics

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Introduction

Fatigue, a decline in muscular force due to exercises affects players' and athletes' performance, so monitoring it is vital in sports. Assessing fatigue helps to optimise athlete and player performance and their readiness to train. Objective assessment of fatigue is usually done in specialised laboratories that are expensive and environmentally constrained. The low-cost lightweight sensors offer a compelling alternative. This research aims at identifying and quantifying the difference between fatigued and non-fatigued run.

Method

We explored the data from 16 athletes running 400m under normal conditions (healthy) and again under fatigued conditions with sensors mounted on their left and right shanks, thighs and one on the lumbar spine (five sensors). Each sensor captured 16 signals (e.g. acceleration, angular velocity, pitch, roll) 256 times per second. The long record of any of the 16 signals can be broken into individual strides forming a series of strides arising longitudinally, and for each sensor, all the 16 signals together bring a multivariate data structure. In this study, we make use of a functional longitudinal model with a functional response – shank pitch angle (degree) to quantify the difference between fatigued and unfatigued running. This model enables us to capture the change in the pitch angle over the run when fatigued and when not.

Results

We will present our preliminary results on the difference between unfatigued and fatigued run.

Conclusions

Longitudinal functional data analysis allows for the full utilisation of biomechanics data.

Practical Applications

Our findings may be used as a foundation in building a cost-effective fatigue assessment tool.

Anthropometric and performance profiling of sub-elite male Gaelic footballers

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Introduction

This study establishes both anthropometric and performance test measures for sub-elite adult male Gaelic footballers. Secondly, this study investigated the differences that exist between grades and playing position. Furthermore, this research developed percentile rank scores for various performance tests, which will be beneficial to sub-elite coaches all over Ireland. As such, no such research exists that compares playing grades or positions at sub-elite Gaelic football. This highlights the need for large-scale research study to support coaches around the country on the physiological capabilities of this cohort.

Methods

The study design is a longitudinal retrospective secondary data-analysis. Data were taken from the Connacht GAA Centre of Excellence fitness testing database, which contains over 2500 sub-elite male Gaelic footballers' results. The metrics that were analysed were as follows: height, weight, body mass index (BMI), percent body fat, sit and reach test (SART) performance, countermovement jump (CMJ) performance, standing long jump (SLJ) performance, max press up (MPU) performance and yoyo intermittent recovery test 1 (YYIRT1) performance. Statistical analysis examined the differences that exist between playing grades and playing positions in the various performance tests. The development of percentile rank scores for performance tests was also created.

Results

Significant differences were observed between all three grades, highlighting the increased athletic ability needed to play at higher levels. Additionally, significant differences were observed across positions, highlighting the different physiological profiles across the various positions.

Table 1. Anthropometric and performance test measures across all three playing grades

Variable	Senior	Intermediate	Junior
No. of Players	893	602	226
BMI (kg.m2)	24.59 ± 2.52	24.63 ± 2.70	24.77 ± 2.99
PBF (%)	13.28 ± 5.15	14.63 ± 5.70**a**	15.27 ± 6.60**b**
SART (cm)	22.26 ± 7.54	22.08 ± 7.45	20.53 ± 7.01**a**
CMJ (cm)	32.73 ± 5.59	32.50 ± 5.36	30.99 ± 5.45**ab**
SLJ (cm)	211.97 ± 23.60	201.03 ± 23.25**a**	198.64 ± 24.12**a**
MPU (reps)	32.57 ± 11.89	29.67 ± 11.42**a**	26.03 ± 11.26**ab**
YYIRT1 (m)	1425.13 ± 459.12	1225.25 ± 408.50**a**	1182.48 ± 429.50**a**

a = significantly different to senior, **b** = significantly different to intermediate

Conclusions

Specifically, this study has demonstrated that senior players had increased muscular power, muscular endurance and aerobic capacity compared to intermediate and junior players. Furthermore, midfielders had increased muscular power and aerobic capacity, highlighting the need for these two components in the position of midfield.

Practical Applications

The present findings offer comparative data of amateur Gaelic football players of different grades and classified according to positions. Sports coaches may utilise this data to assess players' strengths and weaknesses, characterise position-specific benchmarks, and allow them to individualise strength and conditioning programs for players.

Applications and innovations in Functional Data Analysis for Sport and Exercise Biomechanics

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Introduction
Continuous biomechanical data (e.g., joint angles or forces) are often collected to understand sports performance, healthy and pathological movement and the effects of treatments and therapies. These data are recorded by motion capture systems or sensors regularly throughout a movement, so they resemble smooth time-varying functions (or curves). Limitations of traditional statistical methodology mean that these rich data are often reduced to single summary values for analysis (e.g., maximum force or angle), discarding potentially important variability and information in the data.

In this presentation, *functional data analysis (FDA)* is described as a branch of statistics that has excellent applicability for modelling continuous biomechanical data, as it treats the measured data streams as whole functional objects, allowing a more complete characterisation of human movements.

Method
FDA methods are introduced through practical examples on publicly available human gait datasets. An application of FDA is described in relation to a large biomechanical data set on recreational running collected as part of the Dublin City University (DCU) Running Injury Surveillance Centre (RISC) study, where the various complexities of the rich dataset have motivated our group to develop new statistical methods.

Results
The introductory examples will demonstrate the advantage of analysing the full measured data streams over summary scalar values. In the application to the RISC data, our bespoke statistical model identifies practically meaningful changes in an individual's running technique during a short treadmill run.

Conclusions
Functional data analysis allows researchers in sports and exercise biomechanics to fully harness the rich datasets that they routinely collect. In parallel, the rich data structures collected in the field encourage statisticians to develop new statistical techniques.

Practical Applications
This talk will provide researchers in sports and exercise science guidance on how to fully leverage the information in continuous biomechanical datasets. It will also encourage inter-disciplinary collaboration between sports and exercise scientists and statisticians/ data scientists to provide new, cutting-edge solutions.

An investigation into the growth, maturation and physical performance metrics of underage Gaelic Games development squad players

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Introduction
Research has highlighted the influence that growth and maturation can have on a youth athlete's progression and performance across several sports (Gundersen et al., 2022; Turner et al., 2022). Maturity status has also been found to contribute to several key physical performance characteristics (Carling et al., 2012; Carvalho et al., 2013). However, little is known about the effects of growth and maturation in a Gaelic Games development context. The purpose of this study was to examine; (i) maturation status distribution across intercounty underage Gaelic Games development squads, and (ii) differences in physical performance metrics relative to maturity status.

Methods
A sample of 254 male Gaelic Games development squad players participated in this research. Maturation status was established using the Khamis & Roche (1994) method, across U15 and U16 age-grade groups. Participants were tested for lower-body power (i.e. countermovement jump height (cm)), linear speed (i.e. 10m and 20m), upper body muscular endurance (i.e. maximum chin-ups) and aerobic endurance (i.e. GAA modified Bronco). Combined physical performance test scores by maturity status for both age-grade groups were compared using a one-way ANOVA. Subsequent Tukey HSD post hoc tests were conducted in the case of significant main effects.

Results
In the U15 group, 64.9% were found to be early developers (ED), 31.5% were on-time developers (OT) and 3.6% were late developers (LD). Similarly, in the U16 group, 64% were ED, 33.7% OT and 2.3% LD. For the combined physical performance tests significant differences were found for 10m speed between ED and LD (p = .006) and between OT and LD (p = .032). Significant differences were found for 20m speed between ED and LD (p < .001) and between OT and LD (p = .007). ED and OT displayed significantly faster times than LD for both 10m and 20m speed. No other significant differences were found between maturity status groups for all other physical performance tests.

Conclusions
The findings are in line with previous literature which has identified an overrepresentation of early maturing players across other sports (Baxter-Jones et al., 2020; Hill et al., 2020). Previous studies have also highlighted maturity status as a significant contributor to sprint ability (Carling et al., 2012).

Practical Applications
Practitioners should consider that all youth athletes progress towards maturity at difference rates. Additionally, they should consider how this may affect their physical performance, in particular their speed.

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The reliability and usefulness of the plyometric push-up assessment in female athletes

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Sport Institute Northern Ireland

Introduction

Increased availability and advancement of force plate technology has provided a gold-standard assessment for lower-body athletic performance, however, it has yet to be fully utilised for evaluating upper-body. With upper-body strength and power key attributes in many sports, they are typically assessed using bench press and medicine ball exercises. Alternatively, plyometric push-ups (PPU) on force plates have allowed practitioners to measure force-time variables in youth and elite groups (Bohannon et al., 2020; Parry et al., 2021) with limited data on female athletes. This study aims to establish the test-retest reliability and usefulness of the PPU for female athletes.

Method

Fourteen elite netball athletes underwent two assessments 7-days apart. Participants assumed a push-up position with hands under shoulders, at a self-selected width on adjacent force platforms (Type 9286BA, Kistler Instruments Corp) sampling at 1000Hz. Starting in the fully extended 'up' position, participants descended to approximately 90° elbow flexion, before explosively propelling their body up. Vertical GRF data was exported to a customised spreadsheet for calculation of peak and mean force; flight time; take-off velocity; and impulse. Reliability was assessed via intraclass correlation coefficient (ICC) and coefficient of variation (CV%), while usefulness was determined using smallest worthwhile change (SWC) compared to typical error (TE) (Hopkins, 2004).

Results

Results are presented in Table 1. Only peak and mean force met reliability thresholds of ICC > 0.75 and CV% ≤10.

Table 1. Test-retest reliability and usefulness statistics for PPU

	Mean ± SD	ICC (90% CI)	CV% (90% CI)	TE	SWC	Test Rating
Peak Force (N)	659 ± 82	.97 (.93-.99)	2.3 (1.7-3.4)	15	16	Good
Mean Force (N)	506 ± 47	.99 (.97-1.0)	1.1 (0.8-1.6)	6	9	Good
Flight Time (s)	0.20 ± 0.03	.69 (.36-.87)	7.6 (5.7-11.5)	0.02	0.01	Marginal
Take-Off Velocity (m/s)	0.90 ± 0.25	.78 (.51-.91)	16.3 (12.2-25.2)	0.13	0.05	Marginal
Impulse (N/s)	40 ± 10	.82 (.59-.92)	13.7 (10.3-21.1)	5	2	Marginal

Conclusions & Practical Applications

The PPU offers practitioners insight into upper-body athleticism akin to lower-body assessments. This study identified peak and mean force as reliable, consistent with Parry et al (2021). In addition, these results marked a significant improvement compared to young male athletes where CV% for peak force was 39% (Bohannon et al. 2020). This suggests the importance of relative strength and competency, warranting further investigation. Practitioners should be cautious of the reliability and usefulness of PPU metrics derived from force plate technology however, the PPU can serve as a viable method of assessing upper-body performance.

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The reliability of the Cube Reader LFD to measure salivary cortisol and salivary immunoglobulin-A in inter-county hurling players

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Introduction
The collection and analysis of saliva in the assessment of physiological biomarkers such as cortisol and Immunoglobulin A (IgA), is growing in sports and exercise science (Papacosta & Nassis, 2011) with well established benefits (Diaz et al., 2013). The ELISA has been commonly used in salivary analysis research to date. However, specialised laboratory equipment and lengthy experimental testing time make this method impractical in applied environments. The Cube Reader LFD is an immunoassay, a portable, more time efficient system that does not require specialised laboratory equipment. As such, it is more suitable in applied sport settings. Previous research has assessed morning saliva samples, however, in a GAA context this is unpractical. The purpose of this study was to assess the reliability of evening salivary cortisol and s-IgA samples measured using the Cube Reader LFD in inter-county male Hurling players.

Method
Forty (n = 40) participants provided 2 saliva samples collected concurrently before an evening training session. Prior to saliva collection, the players were instructed to go about their day as normal eating and hydrating as normal before training. The saliva collection method followed the manufacturer's guidelines. Reliability was assessed by determining the variation between test 1 and test 2 for both salivary cortisol and s-IgA.

Results
Good reliability was found between test 1 and test 2 for salivary cortisol and s-IgA (both $p < 0.001$) (see Table 1). A Bland-Altman plot was used to illustrate the agreement between test 1 and test 2 for cortisol and s-IgA and to assess for systematic error. Two outliers were identified for salivary cortisol with no outliers for s-IgA. No systematic error was identified for either salivary sample.

Table 1. Reliability values for salivary cortisol and s- IgA

	ICC	95% CI Upper Limit	95% CI Lower Limit
Salivary Cortisol	0.792	0.884	0.639
s-IgA	0.810	0.894	0.669

Conclusions
The findings of the current study show that the Cube Reader LFD can reliably measure salivary cortisol and s-IgA. During periods of intense activity such as pre-season or in-season competition, the cube reader can provide real time information on the internal status of players. As the reliability of the Cube Reader LFD has been establish in this current study with inter-county male players, it is important that salivary testing be conducted in GAA to objectively establish the recovery status of the players.

Practical Applications
The time of testing in the current study differs from those previously published. Given the amateur status of GAA players, it is important that testing fits into schedule of the players. As a result, establishing the reliability of the Cube Reader LFD for use in inter-county players to measure evening salivary samples is significant. The Cube Reader LFD is a time efficient tool that can be used to monitor salivary cortisol and s-IgA. The stress and immune function of players can be established rapidly to provide objective feedback to a coach, paired with subjective monitoring, will give a full rounded view of the players recovery status. This can have the potential to reduce the risk of injury and/or illness.

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Are Irish athletic therapy students confident in concussion assessment and management? A cross-sectional study of final year students' self-efficacy

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Introduction
Concussion is one of the most complex sport injuries (McCrory et al., 2017). Multiple studies demonstrated poor concussion-related healthcare practices worldwide (Lempke et al., 2022). Self-efficacy impacts students' motivation to practise (Schunk, 1985) thus the level of their concussion-related self-efficacy may impact their future clinical practice. This study aimed to explore concussion assessment and management self-efficacy and practices among Irish final-year athletic therapy (AT) students and to investigate factors that impact their self-efficacy.

Method
Cross-sectional survey of 61 final-year AT students (63% of all final-year AT students in Ireland), consisting of (1) demographics, (2) concussion assessment and management self-efficacy levels and practices (0-100 scale), and (3) factors affecting self-efficacy sections (1-5 scale).

Results
The overall levels of self-efficacy were 45.75±19.13 for concussion assessment and 51.93±24.12 for concussion management. The highest assessment scores were for concussion symptom checklist (82.40±24.37), history and clinical evaluation non-specific to concussion (79.45±24.30) and Sport Concussion Assessment Tool (SCAT5) (74.17±29.82). The lowest were for computerised neuropsychological test (14.03±26.65), King-Devick Test (15.05±30.30) and paper/pencil neuropsychological test (17.78±28.75). Among the management skills the highest scores were for advice on physical rest (73.61±28.75), return-to-play progression (66.12±29.17) and advice on cognitive rest (60.76±33.29). The lowest were for treatment of chronic headache (30.20±28.66), advice on nutrition (33.27±33.41) and vestibular/ocular motor rehabilitation (34.51±37.10). A strong positive correlation was observed between self-efficacy and frequency of use of concussion assessment ($r=.542$, $p<.001$) and management ($r=.612$, $p<.001$) skills. The factors having the greatest positive impact on self-efficacy in concussion assessment and management were receiving positive feedback (4.48±.96) from an educator and remaining emotionally (4.34±.95) calm while practicing the skills.

Conclusions
Irish final-year athletic therapy students had moderate self-efficacy in concussion assessment and management. Those who displayed higher self-efficacy levels used the skills more frequently in clinical placement. Student self-efficacy in concussion care can be enhanced through educator's positive feedback and through facilitating calmness while practising.

Practical Applications
Educators should consider provision of positive feedback to students in relation to all concussion assessment and management skills. They should also aim at maintaining a relaxed environment in the classroom.

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An exploration of attitudes towards concussion and the perceived barriers and facilitators influencing concussion reporting behaviours among track cyclists: A qualitative study

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Introduction
Concussion has become a widely discussed topic within scientific research and mainstream media in recent years due to the associated potential adverse health outcomes (McCrory et al., 2017). Within cycling, it is estimated that between one and nine percent of injuries are concussion (Decock et al., 2016). O'Reilly et al. (2020) examined behaviour towards concussion among cyclists from a wide range of disciplines, including track cycling. Within their study, a lack of knowledge was identified as a barrier to medical attention. In the absence of exclusive research, in addition to the high-risk nature of the sport, the barriers and facilitators affecting concussion reporting among track cyclists were investigated in this study.

Method
Underpinned by a qualitative research design, semi structured interviews were carried out with eight track cyclists competing internationally for Ireland. Interview questions focused on participants' experiences with, and attitudes towards concussion as well as perceived barriers and facilitators influencing concussion reporting behaviours. Data was analysed using reflexive thematic analysis.

Results
Four overarching themes were identified: (1) Athlete Mindset; (2) Concussion Awareness; (3) Support Systems; and (4) Screening Protocol. Barriers to reporting concussion identified include: athlete mindset, access to education, unsupportive support systems and negative perceptions of screening protocol. The findings highlight the unique barriers to reporting concussion experienced by track cyclists. Facilitators identified include: education and supportive support systems.

Conclusions
While participants acknowledge the dangers associated with concussion, many participants expressed ambivalence regarding reporting intentions, in favour of performance and maintaining athletic identity (Brewer et al., 1993) and sustaining the sport ethic (Hughes & Coakley, 1991) embodied within the athlete mindset. Athletes are influenced by the athlete mindset which is also influenced by their support system. An athlete's awareness of concussion is influenced by their own, and vicarious experiences of concussion but also education received via governing sport bodies, which ultimately contribute to influencing their support systems. Perceptions of screening protocol are shaped by perceived consequences to performance, resonating with the desire to maintain athletic identity featured within the athlete mindset. These connections demonstrate that concussion reporting behaviour is not determined by one factor, but by an interconnected socioecological system involving all stakeholders.

Practical Applications
Practical applied recommendations include increasing access to education amongst track cyclists in addition to coaches, swannies and medical personnel. Future interventions should seek to reduce negative perceptions towards reporting concussion and increase awareness of the dangers of concussion and the necessity of appropriate concussion protocol and management.

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Sports Participation / Elite Sport Science Support

What are the benefits of sport for all promotion for sports federations?

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Introduction
Physical activity has been shown to have numerous benefits for an individual, and for society. Organised grassroots sport, on the other hand, has had fewer studies conducted on the benefits of participation. Over the last decade, researchers and policymakers have argued that the health and social potential of organised sport has been underexploited as underlined by the White Paper on Sport (European Commission, 2007) and the Global Physical Activity Plan (Murray et al., 2019). The present umbrella review aims at mapping the diversity of benefits of organised sport participation, highlighting gaps in the scientific evidence.

Method
An umbrella review, considered the gold standard for evidence synthesis (Grant & Booth 2009), was conducted. A systematic literature search was conducted on Medline, The Cochrane Library, SPORTdiscus, ISI Web of Knowledge and Embase (January 2018 – 2023). Inclusion criteria were 1) being a literature review, 2) published in English in a peer-review journal and 3) describe how organised sport contribute to health, well-being, community and societal capital. Two authors conducted the selection process and data were analysed to consider types of outcomes, their measurement, methods used, theoretical model and review quality.

Results
Of the 37,617 retrieved articles, 34 reviews involving a total of over 1 million participants, matched the inclusion criteria. These papers contained findings on a variety of benefits, grouped into four major themes: (1). Social benefits (e.g. Relationship formation, social skill development) (2) Mental benefits (e.g. Improved psychological health, increased motivation) (3) Physical benefits (e.g. Improved fitness/diet, increased bone health) (4) Other benefits (e.g. Encouraging diversity, creating volunteer opportunities, decreased smartphone addiction).

Conclusions
From the quantity and variety of benefits found, it can be concluded that organised grassroots sport is worth participating in for an individual, and worth investing in for a sporting organization. The community and society also benefit from sport in ways such as reduced delinquency, and economic development. More research is needed to investigate figures on the societal benefits, including sustainable development or financial return on investment in organised grassroots sport.

Practical Applications
This study will have important implications for policymakers and leaders of sporting organizations who can use this information to promote and encourage participation in sport-for-all for the betterment of individuals and the organizations themselves. Sports federations can disseminate these findings in an effort to increase their membership bases and seek funding for their activities.

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Injury surveillance: A qualitative study of perceptions of elite ladies Gaelic football and camogie players

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Introduction
Inadequate injury surveillance can be a barrier to effective injury prevention (O'Connor et al., 2020). Despite recent increases in female participation in sport, a lack of injury surveillance and epidemiological data in elite female field-based team sport has been reported (Gilhooly et al., 2023). Ladies Gaelic football is the fastest growing female sport in Europe and camogie is one of the most popular female team sports in Ireland. This study aimed to i) explore perspectives on injury surveillance and ii) examine perceived barriers and facilitators to injury reporting of elite ladies Gaelic football and camogie players.

Methods
Six focus groups (three in-person; three on-line) were conducted with twenty-one elite ladies Gaelic football (n=11) and camogie (n=10)) players representing three playing divisions and fourteen inter-county panels. Group discussions began by asking the participants to outline their understanding of injury surveillance and about injury surveillance practices within their teams. This was followed by a written task, where participants listed and then discussed three perceived barriers to injury reporting. These steps were then repeated for perceived facilitators. As a group, the participants then ranked perceived barriers and facilitators in order of importance. This data from each group was amalgamated and analysed to establish most common responses. Group discussions were audio recorded, transcribed and analysed as a written narrative using an approach informed by reflexive thematic analysis (Braun & Clarke, 2019).

Results
Participants' report of current injury surveillance practices for their team echoed closely the participants' interpretation of the definition of injury surveillance, as the reporting of injury to the manager or medical personnel, with the physiotherapist responsible for monitoring progress and communicating with the player, management and strength and conditioning coach. The written task identified fear of missing training/games; losing one's place on the team; and unapproachable management as common barriers to injury reporting. Trusting relationships and a clear reporting pathway were common facilitators. This aligned with the themes generated from the qualitative analysis of the barriers/facilitators to injury reporting, which included organisational, environmental and personal factors. Specifically identified were access to medical care, reporting culture, relationships within the team and player mindset/belief affecting injury reporting.

Conclusion and practical implications
Findings suggest that injury reporting is influenced by environmental, organisational and personal factors that should be considered to bolster data collection efforts, thus improving engagement by all end-users with an injury surveillance system. Reflection and action by all stakeholders on the prevailing culture and environment within and around the team is needed to create a player-centric injury reporting culture for reporting and timely management of injuries.

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Dietary Information for Gut Endurance Sport Testing (DIGEST) Questionnaire: the relationship between Sports Nutrition Knowledge and Gut Health in Elite Sport

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Introduction

Approximately 30-70% of athletes experience gastrointestinal (GI) complaints of varying severity, including bloating, cramping, diarrhoea, and vomiting during exercise (De Oliveira et al., 2014). These symptoms are particularly common among endurance-based athletes, with 96% of long-distance runners experiencing symptoms during training/competition (Costa et al., 2017). Possessing a greater nutrition knowledge and optimal implementation may play an important role in optimising an athlete's performance (Trakman et al., 2019). Despite this, there is a paucity of evidence regarding the GI experiences and sports nutritional knowledge (SNK) in elite sport. The aim of this study was to design a novel questionnaire to assess common GI complaints, GI health, and SNK in elite athletes and coaches. The study explored their attitudes and practices regarding diet, supplementation, exercise workload with the overarching aim of gaining an understanding of potential causative factors to GI complaints.

Methods

This study developed a new sports nutrition knowledge questionnaire, called the 'Dietary Information for Gut Endurance Sport Testing' (DIGEST) questionnaire. A cross-sectional questionnaire was developed by adapting and changing questions from previous SNK questionnaires, NSKQ (Trakman et al., 2017), ANSKQ (Trakman et al., 2019) and probiotics questionnaires (Fijan et al., 2019; Soni et al., 2018). The questionnaire was disseminated 400 elite athletes and their coaches in the UK and Ireland, assessing GI complaints, SNK, probiotic usage, dietary practices, and exercise workload. Chi-square analyses and independent sample t-tests were employed to examine associations between variables.

Results

The study found that 242 participants scored below 65% in the SNK section, indicating inadequate knowledge. However, SNK was not significantly ($p = 0.132$) associated with the occurrence of GI complaints. Among participants, 211 GI complaints were reported, with individual sport participants experiencing significantly higher numbers compared to team sport participants (161 vs 50; $p = 0.04$). Most participants experienced GI complaints pre-exercise (45.5%), challenging the conventional understanding that symptoms are a result of prolonged activity. Participants who reported taking probiotics had significantly ($p = 0.00$) fewer GI complaints than those who did not (70 vs 116).

Conclusions & Practical Applications

These findings suggest that the participants possess sub-optimal SNK when compared with scoring matrices from previous research (Tam et al., 2022; Trakman et al., 2017), and that SNK does not directly impact GI complaints. However, GI complaints remain common in elite sports, especially in individual sports such as distance running, cycling and triathlons. These complaints occur frequently before and towards the end of exercise. Probiotic supplementation shows potential as an adjunctive therapy for managing GI symptoms in athletes. The DIGEST questionnaire can aid nutritionists, dieticians, and coaches in identifying athletes who are experiencing GI complaints and subsequently provide targeted interventions to effectively manage their symptoms.

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Jockey's perceptions on retirement planning - A qualitative study exploring barriers to the use of supports and services

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Introduction
Adjustment to retirement is found to be less successful when it is unplanned, unexpected (Kuettel et al., 2017) and when the athletes have high levels of athletic identity (Lavallee et al., 1997). High prevalence of injuries in jockeys means retirement can come anytime and therefore preparation is vital. This research explored the barriers to the use of career planning and retirement services by both current (C) and retired (R) Irish professional jockeys.

Methods
Semi-structured interviews were completed online with current (n=4, years riding = 14 to 24 years) and retired (n=4, years retired = 1 to 6 years) professional jockeys. Interview questions focused on jockey's perceptions on career planning and barriers preventing them accessing services before, during and after the retirement transition. Interviews lasted nearly 30 minutes (M = 25 min; range = 19-44 min). Completion of the studies interviews were dependant on data saturation. Data was analysed by reflexive thematic analysis.

Results
Findings suggest that current jockeys did not contemplate planning for retirement from horseracing and retired jockeys did not pre-plan for retirement. Barriers to use of career transition services emerging from the data for current (C) and retired (R) jockeys include; belief that pre-planning could lead to decreased performance (C&R), stigma (C), avoidance behaviour (C&R), pressure from trainers to commit full time to jockey role (C&R), lack of visibility of services (C&R), trust issues (C), pre perceptions of what further education entails (C&R).

Conclusion
Supports and services are available within Irish horse racing for jockeys to aid in career transition, however they are not being used. It is evident from initial interviews that jockeys are either unaware of services, uninterested in contemplating retirement or experiencing external pressures preventing use of services. Initial interviews suggest that high levels of athletic identity could be preventing jockeys from retirement planning.

Practical Implications
Further research should explore athletic identity in this cohort and the aptness of current services to ensure they are user friendly and easily accessible.

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Identify key work practices and levels of mental well-being among GAA performance analysts across a competitive season

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Introduction
Performance Analysis (PA) is a widely and accepted discipline within the sports science backroom team. Over the last number of years, the integration of PA within inter-county GAA teams has grown substantially and now forms a significant part in the multi-million preparation of teams. However, literature investigating the performance analyst as a person is limited across all sports including GAA where literature has primarily focused on identifying key indicators of performance across Gaelic football and hurling. Martin et al. (2021) developed a framework which identified the key skills required for a PA to operate at elite levels. It also uncovered that the role of PA is a frequently misunderstood and not a highly valued discipline, with PA's operating in a very demanding and pressurised environment with limited career progressions. Studies have focused on mental well-being, stressors and coping demands among sports coaches, physiotherapists and sport psychologists. Therefore, a study is required to further investigate these factors within the performance analyst role.

Design/Methods
A mixed methods exploration of GAA performance analysts to identify key demographic information, work practices and key components of mental well-being. Performance analysts across both Gaelic football and hurling at senior inter-county level will complete both a questionnaire and a number of self-reported psychometric scales looking at mental toughness, physical fatigue, cognitive weariness, emotional exhaustion, perceived stress, anxiety, and depressive symptoms using a series of reliable and valid measures (Phase 1). A core group of participants will complete the measures on a monthly basis across the competitive season as part of a longitudinal study. (Phase 2). Phase 3 will take the findings from both phase 1 and phase 2 and will incorporate these into an educational package which would be used as part of the GAA Accreditation Programme where new performance analysts within the association and discipline are trained. After students/participants complete the programme, a survey and/or feedback will be administered to evaluate the effectiveness and usefulness of the findings of this research innovation within the discipline and real-life.

Results
Unique data will be established to gain a novel insight into key demographic data, work practices and levels of mental wellbeing among senior inter-county GAA analyst across the duration of a competitive season.

Conclusions and Practical Applications
The study will identify key demographic data and work practices relating to GAA inter-county PA analysts. By repeating the measures monthly over a competitive season by a core group of analysts, an insight will be gained into possible changes across many areas of the role (see below) along with developing an educational pack around work practices and mental wellbeing which can be used by new entrants and existing members within the discipline.

1. mental well-being,
2. identify any specific periods of increased workload and numbers of hours worked,
3. identify both internal and external stressors to the PA role

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Keys to success: Lessons from a club's successful implementation of the Ladies' Gaelic Football Association's Gaelic4Teens Program to retain teenage girls

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Introduction
Adolescent girls are dropping out of sport at a higher rate than boys, with limited research focusing on female, community-based and culturally-relevant sports intervention programmes. Reflecting recent research on how to engage teenage girls (Farmer et al., 2018, 2020; LGFA, 2020; Sport Ireland, 2021), the Gaelic4Teens (G4T) programme aims to increase the retention rate of teenage girls in Ladies Gaelic Football aged between 13-17 years of age (LGFA, 2022). The aims of this study were to investigate (i) why, and (ii) how, a Ladies Gaelic Football (LGF) club which took part in the G4T programme in 2019 successfully implemented the intervention, including (iii) how they overcame any challenges met.

Method
Four (two males, two females) prominent members of a large LGFA (Ladies Gaelic Football Association) club in a commuter town in Ireland participated in semi-structured interviews; these members were involved with the club as coaches (n=3), committee members (n=3) and parents (n=4). In addition, a secondary analysis of a detailed report from nine focus groups undertaken by the club in 2019 with players and parents was conducted. The interviews, alongside data extracted from the club's report on their focus groups, were subjected to reflexive thematic analysis.

Results
The analysis developed three major themes: (1) Why the club took part in the programme (e.g., enhancing player retention; a male dominated coaching environment); (2) How the coaches applied their learning (e.g., incorporating fun into training sessions; being aware of player welfare); and (3) The keys to success (e.g., the G4T programme structure; in-house coaches' forum; finding their champions; involving all stakeholders; sticking with it).

Conclusions
Reasons for taking part in the programme and how it was implemented were both multifaceted and complex. The club's *Keys to success* offer a powerful stimulus for other clubs to consider to overcome challenges associated with implementation. Context specific dissemination and implementation strategies are essential to ensure that knowledge gained from intervention research is not wasted (Owoeye et al., 2020).

Practical Applications
These findings provide valuable insights into the Gaelic4Teens programme that can be used to refine and tailor the initiative, as well as guide dissemination and implementation in other LGFA clubs across the island of Ireland.

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The effect of long-haul transmeridian travel on cognitive performance on Olympic team support staff

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Introduction
Support staff working in elite sport frequently embark on long-haul transmeridan travel (LHTT) for training camps and major international competitions. LHTT across three or more time-zones typically causes travel fatigue and jet lag, and is associated with sleep disruption, physical and mental disturbances, and increased risk of illness (Reilly et al., 1997; Schwellnus et al., 2012), all of which may lead to sub-optimal performance of elite athlete support staff. This study examined the impact of LHTT on sleep, morning-time mood and cognitive performance in support staff travelling to Japan for the Tokyo Olympic Games.

Methods
Nine support staff members of the Irish Olympic team (2M/7F; age 34.2±8.3y (mean±SD)) embarked on an eastward flight across eight time-zones from Ireland to Japan (approx. 24h travel time), to work at the Irish team's pre-Olympic Games camp. Perceived jet lag, fatigue symptoms and mood states were assessed in the morning-time during the week before travel as baseline (BL), and for up to 15 days post-travel (D1-D8, D15). Cognitive performance was assessed in the morning-time at BL and on D1, D3, D5, D8 and D15 using Psychomotor Vigilance Task (PVT), Stroop Test and Trail Making Test (TMT A and B). Night-time sleep was monitored via actigraphy and self-report diaries.

Results
Participants perceived themselves to be significantly jet lagged for six days post-travel ($p<0.05$). In comparison to BL, on arrival participants experienced shortened sleep duration (D2, D3, D6; $p\leq0.01$), lower sleep quality (D2, D6; $p\leq0.04$) and perceived poorer sleep (D1, D2, D4, D5; $p\leq0.04$), all normalising by D7. There were positive changes in morning mood states after LHTT, with significant reductions in confusion (D4, D7, D8, D15; $p\leq0.03$), depression (D1, D2, D15; $p\leq0.03$) and increased vigour (D2, D6, D7; $p\leq0.05$). There were no significant changes in PVT reaction time and accuracy, and significantly improved Stroop scores (D1-D15, $p\leq0.04$) and TMT A and B times (D8, $p\leq0.04$).

Conclusion
It took seven days for Olympic team support staff to perceive themselves recovered from jet lag and for sleep to normalise following LHTT in an eastward direction across eight time-zones. However, in comparison to BL, LHTT did not appear to negatively affect morning mood state or cognitive performance.

Practical Applications
These findings indicate that although high-performance support staff did not experience deterioration in mood or cognitive performance in the morning-time after LHTT; they would benefit from strategies to alleviate travel fatigue and jet lag. They should pay particular attention to their sleep hygiene on the days after arrival to optimize recovery from LHTT.

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Rugby Science

Impact related breast injuries among female athletes – a systematic review

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Introduction
Robust surveillance of injury aetiology and epidemiology is recognised as fundamental for effective injury reduction and management programmes (Ekegren et al., 2016). However, while sex-specific differences in injury type and nature are noted in the literature, it is unclear if these are reflected in surveillance practices, and how the athlete is affected (Moore et al., 2023). This study systematically reviewed impact related breast injuries (IRBI) among adult female athletes.

Method
The following databases were searched: PubMed, EMBASE, SPORTDiscus including MEDLINE, Web of Science and Scopus. The literature search was conducted in May 2023 and the search was limited to articles in the English and German languages. Studies including female athletes, aged 18 and above, in any sports (team or individual) at any level (amateur, semi-professional and professional), where an occurrence of IRBI was documented were included. Studies were included irrespective of their investigated timeframes (e.g. the whole career, one – or multiple seasons). Findings were categorised (e.g. sport, level of competition and investigated timeframe of the study) to enable possible comparisons. Case studies were excluded due to the non-generalisability of findings.

Results
Of the six studies included, Rugby codes (Rugby Union, Rugby League, and Rugby Sevens) had the highest occurrence rate (62%) of IRBIs among eight different investigated sports. (Rugby codes: 62.0% (n=172), boxing: 0.0% (n=61), AFL 51.0% (n=125), softball 59.5% (n=37), volleyball 34.6% (n=26), soccer 46.7% (n=90), water polo 50.0% (n=16), basketball 27.6 (n=58) - 48.8% (n=41)). Between 25.6% and 62.0% of participants reported incurring an IRBI. Among 0.0% and 42.9% of IRBIs were reported to a medical professional or support staff. The identified main causes for IRBIs were contact with another athlete (AFL = 37.6%, Rugby Codes = 56%) the ball (AFL = 31.6%, Rugby Codes = 25.5%) and the ground (AFL = 6.6%, Rugby Codes = 22%). Between 18.2% and 48% of the participants reported that IRBIs did negatively affect their performance. Risk factors increasing IRBIs were positional differences, larger breast size, and higher Body Mass Index (BMI). The reported treatment rate for IRBIs ranged between 0% and 2.1%. In-season injury data collection and surveillance supported through education of both players and medical staff were identified to be of relevance for future IRBI prevention. None of the studies reported incidence rate.

Conclusion & Practical Applications
Despite the frequent occurrence of IRBIs among female athletes, reporting and treatment remains low. Awareness and education of all stakeholders is fundamental to ensuring better breast safety in female sport. Identifying the mechanics, severity, and confounding factors of IRBIs through thorough injury surveillance must be one of the prime focuses in further research.

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Playing for multiple Rugby teams: Short- and long-term effects on player retention

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Introduction
Dropout within youth rugby in Ireland is particularly severe between the ages of 16-20 years (Lunn & Kelly, 2019). Increased opportunities to play have consistently been linked to increased player retention (Jones et al., 2021; Sellars et al., 2018). One feature of youth sport participation which may contribute to dropout/retention, but which has not received much attention in the literature, is playing for multiple teams. This study examined the short and long-term consequences of playing for multiple age grades and/or multiple teams (club, school, both) on rugby player retention within the province of Connacht.

Method
Appearance data for 1867 Under 15-U19 male youth rugby players in the 2017/18 season, and 1811 players from the same age groups in the 2019/20 season were evaluated. For each player, the playing venue (club, school or both) and the number of age grades participated in (1, 2+) was also recorded. Players were classified as retained if they subsequently appeared at youth or adult level during the 2018/19 or 2021/22 season. χ^2 tests of independence were used to establish the relationship between playing at multiple venues or multiple age grades on retention over short (1-2 years) or long (4 year) periods.

Results
From U14 onwards, a higher number of appearances was associated with higher retention rates (p's ≤ 0.001; Cramer's V = 0.227 – 0.384). With one exception, at U15, U16 and U17, playing for multiple age grades was associated with higher retention rates over both short and long timescales (p's ≤ 0.039; Cramer's V = 0.116 – 0.346); the exception was for U15s from 2017/18 to 2018/19, where there was no difference in retention rate. Playing for the school team only was associated with the lowest retention rates across both short and long timescales at U16 and U19 (p's ≤ 0.001; Cramer's V = 0.196 – 0.393). In general, playing for both the club and the school team, or for a club team only, was associated with better player retention than playing for the school only, especially at the 4-year interval.

Conclusions
Analysing player appearance databases has the potential to deliver insights into retention within the grassroots game. Playing more games, playing for multiple age grade teams, and playing for either club only or school and club, were all associated with a higher likelihood of player retention, over both short (1-2 years) and longer (4 year) timeframes within this province.

Practical Applications
With appropriate consideration of individual circumstances, coaches can continue to promote certain players participating on multiple rugby teams. To enhance retention, coaches should explore avenues to increase players' appearances.

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Four year analysis of playing surface relationship to injuries in adult amateur Rugby Union

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Introduction

Large scale multi-season injury surveillance examining the characteristics of injuries in Rugby Union on different playing surfaces is lacking. The use of artificial pitch playing surfaces is common, especially when considering weather changes and use tolerance (Robertson et al., 2022). In Ireland there is a mix of artificial and natural grass surfaces used for training and matches and a need to examine whether there may be injury trends unique to either. This longitudinal study aimed to examine the effect of playing surface on match injury risk in female and male amateur Rugby Union players in Ireland.

Method

Analysis was conducted on four years of data on 1,881 amateur community rugby players in 36 clubs in Ireland competing at the highest club level; 1,472 male and 409 female. Each team registered their players on an online secure portal (IRISweb) and designated an injury recorder medic to report injuries throughout each season. A 24-hour time-loss injury definition was used (Fuller et al., 2007). Measures included injury type, body location and severity.

Results

2,500 match injuries were recorded. 8% of clubs predominantly trained on an artificial surface, 56% predominantly on natural grass, and 36% on both. Artificial surface lower body injury incidence (59%; 95% CI 0.53-0.64) was greater compared to natural grass (48%; 95% CI 0.46-0.51) ($p<0.05$). Injury location findings differed ($p<0.05$) based on playing surface with a higher proportion of the reported injuries occurring in the lower body on artificial surfaces (knee 17%, ankle 16%, thigh 14%, shoulder 12%, head 10%) than grass surfaces (head 13%, thigh 13%, shoulder 13%, ankle 11%, knee 11%) (Table 1). The most commonly reported injuries for artificial surface versus natural grass were strain (27% Vs 27%), sprain (26% Vs 24%), haematoma/contusion (12% Vs 10%), concussion (9% Vs 11%), dislocation (6% Vs 4%), laceration (5% Vs 4%) and fracture (3% Vs 7%). There was no statistically significant difference presented between men and women. There was no statistically significant difference in injury severity (days lost) for artificial compared to grass (48 Vs 51 average day's absence).

Table 1. Injury location (three most common)

Artificial Surface	Natural Grass
Knee (17%)	Shoulder (13%)
Ankle (16%)	Head (13%)
Thigh (14%)	Thigh (13%)

Conclusions & Practical Applications

A relatively higher incidence of lower body injury was reported on artificial surfaces versus natural grass. Laceration proportion did not differ between playing surface type but surveillance of abrasion injury is required which often does not present under the 24-hour time loss definition. These findings can help inform decision making within club and Rugby governing body structures for playing surface integration, and implementation of evidence-based welfare strategies.

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Machine learning for non-contact injury risk prediction in the lower extremities of elite male Rugby Union players

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Introduction

The proliferation of Electronic Performance and Tracking Systems in sport has allowed teams to gather vast amounts of data regarding player well-being and load. Recent research has applied machine learning (ML), a subset of artificial intelligence capable of establishing previously unknown relationships in complex data (Nussbaum, 2023), to these datasets in the search for insights. One such application is the analysis of a player's risk of injury. Despite the regular occurrence of injury in rugby union, ML applications for injury risk analysis are limited in the sport, with only 3% of study subjects in the field relating to "rugby" (union & league) players (Claudino et al., 2019). This work aims to bridge the current gap in rugby union related literature by applying ML techniques to the problem of lower limb soft tissue (LLST) injury risk estimation in elite rugby union players.

Method

Through the analysis of datasets provided by the Irish Rugby Football Union (IRFU), relating to 366 male rugby union players, spanning Ireland's national team, alongside the four provincial sides, artificial neural networks (ANNs) and XGBoost models were developed to estimate injury risk. Prior to this, non-linear features analysis (Boruta algorithm) was applied to two datasets relating to i) GPS load metrics and ii) self-perceived wellness scores to determine the most important factors in each dataset when considering LLST injury risk.

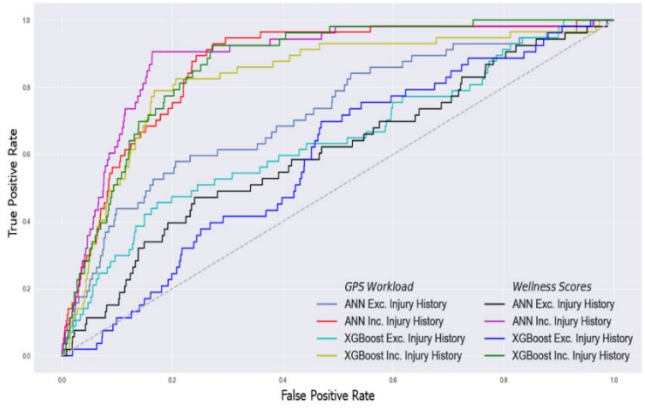

Figure 1: ROC Curve for ANN and XGBoost models.

Results

Feature Importance – Boruta analysis indicated that the most important wellness metric relating to LLST injury was a player's 14-day EWMA of sleep quality. "Zone 1" decelerations were identified as the most important feature in the GPS dataset. A player's injury history was found to be a greater predictor of LLST injury than any single GPS measure. *Injury Risk Prediction* – ANNs were found to outperform XGBoost models in each instance, with the best performing model achieving AUC = 0.885.

Conclusions & Practical Applications

The AUC score of 0.885, achieved using an ANN applied to wellness data, including prior injury history, exceeds the performance of Oliver et al. (0.66), Lovdal et al. (0.724), and Rossi et al. (0.76 ± 0.12). Each of the ANN and XGBoost models performed better when the athlete's injury history was included as a model feature, clearly indicating the importance of prior injury for future LLST injury. Practitioners should consider the importance of a player's EWMA self-perceived sleep quality over a two-week period as a risk factor for LLST injury. Additionally, this work affirms the importance of prior LLST injury history when assessing future risk of injury.

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Investigating nutrition and hydration knowledge and practice among age grade rugby union players

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Introduction

Nutritional needs for peak athletic performance include sufficient calorie intake, proper hydration, and accurate meal timing. Young athletes may be misinformed or have misconceptions on these requirements. The aim of this research was to investigate nutrition (NUT) and hydration (HYD) knowledge among age grade rugby union players. Associations between knowledge and habitual hydration status and dietary practices (energy and macronutrient intakes) were also investigated.

Method

Using validated surveys, NUT and HYD knowledge was assessed in 28 male rugby players (age 16.8 ± 0.4 years; mass 89.8 ± 11.5 kg; height 1.83 ± 0.06 m) participating in the U18's Schools Squad during Munster Rugby's 2023 Summer Age-Grade Development Programme.NUT knowledge was assessed using the Nutrition for Sport Knowledge Questionnaire (NSKQ), while HYD knowledge was assessed using the Hydration Assessment Questionnaire (HAQ). Urinalysis for hydration status was carried out on 5 separate occasions over a 10-day period by means of urine specific gravity (USG) pre-exercise via a digital refractometer (Atago 3730 (PEN-PRO), Cole Palmer, UK). Dietary intakes were recorded using a 3-day estimated food record (eFIR) on the Libro App (Nutritics Ltd, Ireland). Returned diaries were screened for completeness and accuracy and those meeting the inclusion criteria were analysed using Nutritics (Nutritics Ltd, Ireland). Statistical analysis was completed using SPSS (v28, IBM, Chicago, IL, USA). Descriptive statistics are reported as means and standard deviations. Analysis of variance, t-tests, and Pearson correlation coefficients were used to further analyse the data.

Results

Preliminary results indicate that NUT knowledge and dietary practices were suboptimal in this cohort. Mean scores for NUT knowledge were deemed poor (49.6 ± 8.2 %) where ≥ 75 % scored excellent, 65 – 74 % good, 50 – 64 % average, 0 – 49 % poor. Analysis of ten eligible dietary records report mean daily intakes of energy (3028 ± 719 kcals/d), carbohydrates (3.7 ± 1.0 g/kg/d), proteins (2.0 ± 0.6 g/kg/d) and fats (1.2 ± 0.4 g/kg/d or 32.5 ± 7.5 % total kcals/d), incongruent with recommendations from American College of Sports Medicine. Preliminary analysis of data on HYD knowledge and practice (Table 1) suggest a better understanding of hydration requirements. However, pre-exercise USG varied significantly (1.018 ± 0.008 USG) throughout the testing period, where USG > 1.020 defines dehydration.

Table 1. NUT and HYD knowledge (total score & by topic) and practice (n = 28), reported as mean ± SD, dietary data n=10

Knowledge NSKQ Scores (%)		**Knowledge HAQ Scores (%)**	
Overall (%)	49.6 ± 8.2	Overall (%)	78.7 ± 8.9
By topic (%)		By topic (%)	
Weight Management	53.6 ± 11.9	*Knowledge (%)*	84.9 ± 9.2
Macronutrients	55.0 ± 12.2	*Attitude (%)*	78.0 ± 8.7
Micronutrients	44.6 ± 18.8	*Behaviour (%)*	76.1 ± 9.3
Sports Nutrition	46.7 ± 12.1		
Supplementation	36.3 ± 12.8		
Alcohol	59.4 ± 16.2		
Habits eFIR (units/kgBM/d)		**Habits Urinalysis**	
Calorie Intake	33.7 ± 8.0 kcals/kg/d	USG	1.018 ± 1.008
Carbohydrates	3.7 ± 1.0 g/kg/d		
Protein	2.0 ± 0.6 g/kg/d		
Fats	1.2 ± 0.4 g/kg/d		

Conclusions & Practical Applications

Youth athletes in this cohort failed to exhibit adequate NUT and HYD knowledge to support performance. This is corroborated by their reported and observed habitual dietary intakes and hydration assessments. Individualised nutrition support and education may benefit youth athletes and enable them to meet their nutrition and hydration requirements, to support overall health and optimal performance. Further consideration of barriers and facilitators to dietary adherence is also recommended.

An evaluation of the Irish Rugby Football Union Coach Education Framework and its impact on the coach-athlete dyad in adolescent rugby union

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Introduction
The Irish Rugby Football Union Coach Education Framework (CEF) bases its core foundations on the three tenets of Self-Determination Theory (SDT), Explicit Learning Theories (ELT), and Implicit Learning Theories (ILT). This multifaceted CEF aims to upskill coaches in (i) how they motivate, connect, and nurture positive relationships with their athletes using SDT (Deci & Ryan, 2000), (ii) increasing the effectiveness of the language they use when communicating with their athletes using ELT (Winkelman, 2018), and (iii) how they manipulate constraints in their training session content to improve athlete learning and performance via ILT (Renshaw et al., 2022). The purpose of this research was to evaluate the impact of the CEF on coach-athlete interactions and perceptions**.**

Method
Participants were coaches (n = 6) and athletes (n = 62), selected from two adolescent club rugby union teams. Coaches were observed pre- and post-CEF intervention with 54 training sessions (9 per coach) video-recorded and analysed using the Coach Analysis and Intervention System (CAIS) across a 33-month time frame (inclusive of the unforeseen COVID-19 pandemic period). Coach perceptions of their relationship with their athletes were measured using the Coach-Athlete Relationship Questionnaire (CART-Q) in addition to semi-structured interviews. Athlete perceptions of their coaches' behaviours were measured using the Coaching Behaviour Scale for Sport (CBS-S) and focus groups.

Results
CAIS results revealed that all coaches had similar behavioural profiles that utilised high-levels of explicit behaviours ('instruction'), with a significant increase post-CEF in 'management direct' (p = 0.03) and 'management indirect' (p = 0.01) behaviours, and time proportion usage of 'Management state' (p = 0.01). CART-Q results revealed that coaches held highly positive perceptions throughout with no significant differences post-CEF (p = 0.54). CBS-S results also revealed positive perceptions for the athletes in all sub-scales, but with significant increases in 'Personal Rapport' (p = 0.01) and significant decreases in 'Negative Personal Rapport' (p = 0.01) post-CEF. CART-Q and CBS-S positive perceptions between coaches and athletes for pre- and post-CEF were further corroborated and emphasised through thematic analysis of coach interviews and athlete focus group data. Coaches frequently cited video usage as a learning resource, as well as taking a collaborative approach to session design through self-appointed mentors they sought for guidance when attempting to integrate CEF content into their coaching practices.

Conclusions
Despite the disruption caused by the COVID-19 pandemic, the coaches' willingness to integrate CEF content into their regular coaching practices (through altered behavioural profiles and usage of session time) coupled with the increased positive perceptions of the athletes post-CEF is very encouraging for future implementations of the CEF and should be explored in another setting consisting of different teams, coaches and athletes, or other sports.

Practical Applications
Coach education is a non-linear learning process that requires consistent application over extended periods of time. Therefore, providing coaches with further supports, such as access to appropriate mentors and various mediums of CEF content (e.g. online videos), has the potential to further enhance the efficacy of future coach education interventions, and ultimately coach behaviours and effectiveness.

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Esports Science

Movement tracking throughout different esports genres – a pilot study

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Introduction
Esports is defined as organized and competitive video game confrontations (Witkowski, 2012). Different esport genres are accessible to players (i.e., different play styles, environments, and rules), highlighting why esports are considered plural. Current research in esports performance is focused on outcomes analytics which are in-game results and statistics. However, contextual performance investigations (i.e., how to achieve outcome performance from a biomechanical point of view) remain rare while this is of valuable information to develop efficient training methods (McNulty et al., 2023) and preventive measures (Emara et al., 2020). This research has investigated esports athletes' upper limb movements while playing different esport genres.

Method
A sample of 63 players from Gamescom (Cologne, Germany) participated to the study. Participants have been equipped with 3 IMUs placed respectively on their right hand, forearm, and arm. Then, participants have been asked to play 10 minutes of a genre they prefer (Multiplayer Online Battle Arena -MOBA-, First Person Shooter -FPS-, or Adventure) while IMUs and a customed Python script collected respectively arm, forearm, hand, and mouse movements. APDF of accelerations and velocities, number of cycles of accelerations and decelerations, total travelled distance of the mouse, and the area of use of the mousepad have been compared between the genres.

Preliminary results
On the one hand, MOBA required higher acceleration and velocity levels, a higher number of cycles of accelerations and decelerations, and greater total travelled distance compared to FPS and Adventure genres. On the other hand, FPS required a larger area of use on the mousepad compared to Adventure and MOBA.

Conclusions
The results of this study suggest that kinematics requirements are specific to esport genres. Accordingly, MOBA genre demands more repetitive (saccadic) movements than FPS and Adventure genres, while FPS genre demands smoother (fluid) movements than Adventure and MOBA genres. Adventure genre is a combination of the kinematics demands of FPS and MOBA genres but closer to FPS than MOBA. Contrary to previous research looking at performance during gameplay (Buckley et al., 2013), this study highlights the global kinematic profile of esports players' regarding the genre they are performing in.

Practical Applications
Practitioners (coaches, physical trainers and therapists) should consider that kinematics characteristics are varying between esport genres which are emphasizing the need for players' training individualisation to prevent injuries and enhance performance.

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A feature selection approach to identify key performance indicator in simulated racing

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Introduction
Feature selection, referring to the reduction of input variables in order to develop the best performing predictive models, is a critical step in data analysis and machine learning (Kumar & Minz, 2014). When we use the data directly for classification or clustering, the learning algorithms occasionally don't work very well. Irrelevant and redundant features or noisy data may sometimes delay the feature selection process because they are not essential and relevant in relation to the target feature. The aim of this study is to predict performance for simulation (sim) racing in electronic sports (esports).

Method
We proposed a hybrid feature selection approach with three steps; filtering, wrapping, and interpreting. In the first phase, two filtering methods—mutual information (MI)(Kraskov, Stögbauer, & Grassberger, 2004) and low variance (LV) (James, Witten, Hastie, & Tibshirani, 2013)—were applied, and then two correlation coefficients were used. In the second phase, three ML algorithms, including Support Vector Machine (SVM)(Awad, Khanna, Awad, & Khanna, 2015), Random Forest (RF)(Breiman, 2001), and XGBoost (Chen et al., 2015), were utilized to obtain the optimal feature subset. Then the top j features were chosen based on the highest accuracy, and finally, in the last phase, the SHapley Additive exPlanations (SHAP)(Rodríguez-Pérez & Bajorath, 2020) technique was used to interpret and explain the output of the best model.

Results
By means of a racing simulator, we provided a dataset of sim telemetry data from 93 racing drivers and applied our proposed method for predicting sim racing performance. To quantify the quality of our model, we used different techniques such as cross-validation and metric functions. Our findings demonstrated that the accuracy of the resulting model produced by our hybrid approach (86.5%) outperforms that of wrapper-only methods (73.89%). The results showed that "speed" is the most contributing feature, followed by "lateral acceleration", "steering angle", "lane deviation", and "brake".

Conclusions
The experimental outcomes demonstrate that our method can speed up learning, improve quality, and identify important features. This approach helps esports teams to develop reliable techniques using important features.

Practical Applications
The suggested approach can be successfully used in other fields outside esports.

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Circadian advantage in esports; when is the best time to play?

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Introduction
Task performance peaks and nadirs (troughs) over one's day somewhat predictably, with prediction accuracy depending on available information (i.e. an individuals chronotype, sleep/wake behaviour, nature of activity). This phenomenon, sometimes called *circadian advantage*, can be used to explain why westward travel tends to be more detrimental than eastward travel for evening-based sporting competition, despite jet-lag severity/duration being worse following eastward travel (Charest et al., 2021; McHill & Chinoy, 2020; Roy & Forest, 2018; Smith et al., 1997; Winter et al., 2009). Esports (competitive organised video-game play) presents as an ideal medium to further understand the concept of *circadian advantage* in competitive environments, within online gameplay allowing for competition between individuals at different "biological times" without jet-lag as a potential confound. For example, a esports player located in Ireland may commonly play competitive matches at 8PM local time, against opponents living in Saudi Arabia at 11PM local time.

Proposed Methods
A proposed approach to explore *circadian advantage* in an esports context will be outlined. Specifically, we will discuss massive publicly available in-game data repositories, which esports may be logistically advantageous to target, and potentially fruitful analytical approaches. Foreseen issues (i.e., uncertainty of player time-zones) and nuances specific to the context of esports (i.e., server locations) will also be discussed.

Proposed Results
The main objective of this approach is to be able to display the peaks and nadirs of in-game esport performance over a 24-hour period, in a similar vein to that shown for various outcome measures by Skeiky et al. (2021). These could be presented as a group level, but also at an individual level provided sufficient in-game data available, which may provide insight into individual differences of temporal peaks/nadirs.

Conclusions and Practical Applications
One exciting practical application could be the implementation of findings into biomathematical modelling (i.e. the Sleep, Activity, Fatigue, and Task Effectiveness (SAFTE) model; Hursh et al. (2004)). Biomathematical models take inputs (predominately) regarding observed or predicted sleep/wake behaviours, and provide predicted current and prospective performance/fatigue levels as outputs. Biomathematical models are generally optimised on vigilance or sleepiness measures, however time of day effects show task specificity. With inclusion of esports data, a model augmented to specifically predict esport performance based on sleep and temporal factors may be possible.

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Weight Category
Sport Science

The menstrual cycle and female athletes participating and competing in weight category sports: **A narrative review**

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Introduction
The unique physiological variables during the menstrual cycle (MC) may be a consideration when optimising performance, as exercise performance may vary based on MC phase (McNulty *et al.,* 2019). Optimal body mass and body composition is a measure of performance in training and competition (Langan-Evans *et al.,* 2022). Especially for athletes competing in weight categorised sports (WCS), who must meet their specified weight in order to be eligible for competition (Khodaee *et al.,* 2015). This narrative review aims to explore the current literature on the menstrual cycle in female athletes participating and competing in weight category sports.

Method
Key search phrases included: ("menstrual cycle" OR "menstrual cycle phase*" OR "menstruation") AND ("weight category sports" OR "Female Olympic Weightlifter*" OR "female powerlifter*" OR "female rower*" OR "female-jockey*" OR "female boxer*" OR "female MMA*" OR "female wrestler*" OR "female judoka*" OR "female karateka*" OR "Tae Kwon Do"). Databases included: PubMed, Scopus, Web of science, EBSCOhost research databases SETU Library, and Medline. 71 papers were found. Duplicates were removed. Following title, abstract and full text screening, 11 articles were included in the review. Studies were included if they were (i) written in the English language (ii) Female athletes who were eumenorrheic or HC users and participated or competed in weight categorised sports and (iii) investigated any aspect of the menstrual cycle and weight categorised female athletes.

Results

(Table 1 outlines the sports represented across the 11 included papers)

Sport	Powerlifting	Rowing	Boxing	Wrestling	Judo	Other
Papers	1	4	1	1	3	1

The key themes emerged from the literature search include: WCS can increase the risk of female athlete triad Walsh *et al.,* (2020) and due to low body fat mass menstrual irregularities can occur (Trutschnigg *et al.,*2008). Boxers and wrestlers perceive weight control to be the most stressful aspect of competition (Hall *et al.,* 2001).

Conclusion
The associated risk of WCS with menstrual irregularities, female athlete triad and stress of weight control emphasise the need for future research on: mc trends, mc dysfunctions and weight management across mc phases in females competing and participating in WCS.

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The behavioural determinants of weight-making in weight-category sports: A narrative review

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Introduction
Athletes in weight-category sports undertake methods of weight-making such as energy restriction and sweating through using plastic suits, losing up to 5% of their body mass prior to competition (Khondaee et al., 2015). Elite judo athletes have reported to lose up to 13% of body mass in the week of competition (Stangar et al., 2022). These methods can negatively impact markers of bone health (Dunne et al., 2022) and enhance the risk of injury (Hammer et al., 2022) in weight-category athletes. However, previous case study research has highlighted the potential for weight-category athletes to make weight in a safer manner (Wilson et al., 2012). Therefore, there was a need to identify why athletes are not engaging in safer weight-making behaviours when it is possible to do so. The purpose of this review was to identify the behavioural determinants influencing the uptake and maintenance of weight-making in weight-category sports.

Methods
Electronic databases utilised during the literature search were Scopus, Pubmed, PsycInfo and PsycArticles. Examples of keywords and search terms used include 'jockey OR wrestler OR boxer AND weight-making practices OR weight-management-behaviours'. To meet the inclusion criteria for this review, research of a qualitative or quantitative nature must have provided information related to the behavioural determinants of weight-making, the sample populations must have included weight-category athletes, and studies had to be written in English.

Results & Discussion
Twenty-three studies met the inclusion criteria for this review. Themes identified throughout the review relate to the acceptance of weight-making in weight-category sports, the differential impact of varied social influences (e.g. coaches, nutritionists etc.) on weight-making, the age at which athletes are introduced to the concept of making weight, self-control, and the positive and negative beliefs related to weight-making.

Practical Applications
Education for coaches of weight-category athletes should be provided on the negative implications of introducing athletes to weight-making from an early age, along with increasing access to sport science supports.

Conclusion
Despite negative implications, athletes continue to engage in practices of weight-making due to its social and cultural acceptability. There is a belief that making-weight provides these athletes with a mental advantage ahead of competition, positively influencing their perceptions of confidence and preparedness. Future research to identify the specific barriers and facilitators to enhance the potential for behaviour change within the weight-category population is recommended, which should be underpinned by theories of behaviour change.

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Athletics Science

The association between season length at age 14 and athlete retention at ages 16 and 19 in endurance events in track and field

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Introduction
Sport specialisation is defined as the year-round engagement in intensive training in a single main sport at the exclusion of all other sports (Jayanthi et al., 2020). Inadequate rest periods from sport have been associated with increased risk of injury in young athletes (Zoellner et al., 2022), which is a potential risk factor for dropout (Huxley et al., 2014). Yet year-round participation is common in track & field, especially in endurance events (Mann et al., 2021). This study investigated the association between endurance athletes' competition season length in the Under 15 age category and subsequent retention in the Under 17 and Under 20 age categories.

Method
The track and field database, www.thepowerof10.info, was consulted for all records of athletes competing in endurance events in the United Kingdom between the years 2007 and 2018. Athletes who had recorded a minimum of 10 competitions and been active for at least 3 months at 14 years of age were noted. Athletes were divided into three subgroups based on the percentage of events that they had completed at age 14 (U15) which were endurance events: 100% (n = 2364), 50-99% (n = 5370), and 1-49% (n = 5446). The associations between the number of months in which a competition was recorded at age 14 and retention status (retained or not) at both age 16 (U17) and 19 years (U20) were examined using Chi-Squared Tests of Independence, with Cramer's V providing a measure of effect size.

Results
Average retention from U15 to U17 was 79.6% for girls (boys 81.3%), but 94.5% for girls competing 12 months of the year (boys 96%). Average retention from U15 to U20 was 22.9% for girls (boys 22.0%), but 38.2% for girls competing 12 months of the year (boys 41.3%). For all subgroups (only endurance, primarily endurance, minority endurance), there was a significant association between the number of months in which a competition was recorded and retention favouring a longer competitive season (all p's < .001; Cramer's V ranged from 0.149 to 0.295).

Conclusions
Year-round engagement in track and field is associated with better athlete retention through youth age grades. Future research should explore the influence of year-round participation on performance development. Careful attention must be paid to context (e.g., sport, country of origin) and intervening variables (e.g., training intensity) when exploring the extent to which specific elements of specialisation prove beneficial or detrimental to athlete retention.

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Sprinting into the future: Do super spikes alter sprinting spatiotemporal characteristics?

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Introduction
Innovation in contemporary track spike shoe design, coined "Super Spikes" shoes (SSS), integrating new technology such as a rigid carbon fibre curved plate, midsole geometry and lightweight foam has resulted in the breaking of all men's and women's world records for distances ranging from 5 kilometres to the marathon (1). The benefits of this new technology has been firmly established within long-distance running (2), however there are limited investigations on SSS effect on sprinting. One study found significant differences in contact time and vertical impact using SSS (3). Another study investigated SSS effect on sprinting acceleration biomechanics (4) observed conflicting responses among the participants between shoe types. This study aims to add to the limited literature by examining the impact of SSS on spatiotemporal characteristics in sprinting.

Methods
Six elite sprinters (male, n = 5; female n = 1) sprinters volunteered for the study. Participants were randomly assigned to perform a series of maximal 60 m sprint efforts using one of three track spike conditions: Nike Air Zoom Maxfly, Puma Evospeed Tokyo, and a control spike. Two, maximal 60 m sprint efforts, separated by 10mins of passive recovery, were completed per track spike condition, with 30mins passive recovery between conditions (i.e., 6x 60 m trials in total). Photoelectric cells were placed along the 0-60 m track (Optojump, Microgate, Bolzano, Italy) measuring sprint spatiotemporal characteristics (flight time, foot contact time and stride length) sampling at 1000Hz. Data was split into two distinct phases, acceleration (0-30 m), and max velocity (fastest 10 m split). A one-way repeated measures ANOVA was used to analyse the acceleration and max velocity phases respectively.

Results
There was no main effect of condition on 0-60m time ($P = 0.83$; Nike 6.843± 0.358secs; Puma 6.935± 0.302secs, CON 6.942± 0.263secs. There was no statistically significant main effect of condition for either the acceleration or max velocity phase ($P = 0.993$ and $P = 0.381$ respectively). Similarly, significant difference in main effect of condition was not observed in either phase for the contact time in ($P = 0.954$ and $P = 0.190$ respectively), flight time ($P = 0.758$ and $P = 0.739$), or stride length ($P = 0.303$ and $P = 0.723$).

Conclusions
Findings from this study demonstrate no impact of SSS on sprinting spatiotemporal characteristics. Within individual participants, there was a large degree of variability among the response to SSS. This variability underscores the complexity of athlete-shoe interactions and highlights the necessity of considering an individual's biomechanical characteristics when assessing the effectiveness of potential performance-enhancing footwear.

Practical Applications
SSS do not appear to necessarily modify spatiotemporal sprinting biomechanics, therefore coaches, and sports science and medicine practitioners may not consider this a necessary factor when prescribing training. However, it is currently not clear what factors determine an individual's response to running in SSS and thus further work is needed to progress our understanding of the factors underlying variability in an athlete's biomechanical adjustments to performing in SSS.

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