

Performance Nutrition in the English Premier League: An Evaluation of Culture, Nutritional Requirements and Professional Practice

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Abstract

In 2020, The Union of European Football Association (UEFA) published evidence based nutritional guidelines for elite soccer, recommending periodised carbohydrate (CHO) intakes of 3 to 8 g·kg⁻¹BM·day⁻¹, ~1.6 g·kg⁻¹BM·day⁻¹ of protein and dietary fat contributing 20-35% of total energy intake (EI) (Collins et al., 2021). While protein and fat intakes are generally adequate, CHO consumption frequently falls below recommendations (Steffl et al., 2019). In English Premier League (EPL) players, suboptimal CHO intake around match play has been reported (Anderson et al., 2017b; Kasper et al., 2024), potentially compromising muscle glycogen availability and performance (Saltin, 1973; Anderson et al., 2022). This highlights a persistent gap between evidence-based guidelines and real-world practices. Over the past decade, EPL match play has seen significant increases in total, high speed running (HSR) and sprint distances (Allen et al., 2024, 2025), alongside intensified fixture congestion, with players now completing 60-70 matches per season (Allen et al., 2025). Players have expressed concerns regarding injury risk, career longevity and match quality under increasingly congested schedules (Milner and Houghton, 2025). Within this context, this thesis aims to advance the evidence base on nutrition culture, energy requirements and dietary practices of professional soccer players and to develop an applied theory of practice that informs the practice of sports nutritionists operating within elite soccer environments.

Study 1 (Chapter 2) identified the gaps in the existing CHO literature in soccer. A scoping review (258 studies) revealed the dominance of laboratory based experimental studies and field based observational studies. Most observational studies included developmental (~52%) and

professional players (~31%) whereas experimental studies primarily featured recreationally active (~40%) and collegiate/university participants (~26%). These data highlight the lack of experimental research in professional and world class players, limiting the translational applicability of current CHO guidelines. Study 2 (Chapter 3) explored nutrition culture from EPL players' perspectives using semi-structured interviews (n = 10). Reflexive thematic analysis, informed by Bourdieu's Theory, demonstrated that dietary practices were shaped by habitus (familial, ethnic and religious backgrounds), social capitals (managers, teammates and online sources) and economic capital. Hierarchical structures create unequal access to nutritional support, particularly between academy and first team players, while doxic beliefs around body composition perpetuated stigma and unhealthy dietary practices. Overall, nutrition culture in male professional soccer is multifaceted, highlighting the need for practitioners to understand their specific context before implementing any nutritional interventions.

After exploring research gaps and the cultural landscape of nutrition in elite soccer (Studies 1 & 2), Study 3 (Chapter 4) quantified the total daily energy expenditure (TDEE) of male EPL players (n = 9) during one-game week (1GW) and two-game week (2GW) microcycles using doubly labelled water (DLW) over a 15-day in-season period. Mean TDEE was $3551 \pm 507 \text{ kcal}\cdot\text{day}^{-1}$, with no difference between 1GW ($3554 \pm 963 \text{ kcal}\cdot\text{day}^{-1}$) and 2GW ($3467 \pm 821 \text{ kcal}\cdot\text{day}^{-1}$, $p = 0.781$), reflecting similar accumulative weekly external load (total, high speed running and sprint distances). CHO intake was significantly higher on match day (MD) ($5.0 \pm 1.1 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) than the day before the match (MD-1) ($3.5 \pm 1.3 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$), the day after the match (MD+1) ($3.0 \pm 1.0 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) and training days ($3.0 \pm 1.1 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) (all $p < 0.05$); but remained below recommendations. The quantification of TDEE support the continued relevance

of current UEFA CHO guidelines (4-6 g.kg⁻¹ on training days and 6-8 g.kg⁻¹ for match day preparation, competition and recovery). After exploring the energy requirements of fit players, Study 4 (Chapter 5) examined TDEE via DLW method, EI via RFPM and body composition changes across two distinct rehabilitation phases in EPL players. Case Study 1 (22 years-old, 193 cm, 93.7 kg) involved early-stage hamstring rehabilitation, while Case Study 2 (21 years-old, 186 cm, 88.7 kg) captured the transition from partial (PWB) to full weight-bearing (FWB) during rectus femoris rehabilitation. Body composition was measured via dual-energy X-ray absorptiometry in Case Study 1. In Case Study 1, TDEE increased by 1013 kcal·day⁻¹ (Week 1: 3143 kcal·day⁻¹; Week 2: 4156 kcal·day⁻¹) with stable BM (+0.10 kg), but a reduction in fat-free soft-tissue mass (FFSTM) (-0.50 kg), primarily in the trunk and non-injured leg. In Case Study 2, TDEE increased by 538 kcal·day⁻¹ (PWB :3175 kcal·day⁻¹; FWB: 3713 kcal·day⁻¹) but remained below pre-injury levels (4546 kcal·day⁻¹). DLW-estimated EI indicated energy deficits in both phases (PWB: 139 kcal·day⁻¹; FWB: 557 kcal·day⁻¹). These findings demonstrate that energy requirements fluctuate across rehabilitation phases, highlighting the need for individualised nutritional support.

After examining the energetic requirements of EPL players in Studies 3 & 4, Study 5 explored the enablers and barriers influencing dietary practices of EPL players using the Capability, Opportunity, Motivation-Behaviour (COM-B) model. Ten EPL players recorded dietary intake via the remote food photography method (RFPM) over four days (training day, MD-1, MD and MD+1), followed by dietary recall and dietary behaviour interviews. Although “knowledge” (i.e. psychological capability) was identified as the main enabler of dietary behaviour on MD-1 and

MD+1, players failed to meet CHO guidelines (MD-1: $4.6 \pm 0.8 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$; MD+1: $3.6 \pm 0.5 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$). Pre-match ($0.9 \pm 0.3 \text{ g}\cdot\text{kg BM}^{-1}$) and during match ($24 \pm 15 \text{ g}\cdot\text{h}^{-1}$) CHO intakes were insufficient, largely due to prioritising a feeling of “lightness” during match (i.e. reflective motivation). Immediate post-match and post-match recovery meal CHO intakes were also compromised by suppressed appetite (i.e. automatic motivation). These findings highlight the complexity of dietary behaviours in elite soccer and indicate that effective nutrition interventions must extend beyond education and incorporate practical guidance and behaviour change techniques (BCT) to align practices with guidelines.

Following the evaluation of nutrition culture (Study 2), energetic requirements (Studies 3 & 4) and habitual dietary practices (Study 5) of professional soccer players, Study 6 (Chapter 7) explored the practice of performance nutritionists with the aim to develop a theory of practice. Semi-structured interviews were conducted with key stakeholders from one EPL team, including players, coaches, sports scientists, physiotherapists, a chef and a medical doctor ($n = 14$). Using reflexive thematic analysis, informed by Bourdieu’s framework, data demonstrate that successful performance nutritionists must navigate the implicit “rules of the game” shaped by hierarchical structures and entrenched norms in soccer field. Their effectiveness depended on the strategic use of cultural capital (technical, sport specific and interdisciplinary knowledge) and social capital (ability to build relationship with key stakeholders). The accumulation of these capitals was underpinned by a habitus characterised by passion, adaptability, resilience and positivity, which resonates with the cultural expectations of professional soccer. These data demonstrate that the perceived success for performance nutritionists in the EPL extends beyond technical expertise,

requiring the ability to navigate tacit field rules, strategically mobilise cultural and social capital and embody a habitus aligned with the values of elite soccer.

In summary, the data presented in this thesis provide a contemporary examination of nutritional culture, energy requirements and dietary practices of EPL soccer players. These studies identified gaps in existing CHO literature, explored nutrition culture in professional soccer field, quantified energy requirements during in-season and rehabilitation and investigated the enablers and barriers influencing dietary behaviours. Additionally, a theory of practice was developed to inform practitioners working in elite soccer settings. The findings demonstrate that although current recommendations remain appropriate, real-world practices are shaped by complex behavioural and cultural factors. Collectively, the thesis advances the applied understanding of performance nutrition in elite soccer and provides a practical framework to support performance nutritionists operating in professional soccer environments.

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Declaration

I declare that the work in this thesis, which I now submit for assessment on the programme of study leading to the award of Doctor of Philosophy is entirely my own. Additionally, all attempts have been made to ensure that the work is original and does not, to the best of my knowledge, breach any copyright laws and has not been taken from the work of others, apart from the works that have been fully acknowledged within the text.

Publications & Presentations

Publications of the work listed within this thesis are as follows:

1. Foo, W.L., Tester, E., Close, G.L., Cronin, C.J. and Morton, J.P. (2025) Professional male soccer players' perspectives of the nutrition culture within an English Premier League football club: a qualitative exploration using Bourdieu's concepts of habitus, capital and field. *Sports Medicine*, 55, pp. 1009-1022.
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Table of Contents

Abstract	2
Acknowledgements	7
Declaration	11
Publications & Presentations	12
Abbreviations	20
List of Figures	22
List of Tables	25
Chapter 1	26
General Introduction	26
1.1 Background	27
1.2 Aim and objectives of this thesis	31
Chapter 2	33
Fuelling soccer players: a scoping review and audit of literature related to soccer-specific guidelines for carbohydrate intake	33
2.1 Abstract	34
2.2 Introduction	35
2.3 Methods	37
2.3.1 Stage 1: Identification of the Research Question	37
2.3.2 Stage 2: Identification of Relevant Studies	38
2.3.3 Stage 3: Study Selection	39
2.3.4 Stage 4: Charting the Data	40
2.3.5 Stage 5: Collating, Summarizing and Reporting the Results	42
2.3.6 Statistical Analysis	42
2.4 Results	43
2.4.1 Study Types & Research Settings	45
2.4.2 Population & Sample Size	45
2.4.3 Athletic Calibre & Research Topics	46
2.4.4 Journal and Study Impact	52
2.5 Discussion	53
Chapter 3	61
Professional male soccer players’ perspectives of the nutrition culture within an English Premier League football club: a qualitative exploration using Bourdieu’s concepts of habitus, capital and field	61
3.1 Abstract	62

3.2 Introduction	63
3.3 Methods	67
3.3.1 Research philosophy and positionality	67
3.3.2 Participants	68
3.3.3 Procedures	69
3.3.4 Data Analysis	72
3.3.5 Methodological Trustworthiness and Rigour	73
3.4 Results & Discussion	74
3.4.1 Players’ habitus, shaped by familial, ethnic and religious backgrounds, influence dietary habits of professional soccer players	74
3.4.2 Social capital, via managers (head coaches), teammates and online influences, impact players’ dietary practices.	78
3.4.3 The increase in both soccer clubs’ and players’ economic capitals has advanced nutrition provision.	83
3.4.4 An unequal distribution of economic capitals has led to hierarchical practice in the performance nutrition field with personalised nutrition being somewhat enacted at the higher levels.	86
3.4.5 Body composition measurement is a ‘doxic’ practice in professional soccer that warrants challenge.	88
3.4 Practical Implications and Future Research Directions	93
3.5 Conclusion	95
Chapter 4	96
Energy expenditure of male soccer players from an English Premier League team does not differ between one-game and two-game per week microcycles	96
4.1 Abstract	97
4.2 Introduction	98
4.3 Methods	100
4.3.1 Participants	100
4.3.2 Overview of Study Design	101
4.3.3 Quantification of Training and Match Load	102
4.3.4 Measurement of TDEE via DLW	103
4.3.5 Measurement of Physical Activity Level	105
4.3.6 Assessment of Energy and Macronutrients Intake	105
4.3.7 Assessment of EI using the DLW Method	106
4.3.8 Recommended Relative Daily CHO Intakes	107
4.3.9 Statistical Analysis	107

4.4 Results	108
4.4.1 Quantification of Daily and Accumulative Weekly Load (n = 7)	108
4.4.2 TDEE, Resting Metabolic Rate and Physical Activity Level (n = 9)	114
4.4.3 Correlation between TDEE and Accumulative Load (n = 7)	117
4.4.4 Self-reported energy and macronutrient intake via RFPM (n = 9)	118
4.4.5 DLW Derived EI Versus RFPM	120
4.4.6 Recommended Relative Daily CHO Intakes	121
4.5 Discussion	122
Chapter 5	130
Energy requirements of injured soccer players: a doubly labelled water case series from the English Premier League	130
5.1 Abstract	131
5.2 Introduction	132
5.3 Methods	134
5.3.1 Presentation of the Participants	134
5.3.2 Study Design	135
5.3.3 Measurement of TDEE via DLW	138
5.3.4 Nutritional supplementation protocols	139
5.3.5 Rehabilitation exercise programme	140
5.4 Results	142
5.4.1 Player 1	142
5.4.2 Player 2	145
5.5 Discussion	147
Chapter 6	152
An evaluation of dietary practices of English Premier League soccer players using a behavioural change science framework	152
6.1 Abstract	153
6.2 Introduction	154
6.3 Methods	158
6.3.1 Participants	158
6.3.2 Study Design	158
6.3.3 Quantification of energy and macronutrient intakes	160
6.3.4 Dietary Behaviours Interview	161
6.3.5 Statistical Analysis	162
6.4 Results	162

6.4.1 Self-report energy and macronutrient intakes.....	162
6.4.2 Distribution of Macronutrients Across Meals	165
6.4.3 COM-B Analysis of each mealtime	168
6.5 Discussion	183
Chapter 7	192
The rules of the game: towards a theory of practice for performance nutritionists in professional soccer using Bourdieu’s concepts of Habitus, Capital and Field	192
7.1 Abstract	193
7.2 Introduction.....	194
7.3 Methods	196
7.3.1 Research philosophy and positionality	196
7.3.2 Participants	197
7.3.3 Procedures	198
7.3.4 Data Analysis.....	204
7.3.5 Methodological Trustworthiness and Rigour	205
7.4 Results and Discussion	205
7.4.1 Field: a successful performance nutritionist must understand the rules of the game.....	207
7.4.2 Capital: A successful performance nutritionist must have sufficient technical knowledge (cultural capital) but also the ability to build relationships (social capital).....	212
7.4.3 Habitus: The success of a nutritionist is dependent on their ability to accumulate capitals and is shaped by their habitus.	218
7.5 Practical Implications and Future Research Directions	224
7.6 Conclusion	228
Chapter 8	229
Synthesis of Findings	229
8.1 Achievement of thesis aims and objectives	230
8.2 General discussion of findings	234
8.2.1 Audit of the CHO Literature in Soccer	234
8.2.2 Nutrition Culture in Professional Soccer	235
8.2.3 Total Daily Energy Expenditure	237
8.2.4 Energy and Macronutrients Intake	239
8.2.5 Enablers and Barriers to Dietary Intake.....	241
8.2.6 Energy Expenditure and Dietary Intake of Injured Players.....	243
8.2.7 Theory of Practice for Performance Nutritionists.....	244
8.3 Limitations.....	246

8.3.1 Study 1 (Chapter 2)	247
8.3.2 Studies 2 & 6 (Chapters 3 & 7)	247
8.3.3 Studies 3, 4 and 5 (Chapters 4, 5 and 6)	247
8.3.4 Studies 3 & 4 (Chapters 4 & 5)	248
8.4 Recommendations for further research	248
8.5 Summary	250
Chapter 9	252
References	252

Abbreviations

1GW	One-game-per-week
2GW	Two-game-per-week
² H	Deuterium
¹⁸ O	Oxygen-18
95%CI	Ninety-five Percent Confidence Interval
ACC	Acceleration
ACL	Anterior Cruciate Ligament
ATT	Attacker
BCT	Behaviour Change Technique
BM	Body Mass
CASES	Chartered Association of Sport and Exercise Sciences
CHO	Carbohydrate
COM-B	Capability-Opportunity-Motivation and Behaviour Model
DEC	Deceleration
DEF	Defender
DHA	Docosahexaenoic Acid
DLW	Doubly Labelled Water
DXA	Dual-energy X-ray Absorptiometry
EI	Energy Intake
EPA	Eicosapentaenoic Acid
EPL	English Premier League
ES	Effect Size
FFM	Fat Free Mass
FFSTM	Fat Free Soft Tissue Mass
FIFA	Fédération Internationale de Football Association
FODMAP	Fermentable Oligo-, Di-, and Mono-saccharides and Polyols
FWB	Full Weight Bearing
GK	Goalkeeper
GPS	Global Positioning System
HSR	High Speed Running
IF	Impact Factor
IQR	Interquartile Range
LBM	Lean Body Mass
MID	Midfielder
MD-1	The Day Before the Match
MD	Match Day
MD+1	The Day After the Match
MDT	Multidisciplinary
NCAA	National Collegiate Athletics Association
PAL	Physical Activity Level
PRISMA-ScR	Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for scoping review
PWB	Partial Weight Bearing
RFPM	Remote Food Photography Method

RMR	Resting Metabolic Rate
RMS-SD	Root Mean Squared Standard Deviations
SD	Standard Deviation
SEnr	Sport and Exercise Nutrition Register
SRQR	Standard for Reporting Qualitative Research
SSSM	Sports Science and Sports Medicine
TDEE	Total Daily Energy Expenditure
UEFA	The Union of European Football Association

List of Figures

Figure 1. PRISMA-ScR flowchart illustrating the different phases of the search and study selection 40

Figure 2. Histogram of yearly publication rate of all included studies (A) and the proportion of the types of studies included (B)..... 44

Figure 3. The total number of male and female participants (A) and the total number of adult and adolescent participants (B) in experimental and observational studies. 46

Figure 4. The proportion of participants in each athletic tier within observational and experimental studies. 49

Figure 5. Proportion of studies within each athletic calibre for each research topic in observational studies (A) and experimental studies (B)..... 50

Figure 6. Schematic overview of data collection period..... 102

Figure 7. Daily training and match load variables for duration (A), average speed (B), total distance (C), HSR distance (D), sprint distance (E), acceleration (F) and deceleration (G). *Indicates match days (day 2 in 1GW, days 2 and 6 in 2GW). 112

Figure 8. Accumulative weekly training and match load variables completed in the testing period for duration (A), total distance (B), HSR distance (C), sprint distance (D), total accelerations (E), total decelerations (F) and average speed (G). ^aSignificant difference in total weekly accumulative external load between 1GW and 2GW ($p < 0.05$). ^bSignificant difference in weekly accumulative training load between 1GW and 2GW ($p < 0.05$). ^cSignificant difference in weekly accumulative match load between 1GW and 2GW ($p < 0.05$)..... 114

Figure 9. Absolute (A) and relative (B) TDEE for 1GW, 2GW and overall data collection period. Black dots represent individual data points. 117

Figure 10. Self-reported mean absolute and relative energy (A & B), absolute and relative carbohydrate (C & D), absolute and relative protein (E & F) and absolute and relative fat (G & H) intakes on MD-1, MD, MD+1 and training day. *Significantly higher on MD than MD-1, MD+1 and training day ($p < 0.05$)..... 120

Figure 11. Estimated daily EI using the RFPM and DLW method (A), the strength of association between DLW and RFPM EI measurements (B), estimated EB using the RFPM and DLW method (C), and change in BM during the DLW derived EI assessment period (D). *Significant difference between methods ($p < 0.05$)..... 121

Figure 12. Overview of study design for Player 1 (A) and Player 2 (B).	138
Figure 13. Changes in total (a) leg FFSTM, (b) leg fat mass, (c) trunk FFSTM, (d) trunk fat mass, (e) arm FFSTM and (f) arm fat mass throughout the rehabilitation.	144
Figure 14. Total daily energy expenditure of the player during full fitness, partial weight bearing and full weight bearing phases (A) and body mass changes observed throughout the rehabilitation process (B).	146
Figure 15. Self-reported mean absolute and relative energy (A & B), absolute and relative carbohydrate (C & D), absolute and relative protein (E & F) and absolute and relative fat (G & H) intakes on MD-1, MD, MD+1 and training day. ^a Significantly higher on MD-1 than MD+1 and training day ($p < 0.05$). ^b Significantly lower on MD than MD-1.	165
Figure 16. Relative carbohydrate, protein and fat intake meal distribution on training days (A, E, I), MD-1 (B, F, J), MD (C, G, K) and MD+1 (D, H, L).	167
Figure 17. Frequency analysis of each component of COM-B at each mealtime on training days from the perspective of players.....	180
Figure 18. Frequency analysis of each component of COM-B at each mealtime on MD-1 from the perspective of players.	181
Figure 19. Frequency analysis of each component of COM-B at each mealtime on MD from the perspective of players.	182
Figure 20. Frequency analysis of each component of COM-B at each mealtime on MD+1 from the perspective of players.....	183
Figure 21. Towards a theory of practice for performance nutrition in professional soccer. How practitioners practice (hence the nature of practice and associated service provision) is dependent on their habitus, accumulated capitals and how they navigate and present themselves within a given field. In this context, a habitus that is characterised by the ability to go above and beyond is more likely to increase the accumulation of both cultural capital and social capitals. In turn, both habitus and capitals can subsequently determine a practitioner’s ability to understand the rules of the game, thereby informing how they navigate the social hierarchies that exist within the field (i.e. survive and thrive). In considering this theory of practice, it is noteworthy that a specific nutritionist may practice differently (and indeed be perceived to have different success) according to whichever field they are working in. For example, how one practices within a soccer environment may look and feel very different to how they would practice within other team sports (e.g. rugby, basketball	

etc), endurance sports (e.g. running or cycling etc) or weight sensitive sports (e.g. combat sports, gymnastics etc). Furthermore, to be perceived as successful in each of these sports (according to the relevant athletes, coaches and stakeholders), nutritionists may need therefore to present with a different habitus, accumulated capitals and an appreciation of the rules of the game (i.e. the cultural nuances and social dynamics within a given sporting field)..... 206

List of Tables

Table 1. Participant classification framework in soccer.	41
Table 2. Frequency of research topics within all types of research.....	51
Table 3. Players' interview guide and aims.....	71
Table 4. Baseline characteristics of the participants.....	101
Table 5: Individual accumulative training and match duration.....	114
Table 6. Individual data including BM at baseline, change in BM during the data collection period, TDEE, EI measured using the RFPM, estimated EI using the DLW method, delta difference between both EI methods, percentage difference and percentage error with the DLW method assumed to be the true value. Recommended individual CHO intakes are also suggested for each player in an attempt to match energy requirements and energy balance, assuming a daily protein intake of $1.6 \text{ g} \cdot \text{kg BM}^{-1} \cdot \text{day}^{-1}$ and dietary fat intake equivalent to 30% of total daily EI.	116
Table 7. Physical characteristics of Players 1 and 2.....	134
Table 8. Dietary intake and exercise program performed by Player 1 during the data collection period.	140
Table 9. Dietary intake and exercise program performed by Player 2 during the data collection period. OKC = open kinetic chain, CKC = close kinetic chain, DB = dumbbell, SA = single arm, FT = functional trainer.	141
Table 10. Example schedule of a professional soccer player on a training day, MD-1, MD and MD+1.....	159
Table 11. COM-B analysis for all the meals on training days.....	175
Table 12. COM-B analysis of meals on MD-1.....	176
Table 13. COM-B Analysis on MD.....	177
Table 14. COM-B Analysis of MD+1.	178
Table 15. Interview guide and aims for performance and non-performance staff.	200
Table 16. Interview guide and aims for coaches.	201
Table 17. Interview guide and aims for players.	202

Chapter 1

General Introduction

The aim of this General Introduction is to provide an overview and introduction to the relevant research areas, thereby establishing the rationale for the aims and objectives of this thesis.

1.1 Background

Soccer is the world's most popular sport, with an estimated 3.5 billion of fans globally (Society, 2025). It is also the most extensively studied sport, with over 14,000 citations listed on PubMed in 2020 and nearly 60% more publications than the next most researched sport (Kirkendall, 2020). Sports nutrition research in soccer perhaps originated in 1973 when Professor Bengt Saltin demonstrated that starting a soccer match with low muscle glycogen significantly reduced the total distance covered and distance at maximal speed (Saltin, 1973). This seminal work catalysed further investigation and the development of the first nutrition guidelines for elite soccer players in 1994 (Clark, 1994), later updated in 2006 (Burke et al., 2006). More recently, the Union of European Football Association (UEFA) published a comprehensive expert group statement on nutrition in elite soccer (Collins et al., 2021). However, the evidence base underpinning these recommendations remains limited, particularly regarding randomised controlled trials conducted in elite players. Consequently, much of the guidance reflects a synthesis of existing data and practitioner experience. Indeed, recent analyses indicate that fewer than 10% of sports nutrition studies have involved world class or elite athletes (Burke et al., 2025). Therefore, there is a clear need to evaluate the current research landscape in soccer nutrition to identify gaps and inform the development of evidence-based guidelines for elite players.

Beyond evaluating the current sports nutrition research landscape in soccer, it is equally important to understand the cultural context in which players' nutritional behaviours are shaped. Professional soccer is a unique social environment with shared norms, beliefs and hierarchies that influence how players perceive and engage with nutrition, helping explain why they often fail to meet

evidence-based guidelines (Steffl et al., 2019; Danielik et al., 2022). Bourdieu's framework provides a useful lens for interpreting these dynamics, showing how habitus, capital and field interact to influence dietary behaviours (Bourdieu, 1990). Habitus, defined as internal disposition formed through early experiences (Bourdieu, 1984), helps explain why players' cultural backgrounds influence their food choices (Ono et al., 2012), while different forms of capitals including economic (e.g. money and resources), social (e.g. network and relationships) and cultural (e.g. nutrition knowledge), further determine players' engagement with optimal nutrition practices (Noronha et al., 2020; Carter et al., 2023b; Costello et al., 2025). Within the field of professional soccer, dominant beliefs such as emphasis on body composition may reinforce restrictive or maladaptive eating behaviours (McHaffie et al., 2022). Although Ono et al. (2012) identified the role of habitus in shaping dietary behaviours, the concepts of capital and field were not explored. Furthermore, these researchers explored nutrition culture during the 2006/07 and 2007/08 seasons and performance nutrition service provision has evolved considerably since then due to the English Premier League (EPL)'s increasing international diversity (CIES Football Observatory, 2024), rising financial resources (Deloitte Football Money League, 2024) and the growth of sport science and medicine. Managers once sceptical of performance nutrition support (Ono et al., 2012), now acknowledge its values (Wenger, 2021) and performance nutritionists, previously scarce, are now fully integrated into multidisciplinary teams (Meyer, 2021). Consequently, there is a need to examine the current nutrition culture in professional soccer to inform the development of culturally attuned nutritional strategies.

Before implementing nutritional strategies for professional soccer players, it is essential to first establish their energy requirements. During the 2015/16 season, it was first reported that EPL

players had a mean total daily energy expenditure (TDEE) of $3566 \pm 585 \text{ kcal}\cdot\text{day}^{-1}$ during a two-game-per-week microcycle (Anderson et al., 2017b). In the same season, Brinkmans et al. (2019) demonstrated a lower TDEE of $3285 \pm 354 \text{ kcal}\cdot\text{day}^{-1}$ in Dutch Eredivise players. However, these data are a decade old, and the match demands of elite soccer have evolved drastically since then. For instance, between the 2014/15 and 2018/19 seasons, high speed running (HSR) and sprint distances increased significantly by $\sim 12\%$ and $\sim 15\%$, respectively (Allen et al., 2024). Further increase in total distance, HSR and sprint distances from 2018/19 to 2024/25 seasons in EPL have been recently reported (Allen et al., 2025). Beyond the energy requirements of “fit” players (i.e. non-injured players), it is also important to understand the energy needs during rehabilitation. To date, only one study has quantified TDEE using the doubly labelled water (DLW) method, reporting $3178 \text{ kcal}\cdot\text{day}^{-1}$ six weeks after anterior cruciate ligament (ACL) injury (Anderson et al., 2019a). Despite the increased global research trends in sports nutrition and soccer over the past 20 years (De Oliveira et al., 2025), applied research at the elite level remains limited. Updated evidence is therefore required to inform nutritional guidelines for elite soccer players.

In addition to advancing the knowledge of nutritional requirements in elite soccer, there is a clear need to translate existing evidence into practice, as players’ habitual diets consistently fall short of recommendations. While dietary protein and fat intake are typically adequate, carbohydrate (CHO) is frequently insufficient (Steffl et al., 2019; Danielik et al., 2022). Among EPL soccer players, inadequate CHO intakes has been reported on the day before the match (MD-1), the day following the match (MD+1) and during post-match recovery period (Anderson et al., 2017a; b), which has been associated with reductions in total distance covered and average speed in subsequent matches (Ermidis et al., 2024). In-match CHO consumption is also below recommended levels (Kasper et

al., 2024), despite strong evidence that CHO ingestion enhances soccer-specific performance outcomes, including dribbling speed (Harper et al., 2017), passing accuracy (Rodriguez-Giustiniani et al., 2019) and high intensity intermittent running capacity (Foskett et al., 2008). The reasons underpinning poor adherence to nutritional guidelines among elite players are likely multifactorial (Pelly et al., 2022). Behaviour change frameworks such as the COM-B model (Michie et al., 2011) provide a useful lens for understanding these determinants, encompassing the psychological (e.g. knowledge) and physical (e.g. skills) capability, physical (e.g. time, resources, environments) and social (e.g. interpersonal influences and cultural norms) opportunity, and reflective (e.g. beliefs and values) and automatic (e.g. wants and impulses) motivation. From practitioners' perspectives, limited influence on players' dietary behaviours, scepticism about CHO and body composition recommendations and restricted autonomy when delivering nutrition support have been identified as key barriers to implementing UEFA recommendations within the EPL (Costello et al., 2025). However, the specific enablers and barriers affecting EPL players' adherence to nutritional guidelines have yet to be explored from the players' own perspectives.

While it is important to understand the factors that shape the dietary practices of professional soccer players, achieving optimal behaviour change ultimately depends on the quality of performance nutrition delivery by the practitioners. From athletes' perspectives, effective nutritionists are seen as approachable and non-judgemental (Bentley et al., 2021) and successful practitioners demonstrate adaptability, empathy, trustworthiness and strong technical expertise (Rosimus, 2021). In professional soccer specifically, the most critical attribute appears to be the ability to grasp the unique culture of the sport and build meaningful relationships with players and coaches (Burns et al., 2024a). Indeed, according to Bourdieu's framework, practice is shaped by

the interaction between an individual disposition (habitus) and their position within the social environment (capital), within the current state of play of that field: (habitus x capital) + field = practice (Bourdieu and Nice, 1980). Therefore, to develop a grounded theory of practice for performance nutritionist operating in professional soccer, it is essential to understand which forms of habitus and capital are valued by key stakeholders including players, coaches, medical and performance staff.

1.2 Aim and objectives of this thesis

The aim of this thesis is:

To advance performance nutrition guidelines and practice in professional soccer by improving understanding of the research and cultural landscape, refining knowledge of players' nutritional requirements and developing a theory of practice to support practitioners in elite soccer.

This will be achieved through the following objectives:

1. To conduct a scoping review and research audit of the literature (both reviews and original research) with relevance to soccer-specific guidelines for CHO intake (Chapter 2).
2. To qualitatively explore professional soccer players' perspectives of the nutrition culture within the EPL based on Bourdieu's concepts of habitus, capital and field (Chapter 3).
3. To determine the TDEE, dietary intake and external physical load of male EPL players during 1GW and 2GW microcycles (Chapter 4).

4. To examine the TDEE and EI in elite EPL soccer players during two distinct phases of rehabilitation: the initial two weeks post hamstring injury and the transition from PWB to FWB during rectus femoris injury rehabilitation (Chapter 5).
5. To quantify the energy and macronutrient intake and distribution across meals on training days, MD-1, MD and MD+1; and to apply the COM-B model as a framework to explore the factors underpinning the dietary behaviours of EPL male players (Chapter 6).
6. To qualitatively explore the perspectives of professional players and key stakeholders on their perceptions of what defines a successful performance nutritionist practicing in the EPL (Chapter 7).

Chapter 2

Fuelling soccer players: a scoping review and audit of literature related to soccer-specific guidelines for carbohydrate intake

The aim of this Chapter was to conduct a scoping review and research audit of the literature (both reviews and original research) with relevance to soccer-specific guidelines for CHO intake.

This study was published in Sports Medicine in 2025.

Foo, W.L., Tester, E., Close, G.L., Areta, J.L. and Morton, J.P. (2025) Fuelling Soccer Players: A Scoping Review and Audit of Literature Related to Soccer-Specific Guidelines for Carbohydrate Intake. *Sports Medicine*,55, pp. 1467-1485.

2.1 Abstract

Purpose: The aim of this study was to identify the gaps in the existing literature that inform CHO guidelines for soccer players.

Methods: A scoping review was conducted without date restrictions up to 21 March 2024, employing a three-step search strategy to identify relevant English-language primary and secondary articles through PubMed and reference searching. Data were extracted using a standardized audit tool from studies assessing direct and indirect impacts of CHO on soccer players' performance and health.

Results: Within 258 studies identified, experimental studies were the most common (~36%), followed by observational (~33%) and narrative reviews (~26%) with systematic reviews, meta-analyses and case studies making up the rest (~5%). Most observational studies were field-based (~98%), while experimental studies were laboratory-based (~75%). Among 4475 participants, ~16% were female, and only ~12% of the original research was exclusively conducted on female players. Observational studies included developmental (~52%) and professional players (~31%) whereas experimental studies primarily featured recreationally active (~40%) and collegiate/university participants (~26%). Key research topics were “dietary intake” (~52%) and “energy expenditure and dietary intake” (~30%) for observational studies, and “CHO interventions” (~74%) for experimental studies. Only 8 experimental studies exclusively involved professional players, focusing on CHO intervention (n = 7) and CHO co-ingestion (n = 1). Narrative reviews were published in journals with higher impact factor (4.1 ± 6.4) than observational studies (3.2 ± 1.6 , $p < 0.001$) and experimental studies (3.4 ± 1.6 , $p < 0.001$). Narrative reviews had the most studies with Altmetric scores ≥ 20 (n = 26), followed by experimental (n = 16) and observational studies (n = 14).

Conclusion: Current CHO guidelines for elite soccer players lack experimental research specific to professional and world class players. More field-based experimental trials involving elite soccer players are required to ensure evidence-based CHO recommendations.

2.2 Introduction

In 1973, the late Professor Bengt Saltin published the first data evaluating the effects of muscle glycogen availability on soccer-specific performance (Saltin, 1973). These data demonstrated that players ($n = 5$) who commenced the match with low muscle glycogen covered less total distance (9700 m vs 12000 m), particularly in the second half (4100 m vs 5900 m), spent more time walking (50% vs 27%) and less time sprinting (15% vs 24%) than players with high muscle glycogen ($n = 4$). Such seminal data paved the way for the development of soccer-specific sport nutrition guidelines and in the 50 years since, the research base with application to intermittent exercise and soccer has grown considerably.

In one of the earliest nutritional guidelines published in 1994, soccer players were advised to maintain a diet comprising 55-65% CHO on training days, with a specific recommendation to consume between 7 to 10 $\text{g}\cdot\text{kg}^{-1}\text{BM}\cdot\text{day}^{-1}$ to optimize glycogen stores ahead of a game (Clark, 1994). In 2006, players received more nuanced guidance, suggesting a recommended range of 5 to 7 $\text{g}\cdot\text{kg}^{-1}\text{BM}\cdot\text{day}^{-1}$ CHO on moderate training days and up to 12 $\text{g}\cdot\text{kg}^{-1}\text{BM}\cdot\text{day}^{-1}$ CHO on intense training days or when preparing for a match (Burke et al., 2006). The most recent nutritional guidelines for soccer players were subsequently published in 2020, in an expert led group statement (comprising 31 authors with both research and applied practitioner experience) that was endorsed by the UEFA (Collins et al., 2021). In this latest statement, a recommended range of

daily CHO intake of 3 to 8 g·kg⁻¹BM·day⁻¹ was suggested, emphasizing that daily CHO intake should also be adjusted day-by-day in accordance with the training demands, fixture schedule and any player specific objectives.

Despite the publication of these recommendations, the evidence underpinning current guidelines remains uncertain, particularly in relation to randomised controlled trials in elite players. It has been suggested that the publication of such recommendations was based on a combination of interpretation of available data but also practitioner experience when working with elite players. Such a critique of the literature is not unique to soccer and indeed, has also been recognized in the wider context of “sport nutrition” guidelines in general (Jonvik et al., 2022). Indeed, there has been a notable shift in research focus over the last five years, with greater emphasis on reviews rather than original research in sports nutrition (Jonvik et al., 2022). For example, ~20% of published articles have been reviews, ~6% being meta-analyses. Although reviews provide valuable synthesis, they carry the risk of biased interpretation and potential distortion of original information through repeated paraphrasing (Agarwal et al., 2023). Thus, the significance of continuing original research in advancing the field cannot be overstated. Consequently, much of the practical application of sport-specific nutritional guidelines (especially in the context of soccer) is left to the individual interpretation of those practitioners operating in the field. For instance, the current CHO guidelines for soccer players, recommending 3 to 8 g·kg⁻¹BM·day⁻¹, encompass a wide range that includes both low and high CHO intakes. This approach essentially leaves it to the discretion of the nutritionist to determine the appropriate amount for each player. Furthermore, assessments of dietary intakes of players (albeit self-reported) continue to highlight that players do not readily meet recommended CHO intakes especially in preparation for match play (Steffl et

al., 2019), likely due to a combination of complex factors including athlete and stakeholder education, beliefs and the wider nutrition culture of the specific environment (Ono et al., 2012; McHaffie et al., 2022; Carney et al., 2024).

In an attempt to better inform evidence-based soccer-specific nutrition guidelines, the aim of the present study was to conduct a scoping review and research audit of the literature (both reviews and original research) with relevance to soccer-specific guidelines for CHO intake. To this end, we used a well-established scoping review framework (Arksey and O'Malley, 2005), combined with a recently published research audit methodology (Smith et al., 2022a) to perform an extensive audit of literature pertaining to adult male, female and junior soccer players. Importantly, this review identifies gaps in the literature and presents those research areas with the greatest scope to inform practice. In this way, it is hoped that the present paper stimulates concerted and collaborative research worldwide to ensure that future soccer specific nutrition guidelines are supported by a stronger research base.

2.3 Methods

The scoping review followed the well-established five stages framework as suggested by Arksey and O'Malley (Arksey and O'Malley, 2005), integrating the audit protocol from Smith et al. (2022a). Information specific to the current review is detailed below:

2.3.1 Stage 1: Identification of the Research Question

Considering the context, a broad research question was decided upon:

“What are the key gaps in the existing body of research that inform carbohydrate guidelines for soccer players, considering different study designs, competitive levels, research themes and demographic groups?”

2.3.2 Stage 2: Identification of Relevant Studies

The following inclusion and exclusion criteria were established through discussion between the author group.

2.3.2.1 Inclusion Criteria

- All age groups and both female and male participants.
- Research articles are not limited by geographical location or setting.
- Published in English language.
- Full text links are available.
- Any levels of soccer (e.g. sedentary, recreationally active, collegiate/university, developmental, semi-professional, professional and world class).
- Direct measurements of performance or health parameters, and indirect contributions/markers of performance/health.
- Research published without date restrictions and current to 21 March 2024.
- Sources of information – including primary and secondary research studies, reviews, systematic reviews, scoping reviews, case studies, meta-analyses and guidelines.

2.3.2.2 Exclusion Criteria

- ≥ 50 years of age.
- Presence of lifestyle diseases (e.g., obesity, hypertension, diabetes) or smoking.
- Failure to investigate CHO or CHO-related markers as the primary outcome/independent variable.
- Outcomes irrelevant to areas of interest.
- Grey literature (i.e. unpublished and ongoing trials, annual reports, dissertations and conference proceedings).

2.3.2.3 Search Strategies and Database

The search strategy aimed to discover published studies. An electronic literature search of PubMed was conducted using the terms: “(Carbohydrate OR Glycogen OR Glucose OR Sugar) AND (Soccer OR Football OR Team Sports OR Intermittent Running) NOT (Diabetes)”. Following the initial search, the reference lists of all included articles were screened for further relevant papers that were not detected in the primary search.

2.3.3 Stage 3: Study Selection

Following the search, all identified citations were collated and duplicates removed. The titles, abstracts and reference lists of each study were examined to identify the relevant studies. Potentially relevant sources were retrieved in full. Full studies were subsequently screened for their relevance to the selection criteria. Secondary reviewer completed the same process on a random sample of 10% of the titles with concordance $>97\%$. Where a decision was not reached at

any stage of the selection process, it was resolved through discussion. The results of this search and study inclusion process are reported in full in the final scoping review and are presented in a Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for scoping review (PRISMA-ScR) flow diagram (Figure 1) (Tricco et al., 2018).

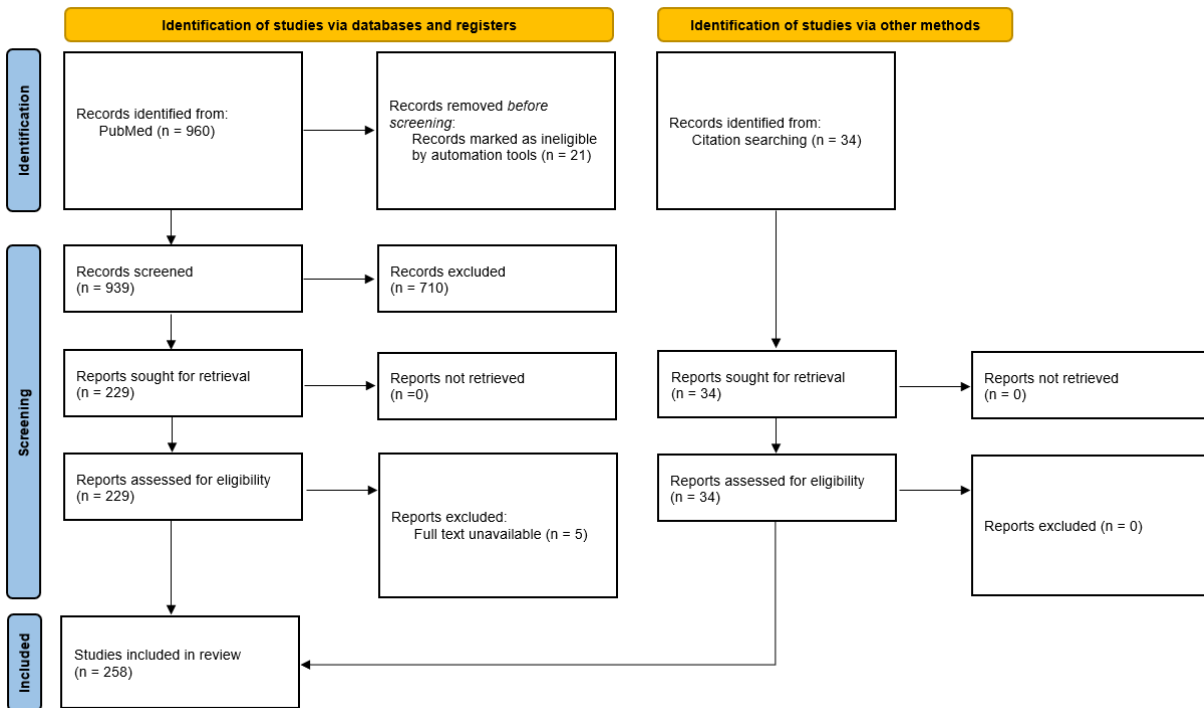


Figure 1. PRISMA-ScR flowchart illustrating the different phases of the search and study selection

2.3.4 Stage 4: Charting the Data

Charting tables to record and collect extracted data from included studies were developed. The lead reviewer conducted the data extraction process, systematically collecting information to a predefined template. Secondary reviewer cross-verified 10% of lead reviewer's data extraction to ensure accuracy and reliability. Any discrepancies were resolved through discussion. This structured approach to data extraction was facilitated through a comprehensive datasheet that encompassed all details and essential information. With the use of the protocol outlined in Smith

et al. (2022a), details of the following metrics were extracted: a) research types: review (narrative), review (systematic), review (meta-analysis), observational, experimental/clinical trials and case studies; b) research settings: field or laboratory-based; c) participants demographics: sex (male or female), age groups (adults – aged ≥ 18 years old or adolescents – aged 10-17 years old); d) athletic calibre (Table 1): sedentary, recreationally active, collegiate, developmental, semi-professional, professional and world class; e) research topics; f) journal publications dates and study impact (Altmetric scores and journal impact factor (IF)); g) mean sample size. In the present review, it was not appropriate to exclude sedentary participants due to the relevance of mechanistic studies not requiring an exercise condition. Studies involving separate investigations were included in the audit and their metrics counted separately.

Table 1. Participant classification framework in soccer.

Competitive Level	Descriptions
World Class	World class players include the most competitive soccer players competing in the most exclusive soccer leagues. World-Class players are usually “starters” for the top teams in the top five leagues in the world and/or the “starters” for top 10 ranked national soccer team in the world. Men: English Premier League, Serie A, La Liga, Bundesliga, Ligue 1 Women: Women’s Super League, Liga F, Division 1 Féminine, Frauen-Bundesliga, National Women’s Soccer League
Professional	Professional players include players competing in a professional league with a full-time contract.
Semi Professional	Semi-professional players include players who are not full-time but still receive regular payments from the club.
Collegiate/University	Players compete in university soccer teams; varsity teams and National Collegiate Athletics Association (NCAA)
Developmental	Participants in the academy or “second team” of professional soccer clubs.

Recreationally Active	Meet World Health Organization minimum activity guidelines: Adults aged 18-64 years old competing at least 150 to 300 min moderate-intensity activity or 75-150 min of vigorous-intensity activity a week, plus muscle-strengthening activities 2 or more days a week (Bull et al., 2020). May participate in multiple sports/forms of activity.
Sedentary	Do not meet minimum activity guidelines. Occasional and/or incidental physical activity (e.g., walking to work, household activities).

2.3.5 Stage 5: Collating, Summarizing and Reporting the Results

Methods undertaken in the protocol by Smith et al. (2022a) permitted us to collate and audit existing knowledge on this body of literature in four different domains:

1. Study types and research settings
2. Population and sample size
3. Athletic calibre and research topics
4. Journal and study impact

In this scoping review, we aimed to (i) identify gaps in the existing literature related to CHO and soccer to guide future research directions; (ii) report and summarize existing research findings for players, practitioners and relevant stakeholders.

2.3.6 Statistical Analysis

Statistical analyses were performed using SPSS for Windows (version 29, SPSS Inc, Chicago, IL) with statistical significance accepted at α level of $p < 0.05$. Frequency-based metrics were reported as a percentage of the total studies. Histogram inspection revealed skewed distributed data for observational/experimental studies-specific sample sizes. As such, a Mann-Whitney U test was

used to compare median numbers of sample sizes in observational and experimental studies, and a Kruskal-Wallis test with a *post hoc* Dunn test was used to assess differences in IF and Altmetric scores across observational studies, experimental studies and narrative reviews. These data were reported as median \pm interquartile range (IQR).

2.4 Results

A (PRISMA-ScR) flow diagram was produced to report the results from the search and study selection process (Figure 1). Of the 960 papers identified during the initial search, 229 were included. Five papers were subsequently excluded due to unavailable full text, resulting in a final total of 224 papers included in the review following the initial screening. From the search of the reference list, an additional 34 papers were subsequently added and hence, a total of 258 papers were included (Figure 1). During the audit period spanning 1973 to 2000, the average publication rates per year for observational studies, experimental studies, and narrative reviews were 0.3, 0.6, and 0.7 studies, respectively (Figure 2A). Subsequently, between 2001 and 2010, these rates escalated to 3.1, 1.7, and 1.7 studies per year. This trend continued with even higher rates from 2011 to 2024, reaching 3.7, 4.7, and 2.3 studies per year for observational studies, experimental studies, and narrative reviews, respectively. Notably, systematic reviews, meta-analyses, and case studies only emerged in publications between 2018 and 2024.

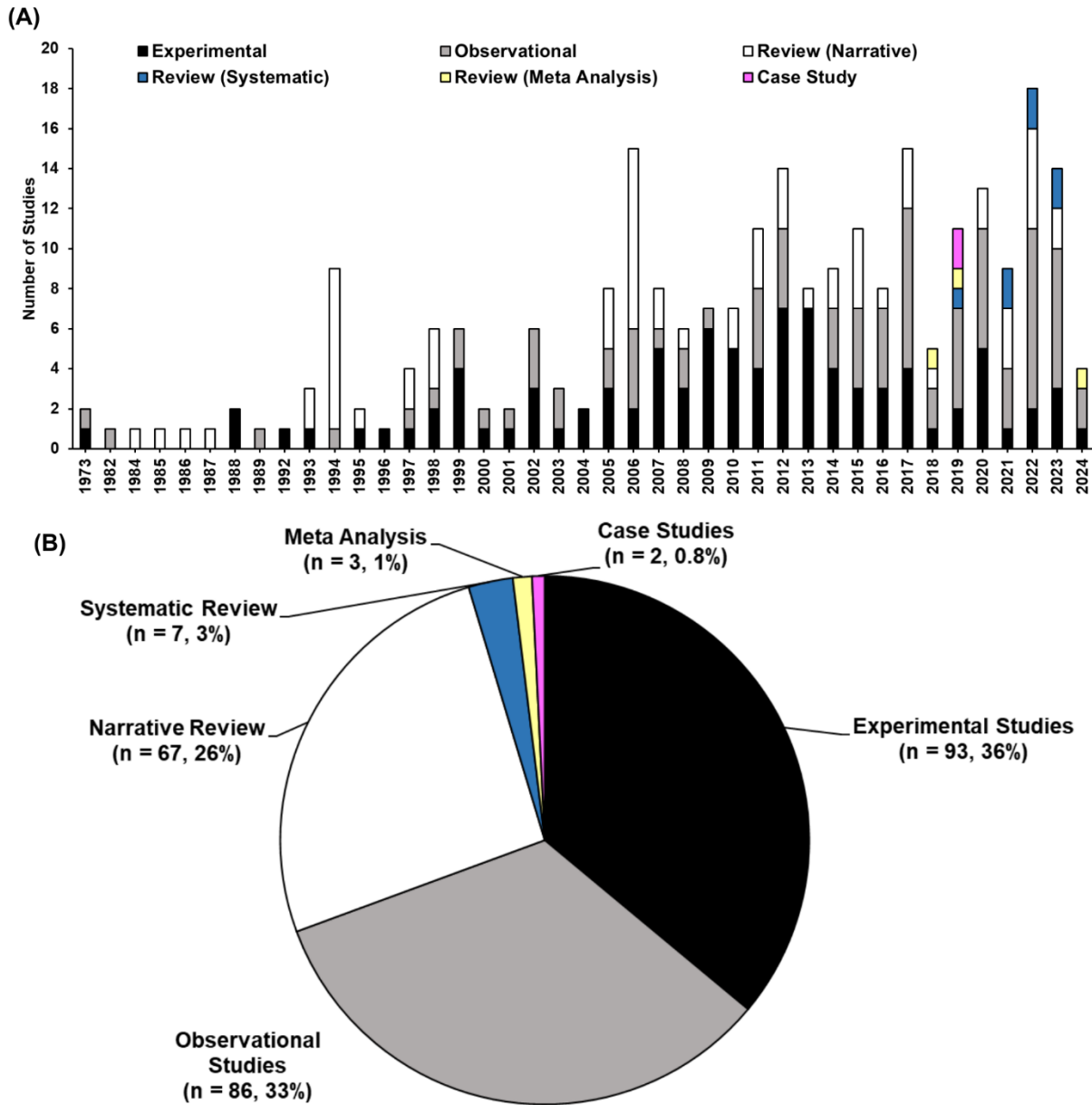


Figure 2. Histogram of yearly publication rate of all included studies (A) and the proportion of the types of studies included (B).

2.4.1 Study Types & Research Settings

Across all papers, experimental studies ($n = 93$, 36%) were the most frequently examined study types, followed by observational studies ($n = 86$, 33%) and narrative reviews ($n = 67$, 26%), (Figure 2B). Case studies ($n = 2$, 0.8%), systematic reviews ($n = 7$, 3%), and meta-analyses ($n = 3$, 1%) constituted the remainder of the studies. Notably, the majority of experimental studies were conducted in laboratory settings (75%), while most observational studies were conducted in field settings (98%).

2.4.2 Population & Sample Size

There was a total of 4475 participants, with 16% being female and 84% being male. Out of the observational, experimental and case studies analysed, 78% or 141 studies involved male-only participants, while 12% ($n = 22$) focused solely on female participants, and the remaining 10% ($n = 18$) utilized mixed sex cohorts. The majority of participants in observational studies ($n = 2597$, 83%), experimental studies ($n = 1162$, 88%), and case studies ($n = 2$, 100%) were male, with female participants accounting for only 18% ($n = 552$) and 12% ($n = 162$) in observational and experimental studies, respectively (Figure 3A). Within observational studies, adults constituted 49.8% of participants ($n = 1567$), while adolescents comprised 50.2% ($n = 1582$). Conversely, in experimental studies, adults formed most participants ($n = 996$, 75%), with only 25% being adolescents (Figure 3B). All participants in case studies were adults. Additionally, the median sample size per study within experimental studies (11 ± 8) was significantly less than observational studies (24 ± 32) ($p < 0.001$).

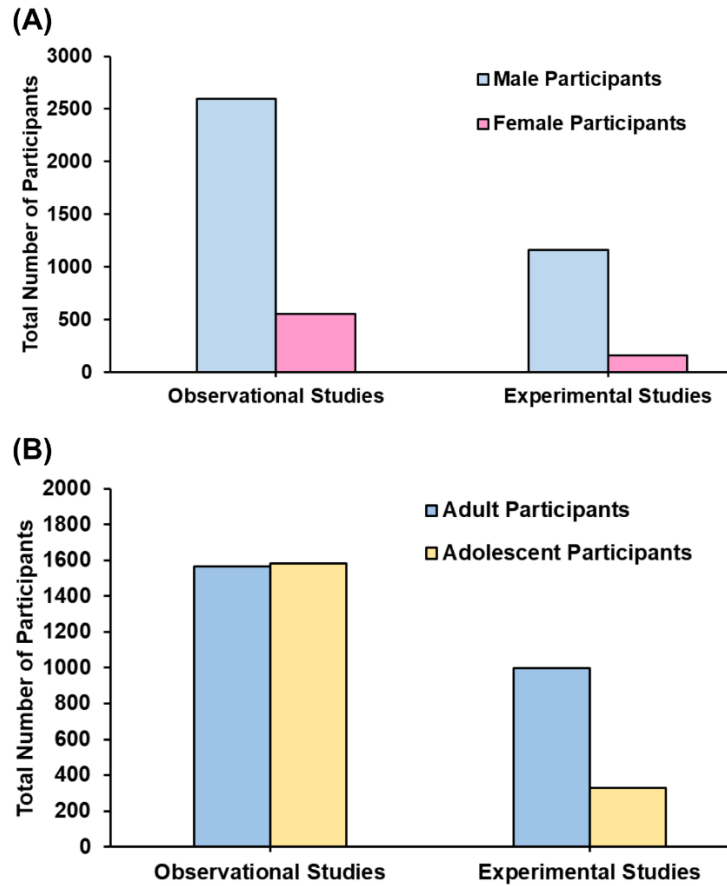


Figure 3. The total number of male and female participants (A) and the total number of adult and adolescent participants (B) in experimental and observational studies.

2.4.3 Athletic Calibre & Research Topics

In the array of studies examined, the majority of participants were categorised as developmental ($n = 1860$, 42%) and professional ($n = 1087$, 24%) players, followed by recreationally active ($n = 630$, 14%), collegiate/university ($n = 586$, 13%), semi-professional ($n = 152$, 3%), world class ($n = 84$, 2%) and sedentary participants ($n = 43$, 1%). The remaining participants were unspecified ($n = 33$, 0.7%). Figure 4 presents the athletic calibre of the participants in observational and experimental studies. A higher proportion of developmental and professional participants were

found in observational studies in comparison to experimental studies (52% vs 25%, 31% vs 10%, respectively). Conversely, experimental studies encompassed a greater representation of recreational active (40% vs 3%) and collegiate/university participants (26% vs 8%) when compared with observational studies. Similar proportions of semi-professional participants were evident in observational (3%) and experimental (5%) studies. Notably, only observational studies included world-class participants (n = 82, 3%).

In observational studies, the most investigated research topic was “dietary intake” (n = 45, 52%), followed by “energy expenditure and dietary intake” (n = 26, 30%), “muscle glycogen assessment” (n = 11, 13%), and “energy availability/balance and dietary intake” at (n = 4, 5%). The majority of studies on the topics of “dietary intake” (n = 15, 33%) and “energy expenditure and dietary intake” (n = 12, 46%) were conducted in developmental players, whereas studies on “muscle glycogen assessment” and “energy availability/balance and dietary intake” focused mainly on professional players (n = 7, 64%) and collegiate/university players (n = 3, 75%), respectively (Figure 5A). Furthermore, most studies focusing on “dietary intake” (n = 22), “energy expenditure and dietary intake” (n = 17) and “energy availability/balance and dietary intake” (n = 2) were conducted during the in-season phase, while the majority of studies on “muscle glycogen assessment” were carried out post exercise/match (n = 3) and pre, during and post exercise/match (n = 3) (Table 2).

In experimental studies, the most frequently examined topic was “CHO intervention” (n = 69, 74%), followed by “CHO co-ingestion intervention” (n = 11, 12%), “CHO mouth rinse” (n = 4,

4%), “gastric emptying” and “nutrition education” (both n = 3, 3%), “muscle glycogen assessment” (n = 2, 2%) and “menu settings” (n = 1, 1%). Most studies on these topics involved recreationally active participants, including “CHO intervention” (n = 29, 42%), “CHO Co-ingestion” (n = 6, 55%), “CHO Mouth Rinse” (n = 3, 75%), “Gastric Emptying” (n = 2, 67%) and “Muscle Glycogen Assessment” (n = 2, 100%). In contrast, studies on “nutrition education” (n = 2, 67%) and “menu settings” (n = 1, 100%) were conducted with developmental players (Figure 5B). Moreover, 58% of CHO intervention studies were carried out during exercise/match (n = 40), while “CHO co-ingestion intervention” was mainly conducted in combination with protein (n = 8) (Table 2).

In the narrative reviews, 46% of the papers were dedicated to presenting nutrition recommendations across various subjects (Figure 6). Additionally, 19% of the studies delved into metabolism/physiology, while 16% focused exclusively on CHO reviews. Other research topics covered in narrative reviews included “muscle glycogen” (n = 4, 6%), “recovery” (n = 3, 5%), “dietary intake” (n = 2, 3%), “sleep” (n = 2, 3%) and “half-time strategies” (n = 1, 2%). During the audit period, systematic reviews were conducted on seven occasions, covering the topics of “dietary intake” (n = 3), “CHO supplementation” (n = 3) and “metabolism/physiology” (n = 1). Additionally, meta-analyses were undertaken three times, focusing on muscle glycogen utilisation, dietary intake, and the impacts of CHO supplementation on mental fatigue. Lastly, case studies delved into the topics of “energy expenditure and dietary intake” and “nutrition during rehabilitation” (Table 2).

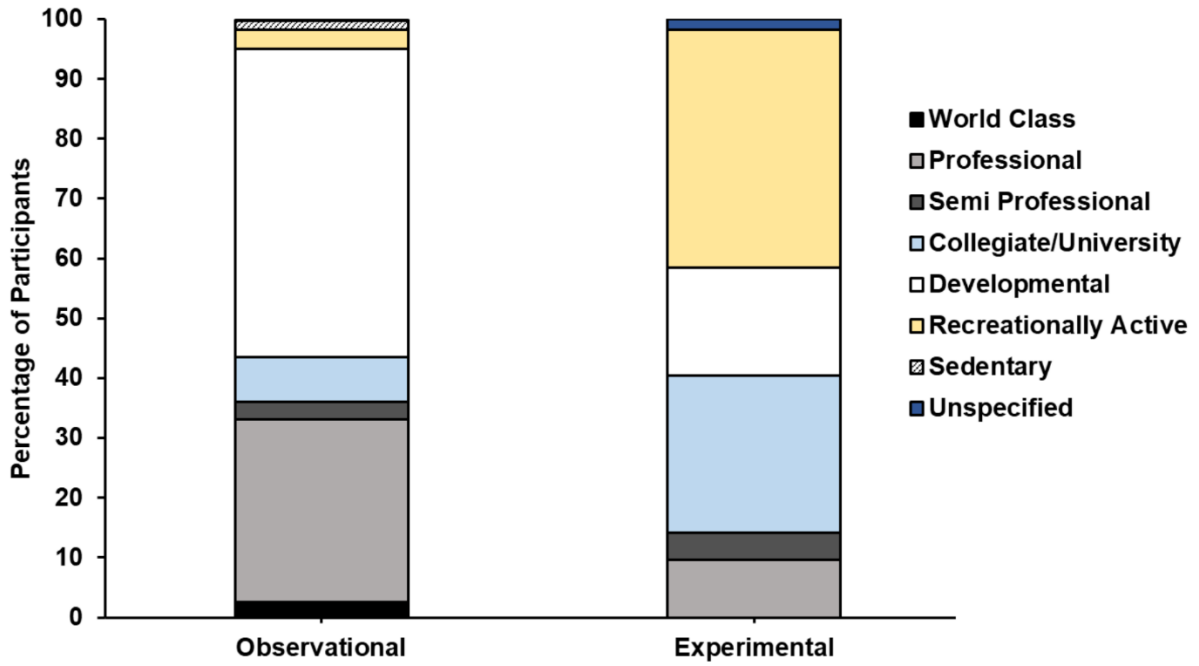


Figure 4. The proportion of participants in each athletic tier within observational and experimental studies.

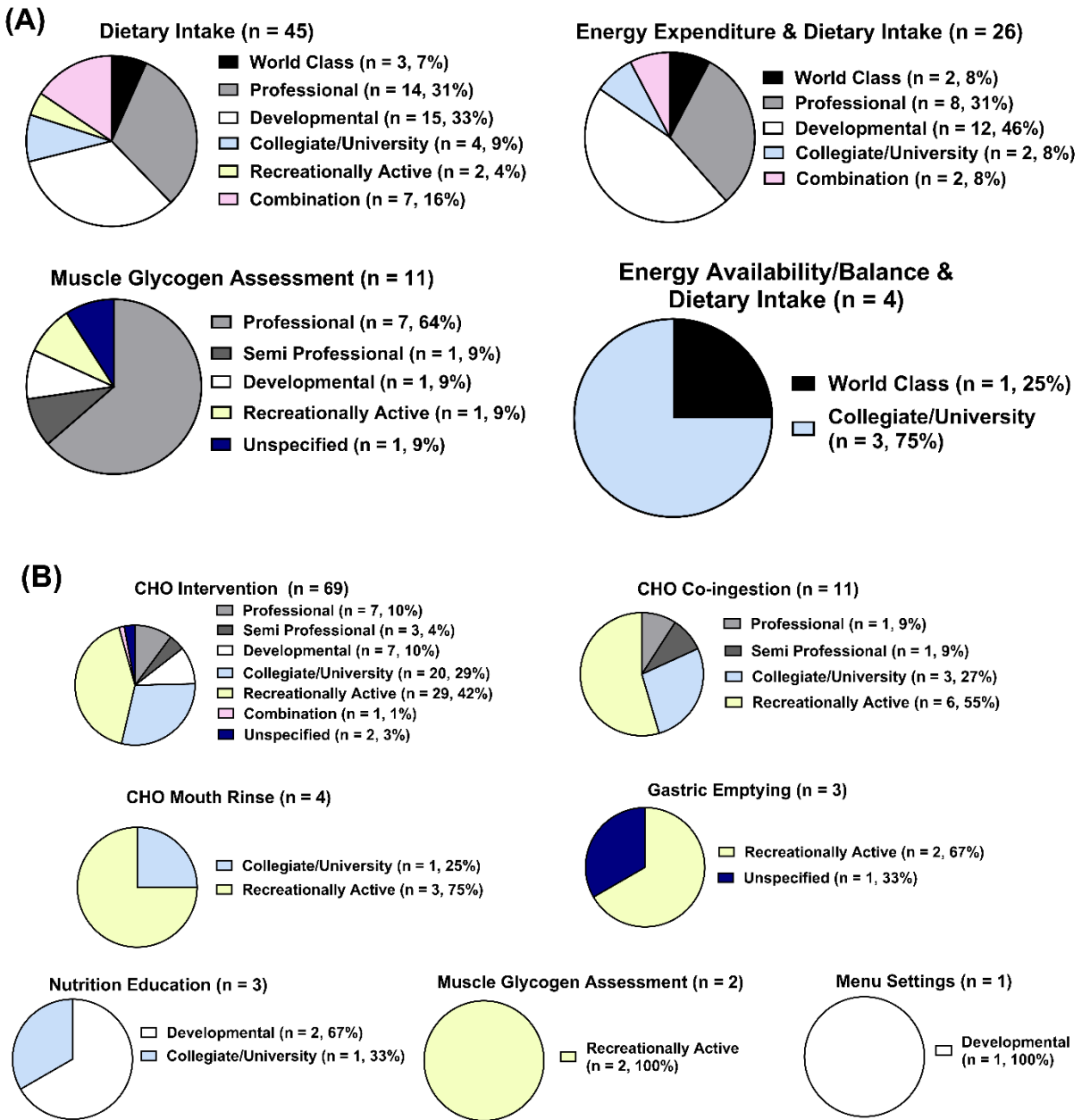


Figure 5. Proportion of studies within each athletic calibre for each research topic in observational studies (A) and experimental studies (B).

Table 2. Frequency of research topics within all types of research.

Research Types	Research Topics
Observational Studies	<p>i) Dietary intake (n = 45)</p> <ul style="list-style-type: none"> In-season (n = 22) (Rokitzki et al., 1994; Maughan, 1997; Hassapidou et al., 2000; Mullinix et al., 2003; Murphy and Jeanes, 2006; Iglesias-Gutiérrez et al., 2008, 2012; Gravina et al., 2012; Ono et al., 2012; Galanti et al., 2015; Andrews and Itsiopoulos, 2016; Bettonviel A et al., 2016; Naughton et al., 2016; Anderson et al., 2017a; Granja et al., 2017; Hosseinzadeh et al., 2017; Wardenaar et al., 2017; Macuh et al., 2022; Carter et al., 2023a; Sebastián-Rico et al., 2023; Chryssanthopoulos et al., 2024; Stables et al., 2024), unspecified (n = 7) (van Erp-Baart et al., 1989; Ruiz et al., 2005; Prado et al., 2006; Van Biervliet et al., 2011; Pilis et al., 2019; Makhafa et al., 2022; Masoga et al., 2022), pre-season (n = 5) (Noda et al., 2009; Devlin et al., 2017b; Raizel et al., 2017; Książek et al., 2020; Gomez-Hixson et al., 2022), during training (n = 2) (Rollo et al., 2021b; Tarnowski et al., 2022), seasonal changes (n = 2) (Clark et al., 2003; Devlin et al., 2017a), concurrent training (n = 1) (Enright et al., 2017), international camp (n = 1) (McHaffie et al., 2023), longitudinal (n = 1) (Leblanc et al., 2002), relationship with muscle fatigue (n = 1) (Rizal et al., 2020), Ramadan (n = 1) (Maughan et al., 2008), relationship with nutrition knowledge (n = 1) (Noronha et al., 2020), validation (n = 1) (Briggs et al., 2015b)
	<p>ii) Energy expenditure & dietary intake (n = 26)</p> <ul style="list-style-type: none"> In-season (n = 17) (Boisseau et al., 2002; Ebine et al., 2002; Iglesias-Gutiérrez et al., 2005; Martin et al., 2006; Caccialanza et al., 2007; Gibson et al., 2011; Russell and Pennock, 2011; Briggs et al., 2015a; Hidalgo y Teran Elizondo et al., 2015; Anderson et al., 2017b; Brinkmans et al., 2019, 2024; Dobrowolski and Włodarek, 2019; Yli-Piipari, 2019; Hannon et al., 2021; Dasa et al., 2023; Martinho et al., 2023; Stables et al., 2023), pre-season (n = 5) (Rico-Sanz et al., 1998; Santos et al., 2016; Cherian et al., 2018; Ersoy et al., 2019; Lee et al., 2021), unspecified (n = 2) (Baker et al., 2014a; Braun et al., 2018), international camp (n = 1) (Morehen et al., 2022)
	<p>iii) Muscle glycogen assessment (n = 11)</p> <ul style="list-style-type: none"> Post exercise/game (n = 3) (Jacobs et al., 1982; Krstrup et al., 2011; Nielsen et al., 2012), pre, during & post exercise/game (n = 3) (Saltin, 1973; Zehnder et al., 2001; Krstrup et al., 2006), during exercise/game (n = 2) (Krstrup et al., 2022; Mohr et al., 2023), pre & post exercise/game (n = 1) (Rico-Sanz et al., 1999a), at rest (n = 1) (Rico-Sanz et al., 1999b), small sided game (n = 1) (Panduro et al., 2022)
	<p>iv) Energy availability/balance & dietary intake (n = 4)</p> <ul style="list-style-type: none"> In-season (n = 2) (Magee et al., 2020; Moss et al., 2021), pre-season (n = 1) (Lee et al., 2020), seasonal changes (n = 1) (Reed et al., 2014)
Experimental Studies	<p>i) Carbohydrate intervention (n = 69)</p> <ul style="list-style-type: none"> During exercise/game (n = 40) (Kirkendall et al., 1988; Nicholas et al., 1995, 1999; Zeederberg et al., 1996; Nassiss et al., 1998; Bishop et al., 1999, 2002; Ostojic and Mazic, 2002; Welsh et al., 2002; Morris et al., 2003; Guerra et al., 2004; Clarke et al., 2005, 2008, 2011, 2012; Winnick et al., 2005; Ali et al., 2007; Backhouse et al., 2007; Patterson and Gray, 2007; Foskett et al., 2008; Ali and Williams, 2009; Bandelow et al., 2010; Phillips et al., 2010, 2012a; b; Sari-Sarraf et al., 2011; Russell et al., 2012, 2014; Goedecke et al., 2013; Kingsley et al., 2014; Harper et al., 2016, 2017; Mizuno et al., 2016; Funnell et al., 2017; Stevenson et al., 2017; Rodriguez-Giustiniani et al., 2019; Sun et al., 2020; Zhu et al., 2020; Noh et al., 2023), pre-exercise/game (n = 9) (Muckle, 1973; Davison et al., 2008; Little et al., 2010; Hulton et al., 2012a; b; Sacheck et al., 2014; Briggs et al., 2017; Mizelman et al., 2020; Wynne et al., 2021), carbohydrate loading (n = 8) (Bangsbo et al., 1992; Abt et al., 1998; Balsom et al., 1999; Skein et al., 2012; Souglis et al., 2013; Park et al., 2018; Hiromatsu et al., 2023; Kazemi et al., 2023), pre & during exercise/game (n = 6) (Abbey and Rankin, 2009; Currell et al., 2009; Little et al., 2009; Bennett et al., 2012; Quinones and Lemon, 2019; Kaviani et al., 2020), post exercise/game (n = 4) (Nevill et al., 1993; Nicholas et al., 1997; Erith et al., 2006; Ermidis et al., 2024), pre, during & post exercise/game (n = 1) (Naclerio et al., 2015), training adaptations (n = 1) (Morton et al., 2009)
	<p>ii) Carbohydrate co-ingestion intervention (n = 11)</p> <ul style="list-style-type: none"> Protein (n = 8) (Davis et al., 1999; Betts et al., 2009; Gilson et al., 2010; Alghannam, 2011; Spaccarotella and Andzel, 2011; Cockburn et al., 2013; Gunnarsson et al., 2013; Highton et al., 2013), caffeine (n = 2) (Cooper et al., 2014; Andrade-Souza et al., 2015), chromium (n = 1) (Davis et al., 2000)
	<p>iii) Carbohydrate mouth rinse (n = 4) (Dorling and Earnest, 2013; Rollo et al., 2015; Přibyslavská et al., 2016; Gough et al., 2022)</p>
	<p>iv) Gastric emptying (n = 3) (Leiper et al., 2001, 2005; Gant et al., 2007)</p>
	<p>v) Nutrition education (n = 3) (Abood et al., 2004; Zeng et al., 2020; Grabia et al., 2022)</p>
	<p>vi) Muscle glycogen assessment (n = 2) (Morris et al., 2005; Skein et al., 2011)</p>
	<p>vii) Menu settings (n = 1) (Garrido et al., 2007)</p>
Narrative Review	<p>i) Nutritional recommendations (n = 33)</p>

	•	Overview (n = 8) (Burke, 1984; Clark, 1994; Final consensus statement, 1994; Mujika and Burke, 2010; Thomas et al., 2016; Abreu et al., 2021; Collins et al., 2021; Hulton et al., 2022), practical application (n = 5) (Williams and Serratos, 2006; Holway and Spriet, 2011; Heaton et al., 2017; Ranchordas et al., 2017; Dardarian and O'Donnell, 2018), female players (n = 4) (Brewer, 1994; Maughan and Shirreffs, 2007; Dobrowolski et al., 2020; de Sousa et al., 2022), carbohydrate & fluid (n = 4) (Shephard and Leatt, 1987; Hawley et al., 1994; Maughan and Leiper, 1994; Shi and Gisolfi, 1998), alcohol (n = 1) (Maughan, 2006), altitude, travel, cold and hot (n = 1) (Armstrong, 2006), carbohydrate & fat (n = 1) (Hargreaves, 1994), cognitive performance (n = 1) (Meeusen et al., 2006), energy & carbohydrate (n = 1) (Burke et al., 2006), extreme environment (n = 1) (Maughan et al., 2010), female & youth players (n = 1) (Rosenbloom et al., 2006), youth players (n = 1) (Bar-Or and Unnithan, 1994), immune health (n = 1) (Nieman and Bishop, 2006), training adaptations (n = 1) (Hawley et al., 2006)
	ii)	Metabolism/physiology (n = 13) (Kirkendall, 1985, 1993; Ekblom, 1986; Tumilty, 1993; Bangsbo, 1994; Coyle, 1995; Reilly, 1997; Mohr et al., 2005; Stolen et al., 2005; Bangsbo et al., 2006, 2007; Reilly et al., 2008; Alghannam, 2012)
	iii)	Carbohydrate (n = 11)
	•	Ergogenic effects (n = 7) (Phillips et al., 2011; Phillips, 2012; Russell and Kingsley, 2014; Baker et al., 2015; Williams and Rollo, 2015; Hills and Russell, 2017; Rollo and Williams, 2023), requirements & guidelines (n = 2) (Burke et al., 2011; Anderson et al., 2022), periodisation (n = 1) (Fernandes, 2020), sports drink (n = 1) (Ryan, 1997)
	iv)	Muscle glycogen (n = 4) (Tsintzas and Williams, 1998; Vigh-Larsen et al., 2021; Mohr et al., 2022; Vigh-Larsen, 2023)
	v)	Recovery (n = 3) (Reilly and Ekblom, 2005; Nédélec et al., 2012, 2013)
	vi)	Dietary intake (n = 2) (Rico-Sanz, 1998; García-Rovés et al., 2014)
	vii)	Half time strategies (n = 1) (Russell et al., 2015)
Review	i)	Carbohydrate intervention (n = 3) (Palucci Vieira et al., 2021; Abreu et al., 2023; Aguinaga-Ontoso et al., 2023)
(Systematic)	ii)	Dietary intake (n = 3) (Jenner et al., 2019; Renard et al., 2021; Danielik et al., 2022)
	iii)	Metabolism/physiology (n = 1) (Field et al., 2022)
Review (Meta	i)	Carbohydrate intervention (n = 1) (Sun et al., 2024)
Analysis)	ii)	Dietary intake (n = 1) (Steffl et al., 2019)
	iii)	Muscle glycogen (n = 1) (Areta and Hopkins, 2018)
Case Studies	i)	Energy expenditure & dietary intake (n = 1) (Anderson et al., 2019b)
	ii)	Nutrition during rehabilitation (n = 1) (Anderson et al., 2019a)

2.4.4 Journal and Study Impact

Across all studies, the median IF of journals was 3.4 ± 2.5 . Narrative reviews were published in journals with higher IF (4.1 ± 6.4) than observational studies (3.2 ± 1.6 , $p < 0.001$) and experimental studies (3.4 ± 1.6 , $p < 0.001$). Altmetric scores were available for 69% of studies and were highly variable, with a median \pm IQR of 12 ± 30 , with no significant difference between observational studies, experimental and narrative review ($p = 0.719$). However, narrative reviews had the most studies with Altmetric scores ≥ 20 ($n = 26$), followed by experimental studies ($n = 16$) and observational studies ($n = 14$).

2.5 Discussion

Utilising the scoping review framework (Arksey and O'Malley, 2005) and a previously published research audit tool (Smith et al., 2022a), we conducted an audit of the literature (both reviews and original research) with relevance to soccer-specific guidelines for CHO intake. We report that experimental studies were the most common research type (~36%), followed by observational studies (~33%) and narrative reviews (~26%), with experimental studies primarily conducted in laboratories, while observational studies were mostly field based. Professional and world class players comprised ~33% of participants in observational studies whereas experimental studies featured a smaller proportion, with professional players comprising only ~10% of participants. Moreover, no experimental studies included world-class players. Only eight experimental studies exclusively involved professional players, focusing on CHO intervention (n = 7) and CHO co-ingestion (n = 1). No field-based experimental studies have been conducted on elite players to assess the CHO requirements during matches, within immediate recovery period post matches or during different phases of the season, such as pre-season, one-game weeks and congested fixtures. This scarcity of experimental trials among elite players contrasts with the numerous narrative reviews aimed at providing nutrition recommendations for elite players (Table 2). Our audit underscores the gap in current CHO literature in soccer, highlighting the need for more field-based experimental trials involving professional and world class players.

Overall, ~30% of the studies were categorised as reviews, including narrative reviews, systematic reviews and meta-analyses, exceeding the ~20% previously reported in a recent audit of sports nutrition literature (Jonvik et al., 2022). The prevalence of reviews in CHO literature within soccer highlights the ongoing need for original research to drive the field forward. Presently,

observational and experimental studies account for ~33% and ~36% of the included studies, respectively. While carefully conducted observational studies with minimal measurement errors and innovative technologies can provide reliable and reproducible evidence on nutrition, well-designed experimental trials are essential for advancing the field (Satija et al., 2018). Furthermore, observational studies lack the ability to establish clear causal sequence because they do not enable researchers to control for confounding variables (Hébert et al., 2016). Experimental studies, on the other hand, offer a clear comparison between intervention and control (Hébert et al., 2016). Nevertheless, only a small proportion of experimental studies were field-based, emphasizing the importance for practitioners and researchers to conduct more of these studies due to its high translational potential to real-life practice (Close et al., 2019a). Moreover, only two out of the 258 included studies were case studies. The underrepresentation of case studies in CHO literature in soccer is surprising, as a rigorously conducted case study could not only offer significant translational potential into practice (Close et al., 2019a) but also provide insights into high-calibre athletes with more complex designs (Halperin, 2018). Additionally, case studies serve as a powerful tool to bridge the gap between research and practice, facilitating communication between coaches and nutritionists. Narrative formats are easier to process, comprehend, recall and are more engaging and persuasive (Halperin, 2018), making case studies particularly valuable in this context. Moreover, careful consideration of study quality is crucial during the research design phase, as studies with a lower risk of bias offer a more accurate representation of the true effects of an intervention (Higgins et al., 2011). To ensure this, future research should adopt rigorous methodologies, incorporate appropriate blinding techniques, use adequately sized samples, and implement strategies to minimize confounding variables, thereby reducing bias and enhancing the reliability of findings.

Females accounted for ~16% of the total participants in CHO literature related to soccer, mirroring the representation in recent audits of studies assessing chronic strategies to manipulate CHO intake around training (Kuikman et al., 2023a), exercise thermoregulation (Hutchins et al., 2021) and heat adaptations (Kelly et al., 2024). This percentage is slightly higher compared to an audit of studies examining acute CHO fuelling strategies (Kuikman et al., 2023b), but it is lower than the reported 22-71% representation of females in other audits within the field of sports science and sports medicine (SSSM) (Costello et al., 2014; Cowley et al., 2021; Smith et al., 2022b; c). There is a shortage of studies on females (~12%), whereas studies exclusively involving male participants make up a significant percentage (~78%), consistent with audits of acute and chronic CHO strategies (Kuikman et al., 2023a; b). Furthermore, this underrepresentation of female participants persisted across observational, experimental and case studies. Despite the limited research on female soccer players, the existing UEFA nutrition guidelines for female players remain the same as those for male players (Collins et al., 2021). Therefore, further research on female soccer players is required to better inform and tailor these nutrition guidelines. The distribution of adults and adolescents was evenly spread across observational studies, while most participants in experimental studies were adults (~75%). The reduced numbers of adolescents in experimental studies could be linked with the increased emphasis on ethical concerns in research with adolescents, including issues such as obtaining assent, parental consent, risk perception and potential impact of participation (Crane and Broome, 2017). Furthermore, in our audit, observational studies tend to report a greater median sample size compared to experimental studies. This necessity for large sample sizes in observational studies stems from the more heterogeneous samples, resulting in increased variability across groups (Biau et al., 2008).

Conversely, in experimental research, excessively large samples can pose challenges by significantly increasing statistical power, potentially leading to an increased likelihood of erroneously rejecting the null hypothesis (Faber and Fonseca, 2014). Consequently, what might be considered insignificant could be falsely deemed significant. Researchers should therefore balance the needs for sufficient sample sizes to ensure statistical validity without excessively inflating the sample, which could lead to misleading results.

The majority of participants (~69%) in the audited studies were categorised as developmental, collegiate/university, recreationally active or sedentary. These findings are consistent with previous audits, which also indicated that most participants were classified within Tier 0 (sedentary), Tier 1 (recreationally active) and Tier 2 (developmental/trained) categories (Smith et al., 2022b; c; Kuikman et al., 2023b; a; Kelly et al., 2024). Professional and world class players made up ~24% and ~2% respectively, of the total participants, which is higher than a previous audit in SSSM that reported ~9.5% from Tier 4 (elite/international) and ~0.5% from Tier 5 (world class) (Smith et al., 2022b). However, only ~10% of participants in experimental studies were professional players, resulting in only eight studies conducted thus far with this elite cohort (Muckle, 1973; Bangsbo et al., 1992; Balsom et al., 1999; Ostojic and Mazic, 2002; Gunnarsson et al., 2013; Park et al., 2018; Kazemi et al., 2023; Ermidis et al., 2024). Additionally, no experimental studies have been conducted on world class players, mirroring findings from the previous audits (Smith et al., 2022b; Kuikman et al., 2023b). Therefore, the limited experimental research conducted on elite soccer players raises concerns about the relevance and applicability of the current nutrition guidelines to this group. Experimental studies focusing on professional soccer players have explored various timings of CHO intervention, including CHO loading (Bangsbo et

al., 1992; Balsom et al., 1999; Park et al., 2018; Kazemi et al., 2023), pre-match (Muckle, 1973), during intermittent exercise protocols (Ostojic and Mazic, 2002), between successive 120-minute matches (Ermidis et al., 2024) and CHO protein co-ingestion 48 hours post-match (Gunnarsson et al., 2013). Five out of these eight studies were field-based (Muckle, 1973; Balsom et al., 1999; Gunnarsson et al., 2013; Kazemi et al., 2023; Ermidis et al., 2024). Currently, no field-based experimental studies have been conducted to evaluate the effects of CHO ingestion during matches and within the immediate recovery period post-match (0-4 hours). These findings align with the UEFA consensus statement, which highlights the need for more robust, sport-specific evidence tailored to the elite soccer environment. A review suggests that elite athletes may respond differently to CHO interventions compared to non-elite counterparts, as evidenced by findings that periodised CHO restriction did not enhance performance in elite endurance athletes (Gejl and Nybo, 2021). Therefore, there is a pressing need for more randomized controlled trials on elite players to evaluate the ergogenic effects of CHO ingestion, particularly during critical time periods such as MD-1, pre-match, during match and post-match and MD+1. Moreover, further research is required to determine the CHO requirements of elite players during different phases of the season, including pre-season, single-game weeks and congested fixture periods.

Observational studies featured a higher representation of professional and world class players (~33%) compared to experimental studies (~10%). A substantial portion of observational studies (~87%) focused on assessing dietary intake, energy expenditure or energy availability. Synthesizing these findings systematically reveals a concerning trend; both male and female soccer players, especially senior players, are failing to meet recommended CHO intake (Steffl et al., 2019; Jenner et al., 2021; Renard et al., 2021; Danielik et al., 2022). The prevalent failure to adhere to

these recommendations among players suggests a glaring disparity between research and practice. Rather than producing yet another narrative review centred solely on nutritional recommendations, which constituted ~46% of the narrative reviews analysed, it becomes imperative to shift our focus towards understanding the underlying reasons for soccer players' noncompliance with CHO intake guidelines. In this context, the COM-B model (Michie et al., 2011) emerges as a promising framework for dissecting the multifaceted dynamics of dietary behaviours among soccer players. Recent studies employing COM-B model to explore the dietary behaviours of academy and female soccer players (McHaffie et al., 2022; Carter et al., 2023b; Carney et al., 2024), highlights its efficacy in illuminating the complex interplay of factors influencing players' dietary choices and habits. Thus, integrating such comprehensive models into research not only enhances our understanding but also paves the way for targeted interventions aimed at bridging the gap between CHO research in soccer and practical implementation in professional soccer players.

Our audit demonstrates that the median IF of journals in which studies were published was similar to previous audits in SSSM (Smith et al., 2022b; c; Kelly et al., 2024). Interestingly, narrative reviews tended to be published in journals with higher IF compared to observational and experimental studies. This observation raises concerns about the incentives for researchers to pursue original research as they may receive less attention in higher-IF journals. Furthermore, our findings suggest that narrative reviews tend to garner more online attention, as indicated by greater number of studies with Altmetric score ≥ 20 compared to observational and experimental studies. This trend is worrying, as articles with significant Altmetric attention often lead to increased number of citations (Llewellyn and Nehl, 2022). Indeed, weak positive correlation between Altmetric attention scores and citations was observed in health sciences research (Kolahi et al.,

2021). As a result, the lure of publishing in high IF journals and attaining heightened Altmetric attention may precipitate a surge in review articles production, mirroring recent trends in sports nutrition research over the past five years (Jonvik et al., 2022). Although reviews offer critical synthesis, they pose the inherent risk of subjective interpretation and the potential dilution of original content through repetitive paraphrasing (Agarwal et al., 2023). In light of this, to propel the field forward, researchers are encouraged to persist in their pursuit of publishing original research, notwithstanding the comparatively lower Altmetric attention and IF associated with journals more likely to publish their research.

In conclusion, the scoping review and audit of CHO research in soccer revealed a varied mix of study types, with experimental studies dominant in laboratory settings and observational studies prevalent in field settings. Notably, narrative reviews occupied a significant space in literature, underscoring the ongoing need for original research to advance the field. While both observational and experimental studies offer unique insights, there is a call for more field-based experimental trials in elite populations to bridge the research-practice gap. The underrepresentation of female participants in this audit highlights the need for more CHO research conducted exclusively on female soccer players. Additionally, the predominance of studies focusing on non-professional players raises questions about the applicability of current CHO guidelines to elite soccer players. It is recommended that professional soccer clubs collaborate with research institutions over an extended period to fully integrate applied research practices, thereby addressing this gap and enhancing evidence-based practices. Research topics primarily revolved around the ergogenic effects of CHO intervention in experimental studies and dietary practices of soccer players in observational studies. However, the poor adherence of soccer players to current CHO

recommendations indicates a disconnect between research and practice. Furthermore, the potential bias towards narrative reviews in journals raises concerns about the incentives for researchers. While narrative reviews may attract higher IF journals and Altmetric attention, there is a need to balance this with the pursuit of original research to drive meaningful advancements in the field. Overall, these findings highlight a lack of experimental research specific to professional and world-class soccer players in current CHO guidelines. More field-based experimental trials involving elite soccer players are necessary to provide evidence-based CHO recommendations.

Chapter 3

Professional male soccer players' perspectives of the nutrition culture within an English Premier League football club: a qualitative exploration using Bourdieu's concepts of habitus, capital and field

The aim of this Chapter was to qualitatively explore professional soccer players' perspectives of the nutrition culture within the EPL with the guide of Bourdieu Theory.

This study has been published in Sports Medicine.

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3.1 Abstract

Purpose: Although behaviour change models have previously explored barriers and enablers to nutritional adherence, the cultural factors influencing players' nutritional habits also warrant investigation. Accordingly, we aimed to explore players' perceptions of the nutrition culture within the professional soccer environment.

Methods: An interpretivist paradigm, which emphasizes that reality is subjectively and socially constructed, underpins this study. Qualitative, face-to-face semi structured interviews (comprising open-ended questions) were conducted with purposively sampled male soccer players from the EPL (5 British, 5 Migrant; mean age: 26 ± 6 ; mean EPL appearances: 106 ± 129). Data were abductively analysed using thematic analysis according to Bourdieu's concepts of habitus, capital, field and doxa practices.

Results: This study revealed five key themes: (1) Players' habitus, as shaped by familial, ethnic and religious backgrounds, influences their dietary habits; (2) Social capital, via managers (head coaches), teammates and online influences, impact players' dietary practices; (3) The increase in both soccer clubs' and players' economic capitals has advanced nutrition provision; (4) An unequal distribution of economic capitals has led to hierarchical practice in the performance nutrition field with personalized nutrition being somewhat enacted at the higher levels, and (5) Body composition measurement is a 'doxic' practice in professional soccer that warrants challenge.

Conclusion: Soccer players' habitual nutritional practices are influenced by personal upbringing and the club context, including economic resources and social capital from managers. The performance nutrition field within professional soccer is also shaped by stakeholders' doxic beliefs

surrounding the perceived optimal body composition of players, with managers exerting social capital.

3.2 Introduction

In 2020, UEFA published an expert consensus statement outlining the latest evidence based nutritional guidelines for elite soccer. Such guidelines suggest that daily CHO intake should vary between 3 to 8 $\text{g}\cdot\text{kg}^{-1}\text{BM}\cdot\text{day}^{-1}$, adjusted according to the energetic demands and specific objectives of the upcoming training sessions and associated fixture schedule (Collins et al., 2021). Players are also advised to consume approximately 1.6 $\text{g}\cdot\text{kg}^{-1}\text{BM}\cdot\text{day}^{-1}$ of protein (distributed evenly across four servings of 0.4 $\text{g}\cdot\text{kg}^{-1}\text{BM}$ throughout the day) while dietary fat intake is recommended to fall within the range of 20-35% of total EI (Collins et al., 2021). Although dietary assessments from elite soccer players (albeit using self-report methods) typically demonstrate that players consume sufficient dietary protein and fat, daily CHO intake often falls short of the recommended guidelines (Steffl et al., 2019; Danielik et al., 2022). For example, in evaluating a cohort of players from the EPL, self-reported CHO intake on the day before and in the acute recovery from match play did not align with the goal of optimising muscle glycogen availability and re-synthesis, respectively (Anderson et al., 2017b).

The specific factors influencing players' apparent lack of adherence to nutritional guidelines are not well understood, especially when considering that determinants of food choices in athletic populations are multi-faceted and highly complex. Indeed, such factors are likely to encompass considerations such as individual athlete performance and health objectives, the stage of the competitive season, athlete experience, cultural background, gender, nature of the sport and the

associated food environment (Pelly et al., 2022). When evaluated through the lens of behaviour change models (e.g. the COM-B model) (Michie et al., 2011), researchers have explored the barriers and enablers to adhering to nutritional guidelines in professional soccer environments (McHaffie et al., 2022; Carter et al., 2023b). Indeed, in female soccer players, personal beliefs regarding the impact of CHO on body composition and body image (i.e. reflective motivation), external pressures from social media and coaches influences on body composition assessments (i.e. social opportunity) were all identified as factors contributing to a culture of under-fuelling (McHaffie et al., 2022). In male academy players, insufficient food provision in both training and home environments (i.e. physical opportunity) as well as limited education provision from sports nutritionists (i.e. psychological capability) were also identified as potential barriers to nutritional adherence (Carter et al., 2023b).

Prior to evaluating the nutritional behaviours of elite players, it is also of interest to initially explore the embedded nutrition culture within the specific environment, recognising that culture in itself has the potential to shape behaviours (Ono et al., 2012; Pelly et al., 2022). In this regard, Bourdieu's connected concepts of habitus, field, capital and doxa practices provide a theoretical lens to collectively evaluate how culture influences an individual's dietary habits (Bourdieu, 1984). In that sense, habitus refers to the internal disposition such as predispositions to certain eating habits, stemming from each individual's upbringing and cultural backgrounds (Bourdieu, 1990). These dispositions may have been influenced by individuals with different forms of capitals; for instance, those with high economic capital (e.g., money and assets) are more likely to have access to higher quality foods, promoting healthier dietary habits. Other capitals, encompassing social (e.g. networks and relationships) and cultural (e.g. knowledge and skills)

capitals (Bourdieu, 1986), may also exert considerable sway over an individual's dietary behaviours. For example, soccer players with greater cultural capital, such as nutrition knowledge, are shown to have better dietary intake (Noronha et al., 2020), which equips them to meet the demands in the field of professional soccer more effectively. The field of professional soccer represents a social arena with its own unique logic and commonly accepted structure (Power, 1999), where coaches, support staff, nutritionists and other stakeholders compete for various forms capitals. Resources are unevenly distributed within the field, creating hierarchies not only between clubs and countries but also within clubs across departments, meaning that players do not have equal access to these resources. Over the past decade, the nutrition sub-field has undergone significant transformation, driven by the ongoing power struggles among key stakeholders. As sport science has become standard for gaining a competitive advantage, managers who were once sceptical of performance nutrition (Ono et al., 2012) now acknowledge its importance for players' performance and health (Wenger, 2021). Historically, doctors were the primary sources of nutritional advice due to the limited access to nutritionist (Ono et al., 2012). However, today, performance nutritionists are fully integrated in club multidisciplinary team (Meyer, 2021), a shift supported by their formal accreditation, which has legitimised their role over non-qualified individuals, solidifying their authority in the nutrition sub-field. Within a field, doxa refers to the unquestioned, taken-for-granted beliefs and assumptions that reinforce and legitimise the established dietary norms (Throop and Murphy, 2002). These norms are upheld and perpetuated by the cultural beliefs and experiences of influential figures with significant capitals, such as coaches, rather than being grounded in evidence-based practices (Bentley et al., 2019). Nevertheless, the increasing integration of nutritionists within the soccer field provides an opportunity to challenge these traditional practices. Given this shift, it is crucial to critically

examine and address these entrenched doxic practices, steering the nutrition sub-field towards more effective and evidence-based nutritional strategies that improve player health and performance.

To date, only one study has used Bourdieu's concepts to explore the interplay between culture and the dietary practices of soccer players (Ono et al., 2012). In using a cohort of male professional players from the English leagues, this research surfaced the conflicts between players' ingrained eating habits, as shaped by their family upbringing, versus the dietary protocols advocated within their respective soccer clubs. As such, habitus was identified as a major factor impacting a player's ability to transition to the "soccer diet". Nonetheless, the remaining components of Bourdieu's concepts such as capitals, field, and doxa practices were not readily explored. A thorough exploration of these components would offer deeper insights into the various influences on players' dietary habits. By understanding how each type of capital affects players' engagement with nutrition differently and examining the ingrained beliefs within the nutrition sub-field, we can better understand the impacts on players' dietary practices. It is also noteworthy that this study was conducted during the 2006/07 and 2007/08 seasons and that the nutrition culture and nature of service provision has changed considerably since then. Indeed, the nature of the performance nutrition landscape has likely evolved due to the EPL's increasingly diverse composition (CIES Football Observatory, 2024), substantial growth in financial resources (Deloitte Football Money League, 2024) and the rise of sport science and medicine within the professional game.

With this in mind, the aim of the present study was to qualitatively explore professional soccer players' perspectives of the nutrition culture within the EPL. This study sought to provide an

overview of the contested nature of the nutrition sub-field in professional soccer, identify key figures shaping nutrition culture in the EPL and examine doxic practices prevalent within the field. To this end, an interpretivist paradigm was utilised to underpin our approach (which emphasizes that reality is subjective and socially constructed) where semi structured interviews (comprising open-ended questions) were conducted with purposively sampled adult male players from the EPL. Data were abductively analysed using thematic analysis according to Bourdieu's concepts of habitus, capital, field and doxa practices. It is hoped that the present data may subsequently inform practitioner education and training programmes that strive to improve the quality of execution of performance nutrition services within the professional game.

3.3 Methods

3.3.1 Research philosophy and positionality

The philosophy of this study was underpinned by an interpretivist paradigm, which emphasizes that reality is subjective and socially constructed (Bogdan and Biklen, 1998). This paradigm operates under a relativist ontology, suggesting a belief in the existence of multiple realities for multiple actors within the studied situation. It asserts that these realities can be investigated and interpreted through human interactions involving both the researcher and the participants. This approach emphasizes the understanding of the individual and their interpretation of the world around them. To address the aims, a qualitative investigation aimed at comprehending the experiences and perspectives of individuals within complex social environments was undertaken (Sparkes and Smith, 2013). The sampling, data collection and data analysis procedures outlined below were designed to offer a trustworthy and transparent portrayal of the nutrition culture in a

single club in the EPL. This study adhered to the Standard for Reporting Qualitative Research (SRQR) recommendations (O'Brien et al., 2014).

3.3.2 Participants

To gain a comprehensive understanding of the perspectives surrounding nutrition culture in professional soccer, male first-team players from a single EPL club were purposefully invited to participate in this study. This methodology mirrors previous qualitative inquiries into nutrition practices within the professional soccer domain (McHaffie et al., 2022; Carter et al., 2023b). This is typical of qualitative studies where the aim is not to generalise from a large sample but to gain in-depth understanding from a small sample purposefully selected due to their experiences. Participants were approached in person to recruit them for the study, with the details of the study explained during these discussions. A total of ten male EPL players (5 British, 5 Migrant; mean age: 26 ± 6 ; mean EPL appearances: 106 ± 129 , mean time spent at the current club = 7 ± 5 years) were interviewed. Migrant players are defined as professional soccer players who move from their home country to another country to pursue their careers. Following the principles of qualitative research, the sample size was not predetermined but instead determined by the data analysis process, with recruitment ceasing after information richness has been achieved by obtaining diverse and in-depth perspectives on nutrition culture in professional soccer from players with varied cultural background (Sparkes and Smith, 2013; Moser and Korstjens, 2017). The study was approved by the ethical committee of Liverpool John Moores University (23/SPS/032) and as condition of this, further details of the participants are not provided to avoid direct identification. All participants provided verbal and written informed consent before completing the interview

3.3.3 Procedures

All ten participants engaged in semi-structured interviews (mean: 44 min; range 29-74 min), with an “open-ended” approach (Gall et al., 2007), where questions were posed in a conversational and informal manner to encourage voluntary input and detailed responses (Lincoln and Guba, 1985). The questions (see Table 3) were informed by the study aims, and Bourdieu’s concepts of habitus, capitals, field and doxa practices. For instance, initial questions were neutrally framed such as “What are your thoughts on...?”. Subsequently, probing questions were used to elicit further insights (Jones, 2022). This format of enquiry enabled participants the freedom to express their experiences and opinions and to guide the discussion toward areas they deemed significant (Braun and Clarke, 2013). Moreover, the life history interview method (Hagemaster, 1992) offered a longitudinal view of participants’ careers, delving into transitions, pivotal moments, and ongoing experiences. Consequently, the study’s findings extend beyond the scope of participants’ current club, providing a comprehensive understanding of their involvement with various clubs and national teams. To assess the suitability of the interview questions, pilot interviews were conducted with two professional players from the same club. Based on the feedback from the senior co-authors for these pilot interviews, the wording of some questions was revised. Pilot interviews were not included in the analysis. All interviews took place in a private office at the club’s training facility and were audio-recorded, then transcribed verbatim. The interviewer was well-versed in the professional soccer subculture, having worked as a performance nutritionist in the industry for the past four years. While this familiarity could potentially bias the interviewer’s approach, it was considered advantageous due to their fluency in understanding the players’ jargon and informal language, and their ability to develop rapport with participants (Cook et al., 2014). To prevent

leading questions, strategies such as piloting interview questions and utilising open-ended questions were implemented.

Table 3. Players’ interview guide and aims.

Interview Questions	Prompts	Aims
Domain 1: Participant Background and Current Dietary Practice		
Q1: Can you tell me about your journey as a soccer player so far?	F1: Clubs, age started, setbacks, injuries.	A1: To understand their background and experience.
Q2: How are training and games going for you now?	F2: Any challenges	A2: To understand their current perceptions about their performance during training and games.
Q3: What does a typical day of eating look like for you?	F3: Main meals, snacks, supplements	A3: To understand their current dietary practices.
Q4: How do your eating habits change on days when you have a game compared to training and rest days?	F4: The day before and the day after Macronutrients content, types of food, hydration	A4: To understand the impact of competition on their dietary practices
Domain 2: Life Course Changes in Dietary Habits of Professional Soccer Players		
Q1: Can you tell me more about your eating habits during the time when you began playing soccer in your youth [Use information from Q1 in Domain 1]?	F1: Key influences, provision of foods, main sources of dietary advice	A1: To understand their dietary practice in their youth soccer career.
Q2: How have your dietary habits evolved throughout your playing careers?	F2: Transition into first team, transfers, food provision	A2: To explore the changes in their dietary practice throughout their careers.
Q3: What has impacted these changes?	F3: Why do you think that?	A3: To understand what have influences the changes in their dietary practice.
Domain 3: Influence of players’ capitals on their food choices		
Q1: Could you explain what influences your current food choices?	F1: What has impacted these?	A1: To understand their current determinants of food choices.
Q2: Have you experienced any nutrition challenges?	F2: When? Why?	A2: To understand what nutrition challenges they face and why.
Q3: Is there any support you have received to overcome these challenges that has been helpful?	F3: Why? What else would be helpful?	A3: To understand what they perceive to be useful

3.3.4 Data Analysis

The principal investigator transcribed all interviews. An abductive approach was taken to explore the data. This analytic procedure entailed a series of inductive and deductive processes, acknowledging the interpretative creativity when applying a theoretical framework to participants' experiences (Sparkes and Smith, 2013). A six-stage process of thematic analysis was utilised (Braun and Clarke, 2006): (1) familiarisation and immersion of the data was achieved through repeated reading and listening during the transcription process; (2) a systematic initial coding process was conducted to identify relevant content; (3) initial codes were reassessed to detect data patterns and generate preliminary themes related to the theoretical framework; (4) identified themes were reviewed for their appropriateness by comparing them with the raw data; (5) upon reaching consensus on the themes, they were refined, defined and named; and finally, (6) data excerpts from each theme were selected to present a concise, coherent, logical, non-repetitive, and engaging narrative that reflects the data's story, both within and across themes. The final author, unacquainted with the club and not involved in the interview process, acted as a "critical friend", who independently checked and challenged data analysis, theme generation and presentation of selected quotes (Smith, 2018). The role of the critical friend is not to seek agreement or consensus but to foster reflexivity by questioning each other's construction of knowledge (Cowan and Taylor, 2016). For example, the concept of doxa was not initially included in the original framework or identified by the principal investigator, but it emerged organically from participants' responses and was subsequently uncovered by the critical friend. Nonetheless, it was recognised that the lead author's involvement within the club and personal interest in the topic introduced a level of subjectivity. However, due to the use of a critical friend who "checked and challenged", this insider

knowledge was considered advantageous for understanding the topic within its social context (Austin and Sutton, 2014).

3.3.5 Methodological Trustworthiness and Rigour

Several measures, consistent with qualitative methods and interpretivist paradigms (Smith and McGannon, 2018), were implemented to ensure rigour. These measures included recruiting a diverse sample, using a robust theoretical framework and piloting the interview questions. Additionally, independent members of the research team, separate from the primary author, provided critical feedback on the interview techniques and data analysis process. Through these steps, the team sought to offer credible and transparent insights into the nutrition culture within professional soccer settings. The data analysis process demonstrated high level of rigour, characterised by open discussions among all authors, who acted as critical friends and maintained a reflective approach throughout (Smith and McGannon, 2018). The worthiness of this research topic was justified by addressing the gap in evidence and practice within this population (Anderson et al., 2017b). Furthermore, the subsequent results and discussion section outlines five themes along with pertinent quotations from the data, enabling readers to interpret the findings independently and contemplate the applicability to their own circumstances (Smith, 2018). To improve the credibility of the manuscript, member check was conducted by providing participants with a one-page summary of the interpretations and findings for their feedback (Korstjens and Moser, 2018).

3.4 Results & Discussion

Via a reflexive thematic analysis, five themes were established that illuminate the nutrition culture in professional soccer. Aligned with previous qualitative investigation in elite soccer (Carney et al., 2024), the themes were elucidated through a discussion section, allowing for the relevant exploration of each theme.

3.4.1 Players' habitus, shaped by familial, ethnic and religious backgrounds, influence dietary habits of professional soccer players

Habitus is defined as an embodied arrangement of social structures that predisposes an individual to certain actions (Bourdieu, 1984). In other words, habitus is the lens through which people perceive the world and shapes how they act within it. Habitus is embodied in individuals' food preferences and tastes (Bourdieu, 1984). The habitus within the professional players dietary habits in this study are primarily formed via the socialization processes in their families as highlighted by one of the British players:

[Participant 6] *My family. My mum is a good cook. She always provides good food. We always tended to eat well and have nutritious meals. It comes from her really. I was very lucky growing up because she's able to cook really well with different varieties of foods.*

Similarly, family also played a significant role in forming a migrant player's food preference:

[Participant 1] *I have very good habits because my grandmom is a great cook. I was lucky because I ate so well during my childhood. I spent more time in my grandparents' flat than in my home because my parents were very busy with work.*

So, I was eating at my grandparents' house every day. So, I used to recover with the food when I eat at my grandmom's foods. It is still the same when I went to {new country}. I ate so well. Everything is about olive oil. It was not greasy at all.

Furthermore, the food preferences of players were also reported to be influenced by their ethnicity and religious backgrounds. Participant 2 acknowledged that “my mum is half Pakistani so I had a lot of curries and Asian influences. That has been throughout my childhood. I guess when you get older you realised that how much influence your parents have.” Similarly, Participant 9 mentioned “I’m from Ivory Coast, west Africa so we have a lot of dishes like placani, almost like planted yam, like a dough mashed things with a little bit of sauce. Then, you have sauce graine, like jollof rice but a bit spicier, like that type of dish. Another one is called sauce grand, rice, chicken and sauce but not as spicy, a bit more orange and with tomato. Then, you have attieke.”

Due to their religious dietary restrictions, players might experience difficulties when moving to a different country:

[Participant 7] *As you know, I don't eat cheese and meat together and I don't eat pork and seafood like calamari and shrimp. So, sometimes when I moved, I needed to ask every time especially the first time I left home, I was shy and afraid to ask so I'm afraid to eat... Yeah, when you go to the restaurant especially with your teammates, most of the things I cannot eat. For normal stuff, I eat everything but sometimes some dishes I cannot eat so sometimes it's difficult.*

The inherent inertia within players' habitus (Wacquant, 2016) may result in resistance to altering established nutritional practices, even when the surrounding environment shifts. For instance, Participant 1 recounted his struggle to adapt to the changes required to increase his protein intake at breakfast: *"I never changed my breakfast. I tried many times, but it is difficult for me to eat salty foods in the morning. I go for toast with a little bit of butter and jam. On the side, I will have fruits, a cup of tea and a cup of coffee depend on my mood. We tried to find protein somewhere which we can get from a protein shake. I tried omelette but it didn't go down very well. I tried yogurt as well but again if I eat yogurt very early – I don't feel well."*

Habitus tends to be relatively stable, it is, however, not fixed. Players can still acquire new dispositions and dietary habits through experiences and exposure to different social environments (Power, 1999). For instance, participants who came from a country with minimal nutritional support experienced significant improvements in their dietary habits when moving into a new country:

[Participant 4] *it (learning) was more like stuff I should eat and how much the portion sizes are. I started to eat more vegetables. Before I came, I never ate vegetables, I don't really like to eat them. So, when I came, I started to eat more.*

[Participant 8] *(when I moved to Italy) I started to get to know more about foods because in Italy, they love foods. They eat amazing food. I started to learn much more about food. I started to eat more pasta. I started to eat a little bit healthier.*

Consequently, there may be a lag in the adoption of new nutritional practices, particularly when the cultural background and food preferences of players conflict with the recommendations

promoted at the club (Bourdieu, 1977). The lag in aligning existing practices with sports nutrition guidelines can be attributed to the inertia ingrained in their habitus, making it difficult for players to fully adhere to the current recommendations:

[Participant 4] *“At the start, I would probably have a piece of chicken and a lot of potatoes and no veg. That’s the way I would eat at home. I would eat a lot of carbs and no veg. That’s the way it was for a little while”*

Overall, one’s habitus is the result of upbringing and culture and continues to shape the way an individual adjusts to new conditions throughout life. As players are instilled with the cultural values of their upbringing, they often perceive their own eating habits as correct, normal and superior (Ono et al., 2012). As a result of this, players may be hesitant to embrace food cultures that deviate from their preferences, which would lead to struggles when transitioning to a different country. Nevertheless, the habitus of the professional soccer players can evolve, particularly when transitioning into a new social environment (Power, 1999) as exposure to other cultures can broaden tolerance and aid in an understanding of how other people live (Fieldhouse, 1998). Developing a habitus that aligns with the expectations of professional soccer offers players a competitive advantage, as it allows them to embody the dispositions and behaviours valued within the sport. The formation of this habitus is largely shaped by access to various forms of capital, including social, cultural, and economic capitals (Bourdieu, 1986).

3.4.2 Social capital, via managers (head coaches), teammates and online influences, impact players' dietary practices.

Social capital, as defined by Bourdieu (1986), encompasses the benefits and assets that individuals gain from their affiliations, relationships and ties within a community. It also embodies a type of symbolic authority within social spheres, wherein those with substantial social capital typically wield influence, garner respect and receive acknowledgement within their communities. In professional soccer, our data suggest that managers and coaches tend to have the most extensive social capital in the club, which could subsequently influence players' dietary practices. Indeed, managers, due to their status and power, often have the ultimate decision-making authority on whether to recruit nutritionists.

[Participant 1] *[Manager 1] was the first to introduce nutritionist... The nutritionist gave directions on what to cook and how to cook. The nutritionist will put different options and decide what is allowed or not to the kitchen. They start to make a difference between professional athlete and employee.*

Critically, it is also important to recognise that managers, rather than nutritionists, held the most capital when making decision related to foods:

[Participant 5] *I had some managers who would insist that you have to wait. You can have lunch and then you have to wait 2.5 hours before you can train. I have a manager who would take away certain foods and be very strict on that front. But every manager has their own way of working. It's not necessarily right or wrong. They're in charge and their jobs are on the line. If they say something goes then it goes. That's the way it is.*

[Participant 6] *At Club A, the food is amazing there as well. They're slightly more lenient than Club B is. Like before the game, they sometimes put dessert on. Club B, especially with the manager we just had, he's very hot on nutrition. Everything has to be quite plain. When I was at Club A, there were definitely more sugary foods available per se.*

Social capital is subsequently converted into cultural capital when soccer players align with the influential figures within the soccer field, in most instances, the coaches, by adopting the expected behaviours and practices:

[Participant 1] *The first two seasons, the focus is only on the pitch, not outside of the pitch. When [Coach 1] arrived, he changed everything, including my mind and my way of thinking about football. I start to develop myself on things outside of football such as nutrition, gym, injury prevention when I was 27 years old. It was the perfect timing for me as it keeps me to perform until today. I need that. The pitch is not enough.*

Nevertheless, players frequently are expected to comply with the standards set by the coaches:

[Participant 5] *When I first started, on match day, you could turn up to the stadium an hour and half before. That's all. You don't have to turn up for pre match. It's fine. Then, the next manager comes in, he wants everyone to be at the stadium for pre match. That was when there is a pre match buffet, but it was very simple – pasta, rice and chicken, kind of like what we have now.*

Furthermore, players discern these standards through their habitus. Players whose habitus did not align as well may struggle to adhere to the strict dietary restrictions expected by the coaches. The inertia of habitus makes it challenging to players to seamlessly integrate these new requirements into their daily lives, highlighting the tension between personal dietary practices and the demands set by coaches within the professional soccer environment:

[Participant 2] *Coach 2, he obviously banned butter and other stuff, which is very extreme. But again, just because you do that is not going to improve. It is stupid. Now you don't have ketchup, it is fine now and now you have a perfect diet. No, there is a place for everything. After a game, you can have something sweet or desserts because you have worked maximally. For instance, after a double session, I want to have an ice cream, of course I can have it as I can did two sessions in the gym. If you have a whole tub, then it is different. I feel food is a huge part of life, I don't want to restrict myself or sacrifice happiness. You can have foods that taste good and you enjoy eating that is also healthy.*

Teammates appear as another social capital that heavily influence the dietary behaviours of soccer players. Players tend to seek advice from players who have achieved high standards or those who possessed great physique:

[Participant 8] *I played in [Club C] with [Player A], he is one of the legends in soccer. He knows almost everybody in the whole world about food because he studied for twenty years. I learnt so much from him, I learnt things about very small details. After that, I started to gain more interest and I have learnt a lot. I have been changing a little bit.*

Gaining insights from an experienced player has the potential to bring about positive changes in dietary behaviour. For instance, participant 9 described:

She was [Player B's] ex-chef. Just before [Player B] went to [Club D] in Italy on loan, she was looking for work and I was looking for chef. So, [Nutritionist A] knows [Private Chef A], so she put me in touch with [Private Chef A] and then I spoke to [Player B] if she's good and he said she's great... Before [Private Chef A], I worked with two others, but they weren't great. When I first started with [Private Chef A], she was amazing.

Nonetheless, players could also be exposed to nutrition advice from senior players that may not be optimal for soccer performance such as gluten free diet and low CHO diet. Participant 8 shared that “*after I got injured, I stopped eating pasta and stop eating bread so like no gluten almost. I stopped eating candy. I almost never eat candy now. When I was younger, I did it every day. So, I just took away a lot of sugar. I stopped eating gluten.*” Furthermore, participant 3 described “*he was in great shape so straight away you are like “It must be working for him.” He was bang on with everything he eats from Monday to Saturday. Then Sunday, he will like “I will just eat whatever I want. I will be back super healthy during the week.” He was doing that, but he was super lean. He was very much like low carbs. That's probably the first time I have seen that.*”

It is not uncommon for professional players to seek nutrition advice from the Internet:

[Participant 2] *It was teenage me googling or going to YouTube. It is the basic understanding of the myths or what you need to do. Like low fat, fat free stuff is*

maybe not necessary the right thing to do. You can't do things super quick; everything takes time. You can eat well.

Players may be at risk of receiving misguided nutrition guidance propagated by unqualified online influencers, potentially leading to adverse effects on their health and overall performance.

[Participant 8] *I followed [Influencer A] on Instagram. He's the one that talks really good about raw meat. I haven't tried it honestly because people say it can damage you. But I see soccer players eat it, so you never know. So far, I have never tried it.*

In summary, Bourdieu's concept of social capital reveals the influential role of social status on soccer players' dietary practice within the professional soccer community. Managers and coaches, possessing considerable social capital, wield influence over decisions related to soccer players' dietary practices. The players then convert this social capital into cultural capital by adhering to the standards and behaviours expected by the coaches. This strategic alignment signals to key gatekeepers, such as coaches, that the players meet the established standards, thereby demonstrating professionalism and respect within the field. This aligns with previous research identifying coaches as dominant figures endorsing cultural beliefs on athletes' diets (Bentley et al., 2019), with athletes often regarding them as trusted sources of nutrition information (Stokes et al., 2018). Furthermore, this study highlighted that players whose habitus does not closely align with the field's expected norms may struggle to meet these standards. Such challenges can impede their ability to convert social capital into cultural capital, placing them at a disadvantage within the hierarchy of the soccer field. Consequently, this dynamic leads to an uneven playing field, where

certain players are more favourably positioned to succeed, thus reinforcing existing social stratifications within professional soccer. Additionally, teammates play a pivotal role in shaping players' dietary habits, as seen where healthy eating behaviours among teammates influenced others to follow suit (Long et al., 2011; Stokes et al., 2018), due to wanting to comply with what is socially acceptable (Hausenblas and Carron, 2000; Smart and Bisogni, 2001; Jenner et al., 2021). Influences may also extend beyond the team environment, as some players may turn to social media for nutrition advice, possibly exposing themselves to potential misinformation from unqualified sources. The potential of social media to compromise health and performance is also highlighted among other team sports athletes (Sharples et al., 2021). While social capital can facilitate positive changes, the diverse sources of influence underscore the need for critical education and informed decision-making among soccer players.

3.4.3 The increase in both soccer clubs' and players' economic capitals has advanced nutrition provision.

Economic capital, which includes money, resources and assets (Bourdieu, 1986), stands out as a significant factor influencing the nutritional habits of professional players. At the individual level, economic capital allowed the players to build their own support team around them. This is not surprising given that EPL players earned an average of £3.1 million per year (Sporting Intelligence, 2024). The heightened economic capital facilitates the conversion into cultural capital, enabling the players to access personal chefs or meal preparation services. This advantage enhances their ability to optimise nutrition, thereby providing them with a performance edge over players with less economic capital:

[Participant 9] *A lot of players here have chefs. A lot of players here have physio as well and so do I. As you are getting older, in your career, time is running out as well. So, you want to maximize everything in a short career. It's not uncommon that a lot of people here will have a chef.*

[Participant 4] *For me, it was just easy because I didn't have to cook. I didn't have to make snacks. I have everything in the fridge that I need. If I come back from training and I go hungry, I have some snacks that they will send me. I can just take out the fridge and eat. For dinner, I can just put in a microwave and eat it. For me, it's just easy. I know it's good food as well.*

Furthermore, there has been a remarkable increase in revenue within clubs. The top 20 soccer clubs generated over €10.5 billion in 2022/23 season (Deloitte Football Money League, 2024). The increase in economic capital has led to a significant improvement in nutrition provision in soccer clubs. Previously, the clubs were not able to afford foods pre and post training as described by participant 3 “*There is no breakfast or lunch. So, you had to eat at home.*” Now, EPL players are served with a wide range of high-quality foods:

[Participant 3] *Compulsory breakfast...just order when you turn up. Like get me one omelette, poached eggs so it will be that. Training will be at 10.30 am, done by 12.30 pm on the pitch. And then, just go up for lunch when you want to go up. There was literally like a buffet, to be fair, really good quality food. Each day they will do it like a live station; they will make different meals each day.*

[Participant 3] *The quality of the food got a lot better. The big thing there was probably post-game. When I first went there, there was pizza and that kind of stuff*

whereas by the end, there was lasagne. For the home game, there will be hot foods to be cooked fresh after. There was probably the big change to go away from after the game you can just eat whatever you want like pizza, wedges, tomato ketchup to actually eating a nutritious meal.

Certain clubs have adopted a menu-based system, enabling players to select their own foods. Additionally, players are given the options to take home any meal of their preference:

[Participant 10] *It's exactly like a restaurant. People came up to you with the food, you said what you wanted. Imagine if today you say no chicken, but fish and they will make fish for you. If you want rice or pasta, they will make it for you. There's always something you can eat and want to eat so I really like it. Also, I can say that I want to eat this tonight and they will make it for you, and you can take it back home. For me, it was perfect.*

In essence, economic capital significantly influences professional players' dietary habits by affording them access to amenities like personal chefs or meal services. Access to higher quality food provision enables players to better meet the physical demands and expectations of professional soccer, helping them to secure and maintain top position within the field. In contrast, players with less economic capital may face significant disadvantages, struggling to compete on an uneven playing field. The considerable earnings of EPL clubs reflect the increased economic capital in the sport, leading to better nutrition provision. This shift has expanded food choices, introducing menu-based systems where players can choose meals and take them home. Such improvements highlight economic capital's role in enhancing players' performance and overall

health as financial burden is often cited as a major challenge to optimal dietary practice (Logue et al., 2021).

3.4.4 An unequal distribution of economic capitals has led to hierarchical practice in the performance nutrition field with personalised nutrition being somewhat enacted at the higher levels.

Field is a social arena that is organised around specific types of capital (Bourdieu and Nice, 1980). Data from this study revealed the field of performance nutrition has undergone swift evolution due to the changes in economic capitals mentioned in the preceding theme. However, there exists a hierarchy in nutritional provision resulting from the unequal distribution of economic capital. For instance, the data shows there is a clear disparity between the level of nutrition support between academy and first team players. First team players have access to high quality foods with more variety and periodised options tailored to their individual needs compared to academy players who have a one size fits all, standardised provision:

[Participant 6] *When I come over to the first team site, there's a lot more options. The academy side has less options. It's a massive upgrade when you come up to the first team site. You're able to pick from a much wider variety of things so you don't end up getting bored or eating the same thing. In the academy, I think sometimes they don't appreciate the portion sizes in terms of you might have a game, but it was not very specific. Then, when you get into the first team, it's more specific about certain days, the portion sizes will be bigger, you know how it works. More carbs and less carbs depending on where you are in the week.*

[Participant 5] *When I was in the academy, we didn't have breakfast, we only had a lunch meal post training and it's kind of dependent on where we were training on that day. We didn't have a training ground. It's just the first team that has the training ground. It happened for most of my time in the academy. A little pasta box from a local café was our lunch.*

Moreover, in other soccer leagues with less economic capital relative to the EPL, sports nutrition support frequently receives minimal attention or recognition. For example, participant 2 reported that when he was on loan in Sweden, “*there was no nutritionist and no food at the training ground. I make everything myself, breakfast, lunch, and dinner.*” Furthermore, in Germany, there was a limited variety of food options available for them to choose from, as described by participant 12:

You don't have a lot of choices to get your food. Not like here, where you can say I want this, and I want this to take home. There were 5-7 things that you could grab. If you want to take food home, you have to take from these 7 things, they are not making anything new for you.

Economic capital between and within clubs therefore plays a significant role in shaping the development of performance nutrition in soccer clubs. It highlights a hierarchical discrepancy in nutrition provision between academy and first team players, with the latter receiving superior and personalized support. These disparities also extend to different soccer leagues, particularly those outside of the EPL often providing minimal nutritional support. These findings correspond with a recent audit, which highlighted that category one soccer academies in the United Kingdom, benefitting from greater economic capital, are able to employ more full-time nutritionists, provide

more service hours and offer better on-site nutrition compared to lower-category academies (Carney et al., 2023). The ability to invest in superior nutrition services allow wealthier clubs to convert economic capital into cultural capital, thereby gaining a performance advantage. This competitive advantage not only reinforces their dominant status within the soccer leagues but also contributes to increased revenue generation (Deloitte Football Money League, 2024). Consequently, a hierarchy emerges between higher and lower league clubs, with wealthier clubs advancing while lower league clubs struggle, leading to stagnation and a widening performance gap. Additionally, similar hierarchical differences in economic capital are evident between elite male and female soccer players, with female players experiencing subpar food quality and unmet dietary needs (McHaffie et al., 2022), in contrast to their male counterparts. These findings emphasize the importance of economic resources in influencing performance nutrition and underscore the necessity for fairer distribution of nutrition resources across the sport.

3.4.5 Body composition measurement is a ‘doxic’ practice in professional soccer that warrants challenge.

According to Bourdieu (1990), doxa is a form of social knowledge that is deeply ingrained in individuals and serves to maintain and reproduce existing social hierarchies and structures. It manifests in practices that are rarely explicitly articulated or questioned by individuals within a society. Rather, it functions at a subconscious level, shaping people's perceptions, judgments, and behaviours without their explicit awareness (Throop and Murphy, 2002). Within professional soccer cultures studied herein, there exists a doxic belief about the ideal body composition for the players. This belief is often driven by the coaches as suggested by participant 2, *“It came from the coaching staff. It was very old school. You just had to be low [in body fat]. It is just a broad thing*

that lower is better". Furthermore, doxa can lead to biases in the evaluation of players based on their body composition. In this culture, players who do not meet expected body composition standards may be seen as unprofessional or lazy whereas players who fit the perceived ideal body type may be favoured over those who do not. This can perpetuate stereotypes and limit opportunities for players who fall outside of the normative body standards:

[Participant 2] *But I think high body fat is often perceived as you are eating bad, or you are lazy.*

[Participant 5] *There is a thing in soccer where people's body fat is analysed and they use that as be-all and end-all of how fit or how professional or how ready you are for the game. In a high stress and high-performance environment, something small like body composition being a little bit too high, for some managers, it can change their mind on a player and change their opinion on how the players live their lives.*

Subsequently, managers could exert significant influence over the food provision based on their beliefs about body composition by dictating the options available to players at training ground and introducing new body composition measurement method:

[Participant 6] *He really cares about body fat. The DXA has been introduced and the food has completely changed. We have to start ordering from the app. Before, it was always the buffet and we selected what we wanted. He was the most on it. To be fair, my body fat came down so much. We became really fit but I do think that was perhaps a little bit overboard. He really wants to control everything.*

Furthermore, managers will enforce a certain body composition target that reflects their doxic belief:

[Participant 2] *When I was younger, I was told that my body fat needed to be below 10%. They used to be very strict about it. Of course, naturally people are different, we have someone in the team who ate terribly but their body fat is super low. If it was me, I could go up and down a lot. It doesn't take much to change it.*

The pressure to attain unrealistic body composition standards is a manifestation of the symbolic violence exerted by the coaches. This pressure induces stress and anxiety among players, as exemplified by participant 5, *"I know that some players, not necessarily myself, if they are in a position where their body composition are a bit high, they get stressed about it and their anxiety is high because they think that they could influence the manager's decision if they play game."* These entrenched doxic beliefs within the field necessitate conformity, compelling players to modify their dietary practices, which are shaped by their habitus, to align with the desirable body composition standards.

[Participant 2] *It was difficult when we were in digs. When we left here, we were living in host accommodation. I got home and I had nothing to do. I was hungry. When I got nothing to do, I was bored, I just wanted to eat. I tried to not have snacks.*

Furthermore, players with low embodied cultural capital such as those who are not naturally lean fear clear disadvantage in meeting these body composition standards. This lack of embodied

cultural capital can place additional pressure on them, as they must put in more effort to meet the same physical expectations as those who have benefitted from more favourable conditions.

[Participant 3] *I had this last year as well when I first came in, they said “Oh, we’ll get you under xx kg.” But I have not been under xx kg since I was 19. I actually felt so much worse about it. You literally do no carbs to go down to that target. I didn’t feel good about it. I didn’t feel strong. I didn’t feel like I had energy to train.*

Conversely, individuals with cultural capital, as those raised in a supportive family environment, often develop a positive habitus that aligns more easily with the expectations in professional soccer. As participant 6 described *“it was never a massive moment where I was like “Wow, I need to change completely”. I always eat relatively healthy... There was never a big moment that I have to change. I was fortunate that my mum was always able to cook really well and always make sure I’m eating healthy, eating fruit and vegetables.”* This upbringing, embedded with optimal nutritional practices, enabled participant 6 to effortlessly meet the body composition standards expected in soccer, as he stated, *“my body fat and skinfold have always been quite low.”*

While body composition is presented as objective measures of a player’s physical readiness, it can sometimes be applied selectively to justify or overlook certain players’ performances. For instance, players with significant social capital within the club, such as star players or team captains, may receive more leniency, where their body composition results are either downplayed or disregarded entirely. In contrast, players lacking this social capital might face stricter scrutiny, with their body composition being used as a decisive factor in evaluating their performance or commitment. This selective application of standards can mask favouritism or entrenched biases, as the focus of body

composition, in reality, reflects subjective dynamics between players and coaches. These underlying biases in body composition standards were verified during the process of member checking.

Deeply ingrained beliefs about body composition in professional soccer, shaped by coaches, may have an adverse impact on players' well-being. These beliefs influence food provision, body composition measurement, and can result in public criticism and penalties for non-compliance, causing stress and anxiety. This pressure often induces unhealthy dietary practices and deters players from seeking support from nutritionists due to fear of embarrassment. These observations align with previous perspectives of professional athletes from the United Kingdom, indicating that coach reinforcement on body composition often elicited an emotional response, negatively impacting athlete adherence to nutritional guidelines and perpetuating further negative effects (Bentley et al., 2021). Similarly, the external pressures to meet body composition targets, coupled with stakeholders' comments, were identified as key factors influencing dietary practice of professional female soccer players (McHaffie et al., 2022). Furthermore, this study highlights how cultural capital, through the consistent access to healthy foods from an early age, can foster the development of a positive habitus, giving players an advantage in meeting body composition standards with minimal difficulty. This finding is consistent with previous research that reported a significant correlation between nutrition knowledge and fat free soft tissue mass in professional soccer players (Devlin et al., 2017b). The selective use of body composition standards can perpetuate inequality within the team, as decisions are influenced more by the social capital of the players. This veneer of objectivity may allow biases to persist unchallenged, under the guise of fairness and performance evaluation.

3.4 Practical Implications and Future Research Directions

Through the lens of Bourdieu's concepts of habitus, capital and field, the present data reveal interconnected themes regarding professional players' perspectives on the nutrition culture, holding significant implications for practitioners in the field. Bourdieu's concepts offer a robust framework for performance nutritionists, helping them comprehend why players choose certain diets, shaped by habitus, field dynamic, capitals (social and economic resources) and doxa (accepted beliefs). For example, understanding players' habitus enables nutritionists to tailor recommendations to align with their preferences, fostering sustainable changes. Recognising field dynamics identifies key capitals shaping nutrition culture, while analysing doxa within cultural context sheds light on why certain nutritional practices are favoured or stigmatized. Consequently, the findings from this study provided profound insights into the factors that facilitate or hinder nutritional adherence among professional players (McHaffie et al., 2022; Carter et al., 2023b), thus enabling a more nuanced understanding for practitioners. Armed with this understanding, practitioners can adeptly manoeuvre through the field, developing contextually relevant and effective strategies for fostering positive dietary habits. This study also highlights the power dynamics in EPL soccer (Harvey et al., 2020), depicting the field as a battleground where players struggle for team selection, a process dominated by coaches. Coaches hold significant power, defining values and maintaining team hierarchy, particularly through their belief that all players must meet specific body composition standards. Players with greater cultural capital (e.g. knowledge and behaviours valued in soccer) are better equipped to meet these expectations, navigating professional soccer field more successfully. In contrast, those whose habitus does not align with these norms often struggle, facing barriers that limit their recognition and opportunities

within the hierarchy. To address these disparities, clubs and practitioners should enhance players' access to cultural capital by providing comprehensive nutrition education, high-quality food, and supportive environments like host families to nurture positive habitus from an early stage. These measures can help players whose habitus may not initially align with the field's expectations, creating a more inclusive environment where all players can succeed. Moreover, our data suggest that practitioners entering a new sport setting would benefit from gaining a thorough understanding of the nutritional culture within that context before introducing any nutritional interventions. Furthermore, universities and professional nutrition accrediting bodies should also provide guidance to prepare aspiring practitioners to comprehend "sports nutrition culture". This may entail integrating Bourdieu's concepts and/or other theoretical models into university curricula, accrediting body competency frameworks and sport-specific practitioner programs that are endorsed by governing bodies (e.g., the EPL). The present study did not include interviews with key stakeholders to avoid information overload and maintain the primary focus on players' experiences. Future research should address this gap by examining the perspectives of key stakeholders on nutrition culture in professional soccer, considering the influence individuals can exert on others' behaviour, as suggested in social conformity theory (Bernheim, 1994). Of particular interest is investigating how body composition has become a deeply ingrained doxic practice within elite soccer. Additionally, the purposive sampling method used may be a potential limitation, as our findings might only reflect the culture and procedures at one club and those willing to participate. Future research should therefore aim to develop a better understanding of the prevalence of such findings within other soccer club settings. Nevertheless, this study allows readers to reflect on this study and assess if the findings resonate with their experiences, the specific setting they operate in, and the people they interact with (Smith and McGannon, 2018).

3.5 Conclusion

In summary, the data demonstrated several critical components of the current nutrition culture within professional soccer. Firstly, habitus emerges as a foundational element, deeply rooted in familial, ethnic and religious backgrounds, that significantly influences players' food preferences and habits. Additionally, social capital, primarily wielded by managers, coaches, teammates and online influences, significantly impacts soccer players' dietary practices. Moreover, economic capital drives advancements in nutrition provision within clubs, enhancing players' access to improved nutrition provision. Nonetheless, the hierarchical nature of the performance nutrition field underscores the unequal access to nutritional support, particularly between academy and first team players and across various leagues. Finally, the pervasive influence of doxic beliefs regarding body composition standards perpetuates biases, leading to public criticism, penalties and stress among players, fostering unhealthy dietary practices and reluctance to seek support from nutritionists. In essence, the findings emphasized the multifaceted nature of nutrition culture within the male professional soccer. Thus, it is imperative for practitioners to grasp the nutrition culture within their own context to facilitate effective implementation of any nutritional intervention. Based on this study, Bourdieu's concepts provide a comprehensive framework for practitioners to understand the complexities of athlete's dietary choices within the specific sport and environment they are working in.

Chapter 4

Energy expenditure of male soccer players from an English Premier League team does not differ between one-game and two-game per week microcycles

The aim of this Chapter was to determine the TDEE, dietary intake, training and match load of male EPL players during a 1GW and 2GW microcycle.

Emma Tester and Panos Markakis assisted with the data collection for this study. Catherine Hambly and John Speakman conducted doubly labelled water analysis for this study.

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4.1 Abstract

Purpose: To determine the TDEE of male EPL players during 1GW and 2GW microcycles, thereby informing CHO guidelines aligned to the increasing physical demands of the game.

Methods: Nine male players from an EPL club were assessed over a 15-day in-season period, including a 1GW followed by a 2GW. Measurements included TDEE (DLW), EI (RFPM) and external physical loading.

Results: Accumulative training and match duration was greater during 1GW (335 ± 22 min) compared to 2GW (307 ± 32 min, $p = 0.013$) whereas average speed was higher in 2GW (73 ± 7 m·min⁻¹) versus 1GW (63 ± 4 m·min⁻¹, $p = 0.012$). No differences were observed in accumulative total (25552 ± 3502 m vs 26360 ± 5462 m), HSR (1744 ± 536 m vs 1705 ± 752 m), or sprint distances (372 ± 150 m vs 324 ± 252 m) between 1GW and 2GW (all $p < 0.05$). Mean TDEE was 3551 ± 507 kcal·day⁻¹, with no difference between 1GW (3554 ± 963 kcal·day⁻¹) and 2GW (3467 ± 821 kcal·day⁻¹, $p = 0.781$). Self-reported EI using RFPM (2975 ± 292 kcal·day⁻¹) underestimated DLW derived EI estimates (3663 ± 665 kcal·day⁻¹) by 724 ± 722 kcal·day⁻¹ (18% error, $p = 0.026$).

Conclusion: TDEE in male EPL soccer players does not differ between 1GW and 2GW microcycles, likely due to the comparable external loads. Data provide further evidence that daily CHO intakes should likely range from 4-6 g.kg⁻¹ on training days, increasing to 6-8 g.kg⁻¹ for match day preparation, match day and recovery.

4.2 Introduction

In 2020, UEFA published an expert consensus statement providing the most recent evidence-based nutritional guidelines for elite soccer players (Collins et al., 2021). These guidelines recommend that a player's daily CHO intake should be adjusted on a sliding scale between 3 to 8 g·kg⁻¹BM·day⁻¹, as dependent on the nature of the weekly microcycle (e.g. training demands and games schedule) and players' body composition goals. Additionally, players are advised to consume approximately 1.6 g·kg⁻¹BM of protein daily (distributed evenly across four servings of 0.4 g·kg⁻¹BM throughout the day) and it also recommended that dietary fat intake should comprise 20-35% of a player's total daily EI (Collins et al., 2021). Although these guidelines represent considerable progress in tailoring nutrition to the needs of elite players as compared to historical guidelines for soccer (Clark, 1994; Burke et al., 2011), it is noteworthy that those studies involving professional soccer players as participants are sparse. Indeed, in Chapter 2 of this thesis, the evidence base from 1973 to 2024 that formulate CHO guidelines for soccer players was evaluated, it was reported that 24% of studies (n = 258) directly involved professional players, and only 2% was conducted in world class players (defined as 'starters' from the highest-ranked nations and teams within the most competitive leagues). The findings from Chapter 2 clearly demonstrate the necessity for further nutrition related research that is specific to the elite player, so that nutritional strategies can be optimised for this population.

To formulate nutritional guidelines and recommendations for professional soccer players, it is important to first understand their energy requirements. In this regard, the DLW technique (Ebine et al., 2002; Anderson et al., 2017b; Brinkmans et al., 2019) represents the most accurate non-invasive method to assess TDEE in free-living conditions across a 7-14 day period. Despite the

methodological advantages of this approach, the understanding of the energy requirements of male adult professional players remains constrained by the scarcity of studies. Indeed, in players studied during the 2015-2016 season, we provided the first report to quantify absolute (3566 ± 585 kcal·day⁻¹) and relative (45 ± 8 kcal·kg BM⁻¹·day⁻¹) TDEE in professional players from the EPL, as assessed during a two-game-per-week microcycle (Anderson et al., 2017b). In the same 2015-2016 season, Brinkmans et al. (2019) also assessed the TDEE of 41 players from three different Dutch Eredivisie clubs over a 14-day period (where players competed in an average of 2 ± 1 matches) and observed lower absolute (3285 ± 354 kcal·day⁻¹) and relative (42 ± 4 kcal·kg BM⁻¹·day⁻¹) TDEE.

Given the limited research base as highlighted in Chapter 2, further research specific to elite players is essential to optimise nutrition strategies. This is particularly important as prior assessments of players' TDEE are nearly a decade old and the physical demands of elite soccer have increased during this period. For instance, between the 2014/15 and 2018/19 seasons, HSR and sprint distances during EPL matches have increased significantly by ~12% and ~15%, respectively (Allen et al., 2024). These trends reflect the growing pace of the game, suggesting that high intensity actions will continue to rise as teams adopt more pressing, counter-pressing and counter attacking strategies (Nassis et al., 2020). Such tactical evolutions fundamentally alter gameplay, exposing players to more frequent and intense bursts of accelerations and decelerations, interspersed with increased HSR actions (Harper et al., 2021). In light of these evolving match demands, there is also a requirement to further study the energy requirements and physical loading patterns across both 1GW and 2GW microcycles. EPL players performed significantly greater total, HSR and sprint distances during 2GW compared to 1GW (Anderson et al., 2016b), indicating

that a 2GW microcycle is more physically demanding than 1GW. However, no studies to date have directly compared the TDEE of elite soccer players between 1GW and 2GW microcycles. This creates a significant gap in the understanding of how energy demands fluctuate across different match schedules, making it difficult to develop fully informed nutritional strategies for elite soccer players. As a result, the knowledge of the energy requirements of professional soccer players, particularly those in the EPL, remains limited.

With this in mind, the aim of the present study was to simultaneously quantify the TDEE, EI, training load and match load in male professional soccer players. A cohort of professional EPL players was investigated during a 15-day in-season period, encompassing a 1GW microcycle followed by a 2GW microcycle, to facilitate direct comparisons of TDEE across the two microcycles.

4.3 Methods

4.3.1 Participants

Twelve male professional soccer players from an EPL soccer club volunteered to take part in the study. Three players were removed from the study due to injuries ($n = 1$) or incomplete data collection ($n = 2$). Participant characteristics of the players who completed the study are presented in Table 4. All experimental procedures and associated risks were explained to players and written informed consent was obtained. The study was conducted according to the Declaration of Helsinki and was approved by the University Ethics Committee of Liverpool John Moores University (23/SPS/052).

Table 4. Baseline characteristics of the participants.

Position	Goalkeepers (n = 2)	Defenders (n = 3)	Midfielders (n = 3)	Attackers (n = 1)	Squad (n = 9)
Age	31 ± 6	25 ± 5	26 ± 3	23	26 ± 4
Height (cm)	196.5 ± 2.1	180.3 ± 5.4	181.0 ± 4.6	185	185.4 ± 7.0
Body Mass (kg)	95.8 ± 10.8	81.4 ± 5.9	82.4 ± 5.3	84.6	85.3 ± 8.2
Predicted Resting Metabolic Rate (kcal·day⁻¹)	1956 ± 169	1931 ± 77	1942 ± 144	2000	1988 ± 129
Total Daily Energy Expenditure (kcal·day⁻¹)	3529 ± 638	3797 ± 228	3213 ± 505	3469	3551 ± 507
Physical Activity Level	1.81 ± 0.33	1.96 ± 0.10	1.66 ± 0.26	1.73	1.78 ± 0.20
Total Years of Competitive Participation	14 ± 5	7 ± 5	8 ± 3	5	8 ± 5
Number of EPL appearances	124 ± 44	154 ± 139	185 ± 78	116	154 ± 86
Players' Continent of Origin	Europe (n = 2)	Europe (n = 3)	Europe (n = 2), Africa (n = 1)	Europe (n = 1)	Europe (n = 8), Africa (n = 1)

4.3.2 Overview of Study Design

An overview of the experimental protocol is shown in Figure 6. Data collection was conducted during the 2023/24 EPL in-season across the months of November and December. Participants continued with their normal in-season training that was prescribed by the club's coaching staff and were available to perform in three competitive games on days 2, 9 and 13 during data collection. During data collection, games 1, 2 and 3 kicked off at 14:00, 16:30 and 20:15, respectively. Games 1 and 3 were home fixtures while game 2 was an away fixture.

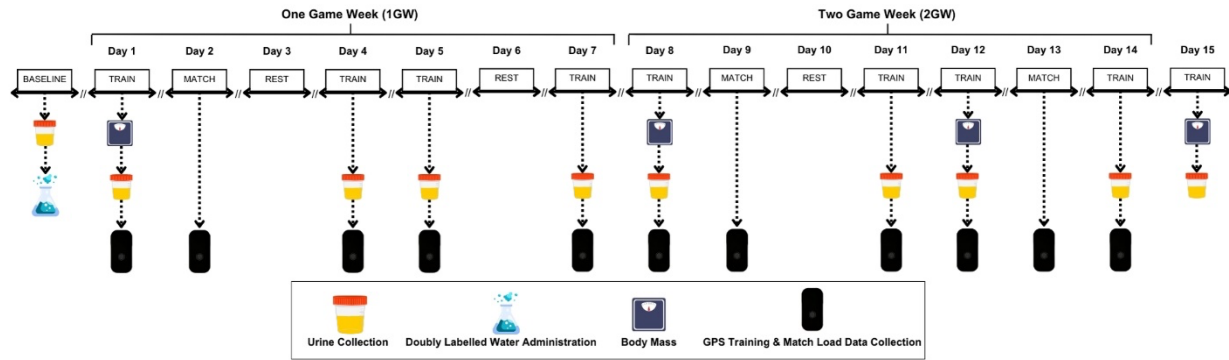


Figure 6. Schematic overview of data collection period

4.3.3 Quantification of Training and Match Load

Pitch based training sessions were monitored using portable Global Positioning System (GPS) units (STATSports, APEX Athlete Series, Northern Ireland) as previously described in professional soccer players (Anderson et al., 2016a; b). The STATSports APEX units have previously demonstrated excellent inter-reliability for 5-30 m sprint measurements (Beato and de Keijzer, 2019), with reported technical errors of measurement of 2.76 m for total distance, 8.90 m for HSR distance, 3 for acceleration (ACC) and 2 for deceleration (DEC) (Beato et al., 2024). The GPS unit was placed inside a custom-made manufacturer provided vest (Apex; STATSports) that held the unit on the upper back between both scapulae, allowing clear exposure of the GPS antennae to acquire a clear satellite connection. The physical output was only available for outfielders as club practice dictates goalkeepers (GK) do not wear GPS units in training. Players' match data were examined using a computerized semi-automatic video match-analysis image recognition system (Second Spectrum[®], Los Angeles, USA) and were collected using the same methods as Ellens et al. (2022). This system has been independently validated to verify the capture process and subsequent accuracy of the data (Di Salvo et al., 2009). Physical indicators were coded

into the following activities: HSR (19.8–25.2 km·h⁻¹), sprinting (>25.2 km·h⁻¹). ACC was defined as the number of ACC >3 m·s⁻² whereas DEC was defined as the number of DEC >-3 m·s⁻².

4.3.4 Measurement of TDEE via DLW

TDEE was determined via the DLW method (the criterion standard method of measuring energy expenditure in free-living conditions) previously used in professional soccer players (Anderson et al., 2017b; Morehen et al., 2022; Stables et al., 2023). Baseline urine samples were collected in a 20-mL tube. Following collection of baseline samples, players were orally administered a single bolus dose of DLW containing the isotopes deuterium (²H) and oxygen-18 (¹⁸O) in the form of water (²H₂¹⁸O) with a desired enrichment of 10% ¹⁸O and 5% ²H₂ using the calculation:

$$\text{Dose (mL)} = 0.65 (\text{BM, g}) \times \text{DIE/IE}$$

Where 0.65 is the approximate proportion of the body comprised of water, DIE is the desired initial enrichment in the body ($\text{DIE} = 618.923 \times \text{BM (kg)}^{-0.305}$) and IE is the initial dose enrichment (10%) 100,000 parts per million (Speakman, 1997) dosed according to BM. To ensure the whole dose was administered, participants were observed consuming each bolus dose and each glass vial was refilled with additional water which players were asked to consume. Time of dosing was recorded and accurate weight of the dose. Isotopes were purchased from Sercon (Cheshire, UK).

In the morning of day 1 (08:00-11:00), BM was assessed (SECA, model-875, Dorset, UK) and urine samples were collected to determine the initial isotope enrichment following total body water (TBW) equilibrium (Speakman, 1997). Thereafter, BM was collected during the morning of days

8, 12 and 15 and urine samples were collected during the morning of days 4, 5, 7, 8, 11, 12, 14 and 15 (in line with logistical constraints) to determine elimination rates of both isotopes via the multipoint method (Westerterp, 2017). Urine samples were aliquoted into cryovials after collection on the same day.

For the DLW analysis, urine was encapsulated into capillaries, which were then vacuum distilled (Nagy, 1983) and water from the resulting distillate was used. This water was analysed using a liquid water analyser (Los Gatos Research; (Berman et al., 2012)). Samples were run alongside three laboratory standards for each isotope and three International standards (Standard Light Arctic Precipitate-2, Standard Mean Ocean Water-2 and Greenland Summit Precipitation) (Craig, 1961; Speakman, 1997) to account for machine day to day variation and correct delta values to parts per million. Daily isotope enrichments were \log_e converted and the elimination constants (k_o and k_d) were calculated by fitting a least squares regression model against sample time. The back extrapolated intercept was used to calculate the isotope dilution spaces (N_o and N_d). Isotope elimination rates and dilution spaces were converted to TDEE using an updated two-pool model equation (Speakman et al., 2021) and a mean calculated food quotient of 0.85 ± 0.2 . The results from the TDEE are expressed as a daily average from the 15-day data collection period. Two participants had enrichment values approaching background levels by day 15; therefore, data from these time points were excluded from analysis. TDEE was also calculated separately for 1GW and 2GW microcycle. For the 1GW microcycle, isotope data were processed using the standard procedure: daily enrichment was corrected for background levels and was \log_e converted to linearise the data. The elimination constants (k_o and k_d) were calculated from the gradient of enrichment washout over time. Enrichment values were then back extrapolated to the time of

dosing to calculate TBW and dilution spaces (N_o and N_d). For the 2GW microcycle, the same body water pool size was retained, while the k_o and k_d values were recalculated based on the updated isotope enrichment data and associated sampling times.

4.3.5 Measurement of Physical Activity Level

Physical activity level (PAL) was determined by dividing the TDEE by the resting metabolic rate (RMR), with the latter estimated via the Harris-Benedict equation (Harris and Benedict, 1918), an equation found to be the most accurate in male athletes (Jagim et al., 2018).

4.3.6 Assessment of Energy and Macronutrients Intake

Energy and macronutrient intake was measured via two methods on four days over the data collection period, including a training day, MD-1, MD and MD+1. Due to practical constraints inherent to the applied setting, a staggered sampling approach was adopted, whereby 2–3 players were assessed per day rather than all nine concurrently. Prior to the data collection, participants were briefed individually about the process of how to collect dietary intake using the RFPM (Martin et al., 2009). The individual briefing session was delivered by the researcher who is accredited by the Sport and Exercise Nutrition Register (SENr) and has four years of experience working with this population.

Firstly, at mealtimes (breakfast and lunch), the dietary intake was assessed via weighed food inventory, which has been previously used alongside DLW with professional soccer players (Morehen et al., 2022). As a menu-based system is utilised in the club, the main meals were weighed with a calibrated weighing scale (Model 405, Salter Brecknell Weighing, West Midlands,

United Kingdom) before serving to the participants. Participants subsequently used the RFPM to self-report additional food items consumed at mealtimes (e.g. salad, fruits, beverages etc.) and any foods consumed for dinner and snacks. The RFPM had previously employed by this research group within similar age groups (Anderson et al., 2017b). When using the RFPM to assess all food and drink they consume, participants are required to take a photo prior to consumption at 90° angle. Participants will then send a short description of the food within the images to the principal investigator on a smart phone via WhatsApp. The aim of the short description was to provide the principal investigator with as many details as possible (i.e. information on quantities, brands, preparation and cooking methods) to assist with the accuracy of the data analysis. Furthermore, most meals were consumed under the supervision of club nutritionists, including a registered dietitian and a SENr-Practitioner registrant, who provided support to players in accurately documenting meal details and capturing food photographs. Additionally, 24-h recall was performed with all participants on the day after each dietary assessment using the triple-pass method to ensure players did not omit any foods/drinks and to cross-check the two sources of dietary intake information (Capling et al., 2017). Dietary intake was analysed by the principal investigator using the dietary analysis software (Nutritics v5, Dublin, Ireland), which calculates the energy and macronutrient intake for each participant. The estimated EI was reported in kilocalories per day ($\text{kcal}\cdot\text{day}^{-1}$) and macronutrient intake was reported in grams per day ($\text{g}\cdot\text{day}^{-1}$) and grams per kilogram BM per day ($\text{g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$).

4.3.7 Assessment of EI using the DLW Method

EI was calculated using the DLW method through the adjustment of TDEE for changes in energy stores, as outlined previously by Schulz et al. (1992). This was measured from day 1 up until the

final day (day 15). The equation used was $EI \text{ (kcal}\cdot\text{day}^{-1}) = TDEE \text{ (kcal}\cdot\text{day}^{-1}) + \text{changes in energy stores (kcal in grams of body fat} + \text{kcal in grams of fat free mass (FFM) changes)}$. As outlined by Schulz et al. (1992), this was estimated with the assumption that $\frac{2}{3}$ of change in BM was metabolic and $\frac{1}{3}$ was water and that $\frac{3}{4}$ of the change in metabolic weight was fat mass and $\frac{1}{4}$ was FFM. For weight loss, $9 \text{ kcal}\cdot\text{g}^{-1}$ of fat mass and $1 \text{ kcal}\cdot\text{g}^{-1}$ of FFM and for weight gain, it is assumed $13.2 \text{ kcal}\cdot\text{g}^{-1}$ of fat mass and $2.2 \text{ kcal}\cdot\text{g}^{-1}$ of FFM (Forbes et al., 1986).

4.3.8 Recommended Relative Daily CHO Intakes

Recommended relative daily CHO intakes ($\text{g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) are calculated for each player to align with TDEE and maintain energy balance, based on an assumed daily protein intake of $1.6 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$ and dietary fat contributing 30% of total daily EI.

4.3.9 Statistical Analysis

All data were initially assessed for normality of distribution using Shapiro-Wilk's test. Differences in training load, match load, daily energy and macronutrient intake and changes in BM were analysed using one-way repeated measures ANOVA. When there was a significant ($p < 0.05$) effect of "day", Bonferroni post hoc pairwise comparisons were performed to identify which day differed. Differences between TDEE and self-reported EI, TDEE between 1GW and 2GW, self-reported EI and DLW-estimated EI, training and match load between 1GW and 2GW were analysed using a paired sample t-test. Effect sizes (ES) for the paired sample T-test were calculated and interpreted as follows: trivial (≤ 0.20), small ($0.20-0.59$), medium ($0.60-1.19$), large ($1.20-1.99$), and very large (≥ 2.00) (Hopkins et al., 2009). Ninety-five percent confidence interval

(95%CI) for the differences are also presented. The strength of association between TDEE and accumulative load and DLW and RFPM EI measurements was assessed using Pearson (r) correlation analysis, employing the following criteria to explain the relationship of association: trivial (<0.1), small (0.1-0.29), moderate (0.3-0.49), large (0.5-0.69), very large (0.7-0.89) and almost perfect (0.9-1.00) (Hopkins et al., 2009). 95%CI for the correlation is also presented. To assess the validity of the RFPM, we evaluated its accuracy by calculating the percentage error in EI measurements taken with RFPM, using EI measured by DLW method as the reference standard. The percentage error was determined by comparing the observed values from RFPM to the true values obtained from DLW. Additionally, the percentage difference between these two methods was calculated to further quantify discrepancies in measurement accuracy. All statistical analyses were completed using SPSS (version 29, SPSS, Chicago, IL) where $p < 0.05$ is indicative of statistical significance. Data are presented as mean \pm standard deviation (SD).

4.4 Results

4.4.1 Quantification of Daily and Accumulative Weekly Load (n = 7)

Figures 7 and 8 provide an overview of daily and weekly training and match loads. Accumulative weekly training and match duration was significantly higher in 1GW (335 ± 22 min) than 2GW (307 ± 32 min, 95%CI of mean difference = 9 to 49 min, ES = 1.32, $p = 0.013$; Figure 8A). Accumulative training duration was greater in 1GW (254 ± 17 min) than 2GW (157 ± 36 min, 95%CI of mean difference = 67 to 126 min, ES = 3.04, $p < 0.001$) while match duration was higher in 2GW (150 ± 58 min) than 1GW (82 ± 35 min, 95%CI of mean difference = 25 to 111 min, ES = 1.46, $p = 0.008$). Individual accumulative training and match duration was summarised in Table 5. Accumulative weekly total distance was comparable between 1GW (25552 ± 3502 m) and 2GW

(26360 ± 5462 m, 95%CI of mean difference = -2762 to 4380 m, ES = 0.21, $p = 0.599$; Figure 8B). The total distance covered during training was significantly greater in 1GW (17024 ± 1528 m) compared to 2GW (9214 ± 2035 m, 95%CI of mean difference = 5741 to 9878 m, ES = 3.49, $p < 0.001$). Conversely, the total distance covered during games was significantly lower in 1GW (8528 ± 3716 m) compared to 2GW (17146 ± 6734 m, 95%CI of mean difference = 3322 to 13914 m, ES = 1.51, $p = 0.007$). Overall average speed was significantly lower in 1GW than 2GW (63 ± 4 m·min⁻¹ vs 73 ± 7 m·min⁻¹, 95%CI of mean difference = 3 to 18 m·min⁻¹, ES = 1.35, $p = 0.012$; Figure 8G). However, significantly greater average speed during training was reported in 1GW when compared to 2GW (68 ± 5 m·min⁻¹ vs 51 ± 6 m·min⁻¹, 95%CI of mean difference = 9 to 24 m·min⁻¹, ES = 2.01, $p = 0.002$) but no significant difference in average speed during matches was observed between 1GW (105 ± 14 m·min⁻¹) and 2GW (117 ± 8 m·min⁻¹, 95%CI of mean difference = -3 to 27 m·min⁻¹, ES = 0.74, $p = 0.098$).

No significant difference was found in accumulative weekly HSR distance between weeks (1GW = 1744 ± 536 m; 2GW = 1705 ± 752 m, 95%CI of mean difference = -379 to 458 m, ES = 0.09, $p = 0.434$; Figure 8C). However, the accumulative weekly HSR distance in 1GW was greater during training (894 ± 229 m vs 155 ± 85 m, 95%CI of mean difference = 574 to 904 m, ES = 4.14, $p < 0.001$) but lower during matches (850 ± 384 m vs 1550 ± 704 m, 95%CI of mean difference = 287 to 1113 m, ES = 1.57, $p = 0.006$) when compared to 2GW. Similarly, no significant difference in accumulative weekly sprint distance was reported between weeks (1GW = 372 ± 150 m; 2GW = 324 ± 252 m, 95%CI of mean difference = -140 to 237 m, ES = 0.24, $p = 0.551$; Figure 8D). Accumulative weekly sprint distance during training was greater in 1GW than 2GW (167 ± 77 m vs 8 ± 15 m, 95%CI of mean difference = 90 to 226 m, ES = 2.16, $p = 0.001$); however, no

significant difference was observed during matches between 1GW (206 ± 124 m) and 2GW (316 ± 239 m, 95%CI of mean difference = -51 to 270 m, ES = 0.63, $p = 0.145$). Accumulative weekly total ACC and DEC were significantly higher in 1GW than 2GW (ACC = 310 ± 46 vs 249 ± 32 , 95%CI of mean difference = 28 to 94, ES = 1.72, $p = 0.004$; DEC = 246 ± 33 vs 222 ± 35 , 95%CI of mean difference = 6 to 40, ES = 1.27, $p = 0.015$; Figures 8E & 8F). During training, accumulative weekly total ACC and DEC were significantly greater in 1GW than 2GW (ACC = 247 ± 32 vs 131 ± 50 , 95%CI of mean difference = 64 to 170, ES = 2.04, $p = 0.002$; DEC = 173 ± 26 vs 86 ± 45 , 95%CI of mean difference = 53 to 120, ES = 2.36, $p < 0.001$). Conversely, significantly higher accumulative weekly total ACC and DEC during matches were observed in 2GW than 1GW (ACC = 118 ± 44 vs 62 ± 24 , 95%CI of mean difference = 31 to 81, ES = 2.04, $p = 0.002$; DEC = 136 ± 57 vs 73 ± 34 , 95%CI of mean difference = 18 to 109, ES = 1.29, $p = 0.014$).

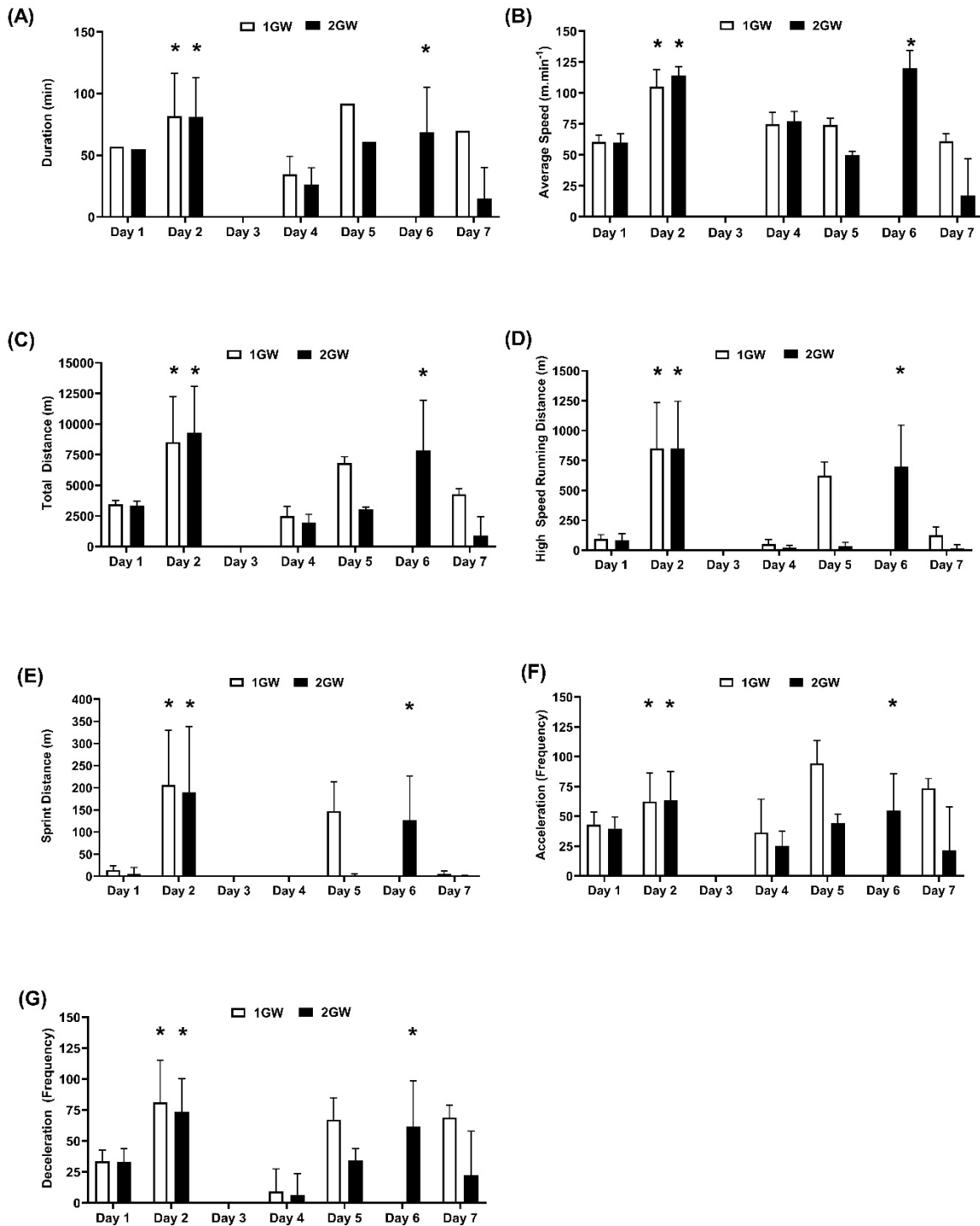


Figure 7. Daily training and match load variables for duration (A), average speed (B), total distance (C), HSR distance (D), sprint distance (E), acceleration (F) and deceleration (G).

*Indicates match days (day 2 in 1GW, days 2 and 6 in 2GW).

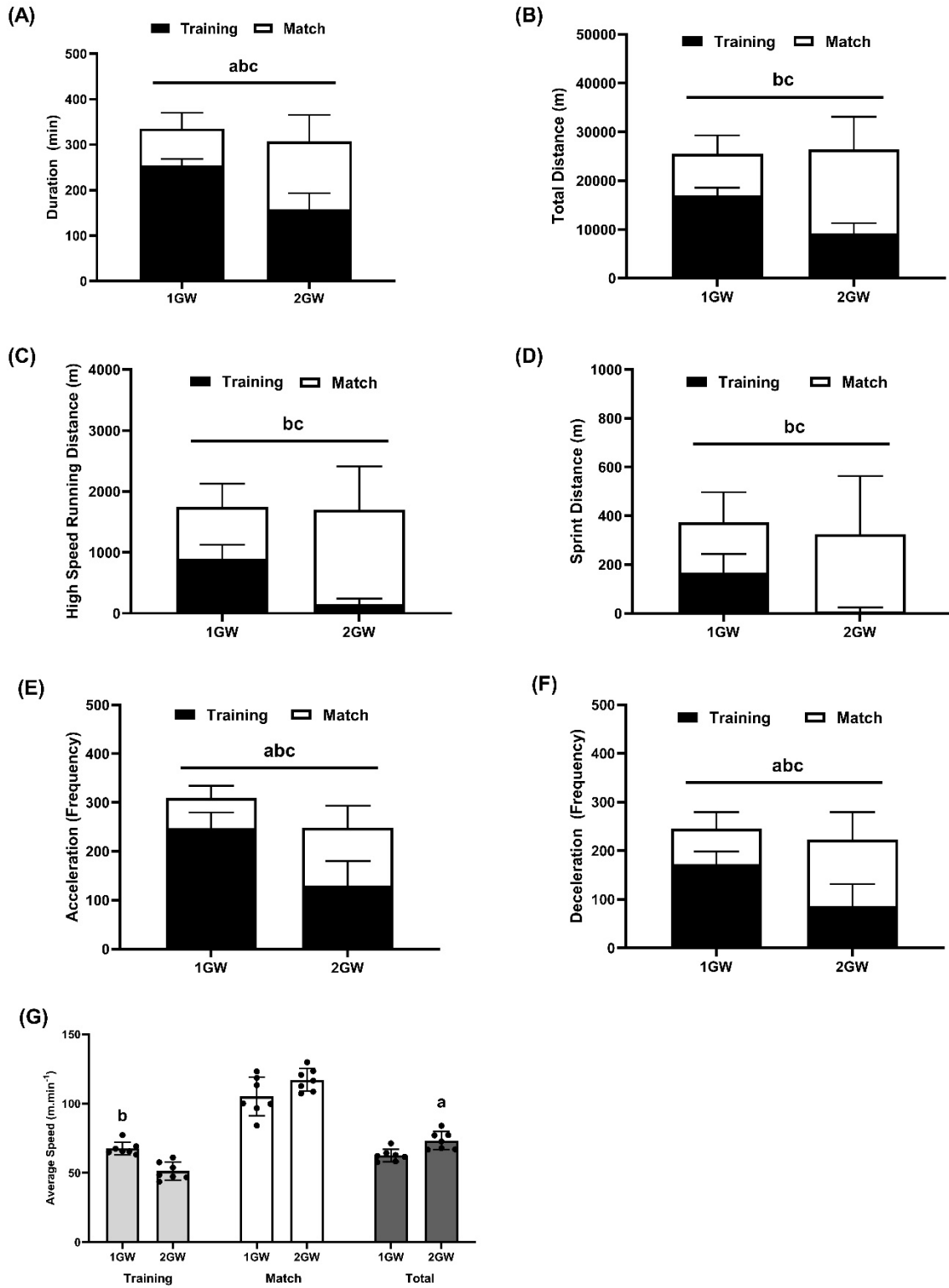


Figure 8. Accumulative weekly training and match load variables completed in the testing period for duration (A), total distance (B), HSR distance (C), sprint distance (D), total accelerations (E), total decelerations (F) and average speed (G). ^aSignificant difference in total weekly accumulative external load between 1GW and 2GW ($p < 0.05$). ^bSignificant difference in weekly accumulative training load between 1GW and 2GW ($p < 0.05$). ^cSignificant difference in weekly accumulative match load between 1GW and 2GW ($p < 0.05$).

Table 5: Individual accumulative training and match duration.

Player	Training Duration in 1GW (min)	Training Duration in 2GW (min)	Match Duration in 1GW (min)	Match Duration in 2GW (min)
Player 1	275	137	41	175
Player 2	245	137	107	198
Player 4	245	137	75	121
Player 5	245	137	107	198
Player 6	245	189	107	108
Player 7	275	225	27	49
Player 8	245	137	107	198
Mean ± SD	254 ± 15	157 ± 36	82 ± 35	150 ± 58

4.4.2 TDEE, Resting Metabolic Rate and Physical Activity Level (n = 9)

TDEE, RMR, PAL and recommended relative daily CHO intakes are outlined in Table 6. There was a significant difference between TDEE ($3551 \pm 507 \text{ kcal}\cdot\text{day}^{-1}$) and mean EI ($2975 \pm 292 \text{ kcal}\cdot\text{day}^{-1}$, 95%CI of mean difference = 151 to 1003 $\text{kcal}\cdot\text{day}^{-1}$, ES = 1.04, $p = 0.014$). Furthermore, there was no significant difference between absolute TDEE in 1GW ($3554 \pm 963 \text{ kcal}\cdot\text{day}^{-1}$) and 2GW ($3467 \pm 821 \text{ kcal}\cdot\text{day}^{-1}$, 95%CI of mean difference = -605 to 777 $\text{kcal}\cdot\text{day}^{-1}$, ES = 0.10, $p = 0.781$; Figure 9A). Similarly, the relative TDEE in 1GW ($41.7 \pm 11.3 \text{ kcal}\cdot\text{kg BM}^{-1}$

$\cdot\text{day}^{-1}$) was not significantly from relative TDEE in 2GW ($40.5 \pm 8.9 \text{ kcal}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$, 95%CI of mean difference = -7.3 to $9.6 \text{ kcal}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$, ES = 0.11, $p = 0.756$; Figure 9B).

1 **Table 6.** Individual data including BM at baseline, change in BM during the data collection period, TDEE, EI measured using the RFPM,
 2 estimated EI using the DLW method, delta difference between both EI methods, percentage difference and percentage error with the
 3 DLW method assumed to be the true value. Recommended individual CHO intakes are also suggested for each player in an attempt to
 4 match energy requirements and energy balance, assuming a daily protein intake of 1.6 g·kg BM⁻¹·day⁻¹ and dietary fat intake equivalent
 5 to 30% of total daily EI.

Player	Baseline BM (kg)	BM Change (kg)	TDEE (kcal·day ⁻¹)	Relative TDEE (kcal·kg BM ⁻¹ ·day ⁻¹)	EI (RFPM) (kcal·day ⁻¹)	EI (DLW) (kcal·day ⁻¹)	ΔEI: DLW minus RFPM (kcal·day ⁻¹)	Difference (%)	Error (%)	Recommended Daily CHO Intake (g·kg BM ⁻¹ ·day ⁻¹)
Player 1	81.8	0.2	2801	34.2	3056	2894	161	5.4	5.6	4.4
Player 2	78.0	-0.2	3364	43.1	3297	3302	5	0.1	0.1	5.9
Player 3	103.4	1.8	3870	37.4	2456	4706	2250	62.8	47.8	4.9
Player 4	88.0	0.0	3450	39.2	2905	3450	544	17.1	15.8	5.3
Player 5	84.6	0.0	3469	41.0	2859	3469	610	19.3	17.6	5.6
Player 6	78.0	0.2	3482	44.6	3297	3575	278	8.1	7.8	6.2
Player 7	77.4	-0.7	3080	39.8	2643	2862	220	8.0	7.7	5.4
Player 8	88.2	-0.2	4546	51.5	3235	4484	1249	32.4	27.9	7.4
Player 9	88.1	0.7	3902	44.3	3024	4227	1203	33.2	28.4	6.2
Mean ± SD	85.3 ± 8.2	0.2 ± 0.7	3551 ± 507	41.7 ± 5.0	2975 ± 292	3663 ± 665	724 ± 722	20.7 ± 19.6	17.6 ± 14.9	5.7 ± 0.9

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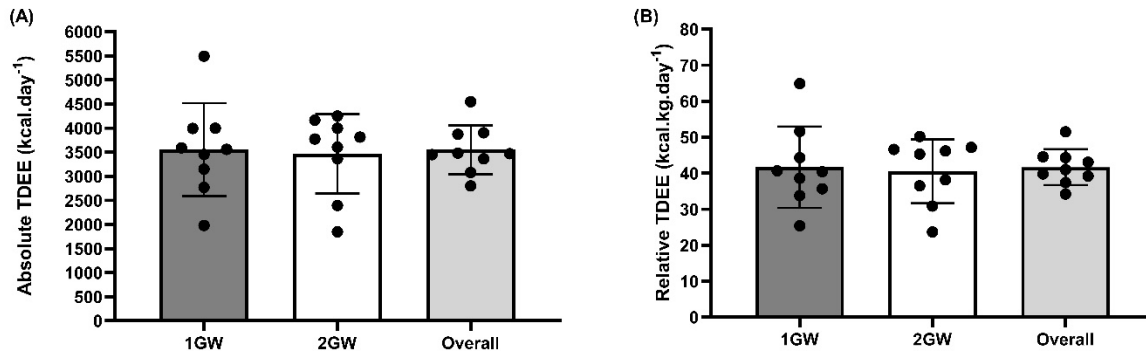


Figure 9. Absolute (A) and relative (B) TDEE for 1GW, 2GW and overall data collection period. Black dots represent individual data points.

4.4.3 Correlation between TDEE and Accumulative Load (n = 7)

Overall, the mean TDEE was not significantly correlated with mean accumulative weekly total distance ($r = 0.323$, 95%CI = -0.568 to 0.866, $p = 0.480$) or HSR distance ($r = 0.680$, 95%CI = -0.149 to 0.948, $p = 0.093$). However, a significant correlation was observed between mean TDEE and mean accumulative weekly sprint distance ($r = 0.774$, 95%CI = 0.051 to 0.965, $p = 0.041$). When analysed by microcycle type, no significant correlation was found in 1GW microcycle between mean TDEE and weekly accumulative total distance ($r = 0.540$, 95%CI = -0.359 to 0.919, $p = 0.211$), HSR distance ($r = 0.595$, 95%CI = -0.286 to 0.931, $p = 0.159$) or sprint distance ($r = 0.333$, 95%CI = -0.561 to 0.868, $p = 0.466$). In contrast, during 2GW microcycle, TDEE was significantly correlated with weekly accumulative total distance ($r = 0.781$, 95%CI = 0.068 to 0.966, $p = 0.038$), HSR distance ($r = 0.834$, 95%CI = 0.218 to 0.975, $p = 0.020$) and sprint distance ($r = 0.771$, 95%CI = 0.043 to 0.964, $p = 0.042$).

4.4.4 Self-reported energy and macronutrient intake via RFPM (n = 9)

There were no significant differences in absolute and relative EI between MD-1 (2986 ± 408 kcal·day⁻¹, 35.5 ± 7.2 kcal·kg BM⁻¹·day⁻¹), MD (3347 ± 412 kcal·day⁻¹, 39.6 ± 6.6 kcal·kg BM⁻¹·day⁻¹), MD+1 (2685 ± 381 kcal·day⁻¹, 31.8 ± 6.3 kcal·kg BM⁻¹·day⁻¹) and training day (2880 ± 381 kcal·day⁻¹, 34.2 ± 6.0 kcal·kg·day⁻¹) (all $p > 0.05$; Figures 10A & 10B). Total absolute CHO intake was significantly higher on MD (423 ± 84 g·day⁻¹), in comparison to MD-1 (285 ± 98 g·day⁻¹, 95%CI of mean difference = 29 to 245 g·day⁻¹, $p = 0.013$), MD+1 (247 ± 72 g·day⁻¹, 95%CI of mean difference = 40 to 313 g·day⁻¹, $p = 0.012$) and training day (251 ± 77 g·day⁻¹, 95%CI of mean difference = 75 to 269 g·day⁻¹, $p = 0.002$; Figure 10C). Relative to BM, CHO intake was also significantly higher on MD (5.0 ± 1.1 g·kg BM⁻¹·day⁻¹) when compared to MD-1 (3.5 ± 1.3 g·kg BM⁻¹·day⁻¹, 95%CI of mean difference = 0.5 to 3.7 g·kg BM⁻¹·day⁻¹, $p = 0.009$), MD+1 (3.0 ± 1.0 g·kg BM⁻¹·day⁻¹, 95%CI of mean difference = 0.7 to 3.3 g·kg BM⁻¹·day⁻¹, $p = 0.011$) and training day (3.0 ± 1.1 g·kg BM⁻¹·day⁻¹, 95%CI of mean difference = 0.9 to 3.1 g·kg BM⁻¹·day⁻¹, $p = 0.001$; Figure 10D).

There were no significant differences in absolute and relative protein intakes between MD-1 (183 ± 29 g·day⁻¹, 2.2 ± 0.5 g·kg BM⁻¹·day⁻¹), MD (171 ± 37 g·day⁻¹, 2.0 ± 0.6 g·kg BM⁻¹·day⁻¹), MD+1 (157 ± 34 g·day⁻¹, 1.9 ± 0.5 g·kg BM⁻¹·day⁻¹) and training day (190 ± 29 g·day⁻¹, 2.2 ± 0.3 g·kg BM⁻¹·day⁻¹) (all $p > 0.05$; Figures 10E & 10F). Similarly, no significant differences in absolute and relative fat intake were reported between MD-1 (124 ± 21 g·day⁻¹, 1.4 ± 0.3 g·kg BM⁻¹·day⁻¹), MD (108 ± 25 g·day⁻¹, 1.3 ± 0.3 g·kg BM⁻¹·day⁻¹), MD+1 (119 ± 31 g·day⁻¹, 1.4 ± 0.3 g·kg BM⁻¹·day⁻¹) and training day (124 ± 26 g·day⁻¹, 1.4 ± 0.3 g·kg BM⁻¹·day⁻¹) (all $p > 0.05$; Figures 10G & 10H).

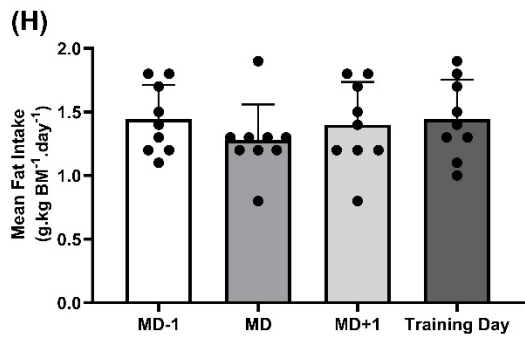
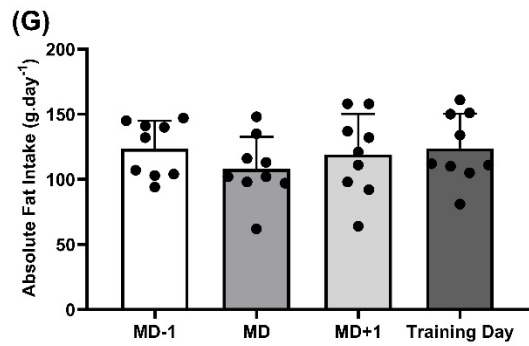
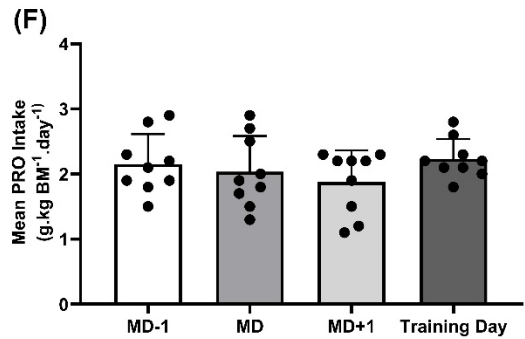
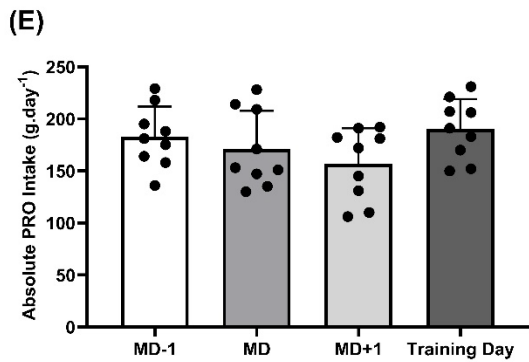
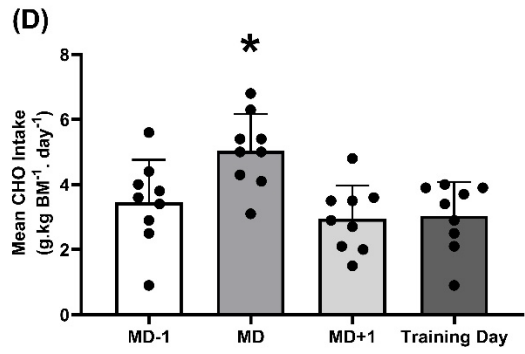
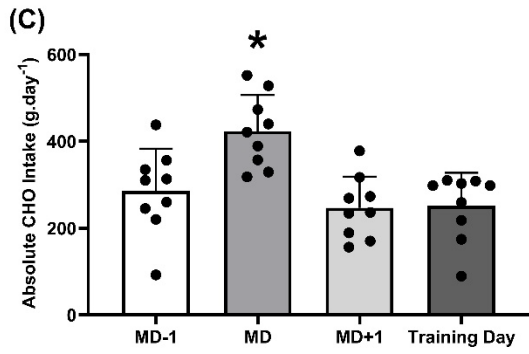
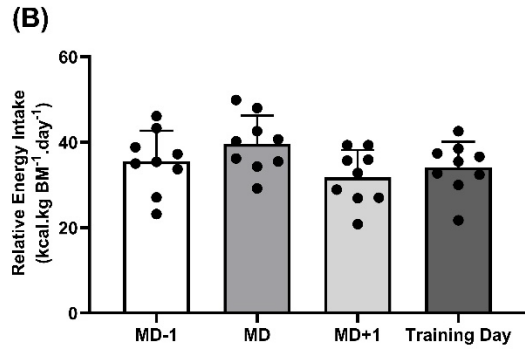
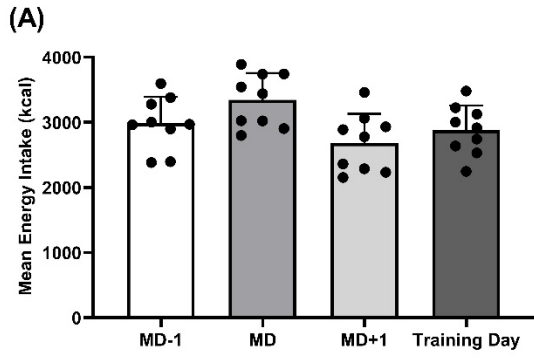


Figure 10. Self-reported mean absolute and relative energy (A & B), absolute and relative carbohydrate (C & D), absolute and relative protein (E & F) and absolute and relative fat (G & H) intakes on MD-1, MD, MD+1 and training day. *Significantly higher on MD than MD-1, MD+1 and training day ($p < 0.05$).

4.4.5 DLW Derived EI Versus RFPM

The mean EI measured using the RFPM ($2975 \pm 292 \text{ kcal}\cdot\text{day}^{-1}$) was significantly lower than EI estimated using the DLW technique ($3663 \pm 665 \text{ kcal}\cdot\text{day}^{-1}$, 95%CI of mean difference = 104 to 1273 $\text{kcal}\cdot\text{day}^{-1}$, ES = 0.91, $p = 0.026$), representing a mean daily Δ of $724 \pm 722 \text{ kcal}\cdot\text{day}^{-1}$ (Figure 11A). This corresponds to a 21% difference between methods and an 18% error when using the RFPM, as calculated where the DLW method is assumed as the true value. There was no significant correlation between the DLW and RFPM EI measurements ($r = -0.131$, 95%CI = -0.732 to 0.584, $p = 0.736$; Figure 11B). Furthermore, mean daily energy balance was significantly lower when calculated using the RFPM ($-577 \pm 554 \text{ kcal}\cdot\text{day}^{-1}$), in comparison to the DLW method ($112 \pm 309 \text{ kcal}\cdot\text{day}^{-1}$, 95%CI of mean difference = 104 to 1273 $\text{kcal}\cdot\text{day}^{-1}$, ES = 0.91, $p = 0.026$; Figure 11C). There were no significant changes in BM between day 1 ($85.3 \pm 8.2 \text{ kg}$), day 8 ($85.2 \pm 8.5 \text{ kg}$), day 12 ($85.7 \pm 9.0 \text{ kg}$) and day 15 ($85.5 \pm 8.8 \text{ kg}$) (all $p > 0.05$; Figure 11D).

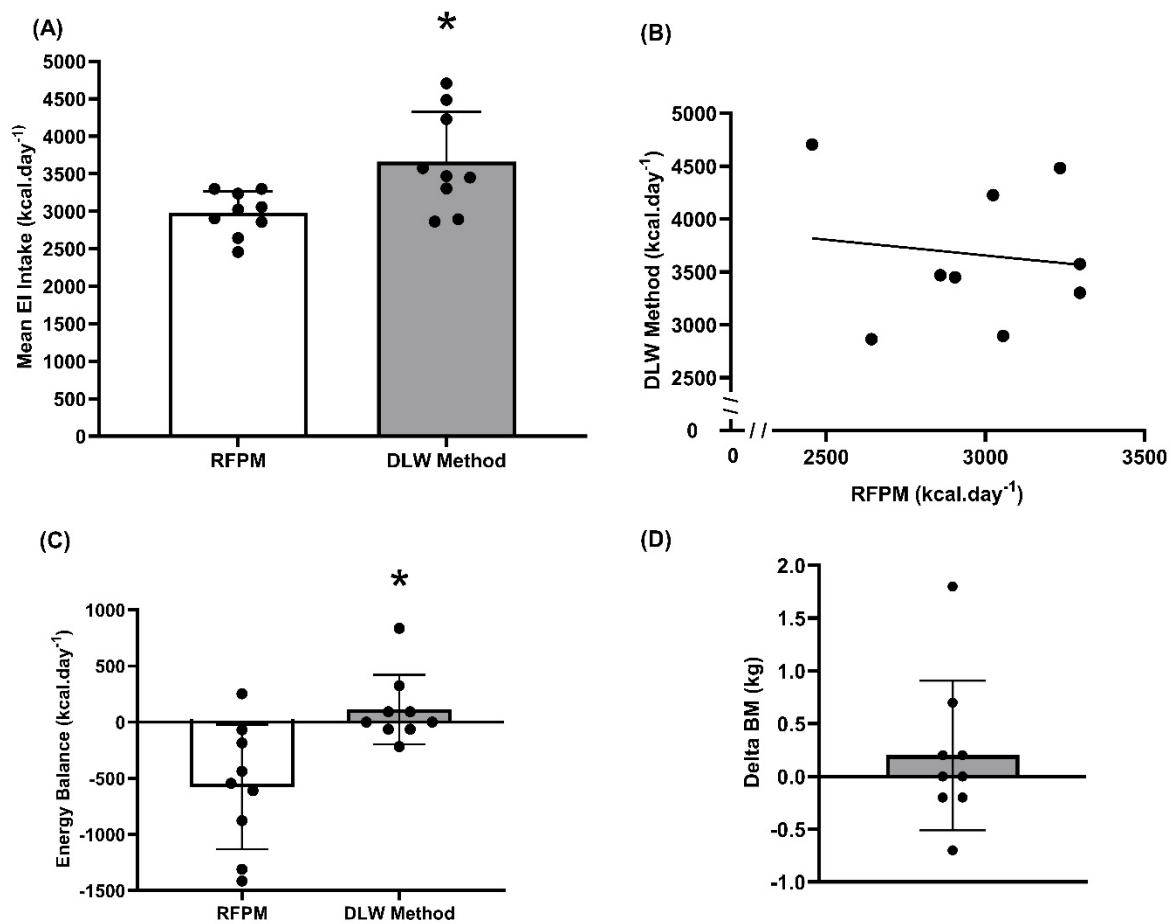


Figure 11. Estimated daily EI using the RFPM and DLW method (A), the strength of association between DLW and RFPM EI measurements (B), estimated EB using the RFPM and DLW method (C), and change in BM during the DLW derived EI assessment period (D). *Significant difference between methods ($p < 0.05$).

4.4.6 Recommended Relative Daily CHO Intakes

The mean recommended CHO intake was 5.7 ± 0.9 g·kg BM⁻¹·day⁻¹, with values ranging from 4.4 to 7.4 g·kg BM⁻¹·day⁻¹ (Table 5). When GK (Participants 3 and 9) were excluded, the mean recommended CHO intake remained at 5.7 ± 0.9 g·kg BM⁻¹·day⁻¹, which falls below the recommended range of 6–8 g·kg BM⁻¹·day⁻¹ on MD-1, MD, and MD+1.

4.5 Discussion

In using the DLW method, the first direct comparison of TDEE between 1GW and 2GW microcycles was presented in professional male soccer players from a single EPL club. Data demonstrated no significant differences in TDEE between 1GW and 2GW microcycles. This outcome is likely attributed to the absence of significant variations in cumulative external load metrics such as total distance covered, HSR distance and sprint distance between the two microcycles. Additionally, players practiced elements of CHO periodisation, with daily CHO intake being higher on MD compared to training days, MD-1 and MD+1. However, the reported CHO intakes fell short of the recommended levels of 6–8 g·kg BM⁻¹·day⁻¹ for MD-1, MD and MD+1 whereas the CHO intake on training days was at the lower threshold of the guidelines (3–6 g·kg BM⁻¹·day⁻¹), highlighting a potential gap between actual dietary practices and established nutritional recommendations. From a practical perspective, the absence of significant differences in TDEE between 1GW and 2GW microcycles suggest that the most recently published CHO guidelines which range from 4-6 g·kg BM⁻¹·day⁻¹ on rest and training days (see Table 6), and increasing to 6-8 g·kg BM⁻¹·day⁻¹ for MD-1, MD and MD+1, may adequately support the demands of elite soccer players during both types of microcycles.

To address the aims, the largest cohort of male professional soccer players from a single EPL club to date (n = 9) was examined during the in-season period. Data collection took place over two consecutive weeks, with one game in the first week and two games in the second week. By conducting this study during the 2023/24 season, the most up-to-date insight into EPL players' energy demands was provided, as well as the training and match loads associated with 1GW and

2GW microcycles. Contrary to prior research (Anderson et al., 2016b), we found a small and non-significant difference in the total weekly distance covered between 1GW and 2GW microcycles. The distance covered in 1GW (25.5 ± 3.5 km) was similar to the previous study (25.9 ± 2.0 km) (Anderson et al., 2016b), although a higher total distance for 2GW had been reported in previous research (32.5 ± 4.1 km vs 26.4 ± 5.4 km), possibly due to longer accumulative activity duration (~ 401 min vs ~ 307 min). Similarly, a trivial and non-significant difference was observed in weekly accumulative HSR distances between 1GW and 2GW microcycles, though the HSR distance in 1GW (1744 ± 536 m) was greater than previously reported (~ 862 m) (Anderson et al., 2016b). Furthermore, a small but not significant difference was found in weekly accumulative sprint distance between 1GW and 2GW, contrary to findings of Anderson et al. (2016b), who reported higher sprint distances in 2GW compared to 1GW. The sprint distances in the present study were greater than previously reported during 1GW (372 ± 150 m vs ~ 298 m) but lower during 2GW (324 ± 252 m vs ~ 520 m) (Anderson et al., 2016b). The discrepancies between this study and prior research may be attributed to variations in coaching philosophy (Malone et al., 2015), players position (Owen et al., 2017) and players' starting status (Martín-García et al., 2018), playing formation (Bradley et al., 2011) and technical ability (Bradley et al., 2013). The findings suggest an increase in external load intensity during 1GW, with the heightened HSR and sprint distance covered despite a comparable total distance with the previous literature, aligning with the recent evolutions in match parameters within the EPL (Barnes et al., 2014; Allen et al., 2024). The results indicate that varying coaching philosophies could lead to different approaches to training and match load management. Therefore, practitioners should be aware of their club's specific loading patterns to design personalised nutritional strategies tailored to each player's unique demands.

The mean absolute and relative TDEE observed in the present study ($3551 \pm 507 \text{ kcal}\cdot\text{day}^{-1}$, $41.7 \pm 5.0 \text{ kcal}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) were consistent with the findings from the previous DLW studies conducted on professional male soccer players from the EPL ($3566 \pm 585 \text{ kcal}\cdot\text{day}^{-1}$, $44.7 \pm 8.4 \text{ kcal}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) (Anderson et al., 2017b) and the Dutch Eredivisie ($3285 \pm 354 \text{ kcal}\cdot\text{day}^{-1}$, $42.4 \pm 3.5 \text{ kcal}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) (Brinkmans et al., 2019). However, the relative TDEE in our study was lower when compared to J-League professional soccer players ($50.9 \pm 7.6 \text{ kcal}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) (Ebine et al., 2002). This discrepancy may be attributed to ethnic variations in TDEE alongside differences in training regimes, habitual physical activity patterns and climatic conditions (Brinkmans et al., 2019). It is noteworthy that previous studies primarily focused on 2GW microcycles (Ebine et al., 2002; Anderson et al., 2017b). This study is the first to report TDEE during 1GW microcycle among professional male soccer players. Interestingly, a trivial and non-significant difference in TDEE between 1GW and 2GW microcycles ($3554 \pm 963 \text{ kcal}\cdot\text{day}^{-1}$ vs $3467 \pm 821 \text{ kcal}\cdot\text{day}^{-1}$) was found, which is likely to be explained by the comparable external loads observed between 1GW and 2GW microcycles, as discussed in the previous section. Moreover, we observed wide interindividual variation in absolute and relative TDEE (2801 to $4546 \text{ kcal}\cdot\text{day}^{-1}$, 34.2 to $51.5 \text{ kcal}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$), consistent with the variation reported in the previous study (3047 to $4400 \text{ kcal}\cdot\text{day}^{-1}$, 33.8 to $58.3 \text{ kcal}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) (Anderson et al., 2017b). The variability in TDEE may, in part, be explained by the weekly accumulative external load imposed on the players, as significant correlations were observed between mean TDEE and weekly accumulative total distance, HSR distance and sprint distance during the 2GW microcycle. In contrast, no such associations were identified during the 1GW microcycle, which challenges the consistency and potential causality of this relationship. Moreover, the limited sample size of outfield players restricts the ability to draw definite conclusions. Future research should aim to further investigate

the relationship between TDEE and external load in elite soccer players, using a larger cohort. Other factors may also contribute the interindividual variability in TDEE including differences in the sizes of energy-demanding organs such as brain, kidneys and heart as well as individual differences in mitochondrial efficiency (Müller et al., 2018; Halsey et al., 2022). In addition to these physiological factors, habitual physical activity outside of formal training and matches may also contribute to the variation in TDEE. For instance, it has been previously reported that female professional soccer players had a mean daily step count exceeding 10,000 steps (Brinkmans et al., 2024), suggesting that non-training physical activity can significantly impact overall energy expenditure. However, the present study did not monitor habitual physical activity outside of training and matches, highlighting an area for future research.

With the use of RFPM to evaluate players' self-reported EI during a 4-day period, we reported a mean absolute EI of 2975 ± 292 kcal·day⁻¹ (range: 2456 to 3297 kcal·day⁻¹). This aligns with prior studies on EPL (3186 ± 367 kcal·day⁻¹) (Anderson et al., 2017b) and J-League male soccer players (3113 ± 581 kcal·day⁻¹) (Ebine et al., 2002) during a 7-day assessment period. However, when comparing RFPM results with EI estimated using the DLW method, a moderate discrepancy emerged, with a mean difference of 724 ± 722 kcal·day⁻¹, reflecting a 21% difference and an 18% error. These findings echo those in Dutch Eredivisie male players, which reported an 18% error in dietary assessment (Brinkmans et al., 2019) and a systematic review that indicated a 19% underestimation of EI when comparing self-reported EI with DLW-measured energy expenditure (Capling et al., 2017). Additionally, a recent study (completed in female soccer players) also demonstrated 25% difference between EI derived from RFPM and DLW methods, along with a 22% error when using RFPM (McHaffie et al., 2024). Taken together, these data highlight the

challenges associated with accurately assessing EI through RFBM in real-world settings. Factors such as dietary restraint, motivation, social expectations and the nature of testing environment likely contribute to underreporting (Burke et al., 2001; Hill and Davies, 2001). Variability is further introduced by inaccuracies in coding portion sizes and accounting for “hidden” ingredients, with research showing that even trained sports nutritionists can underestimate meal energy content by ~10% (Stables et al., 2021). These findings point to the inherent limitations of RFBM and emphasize the need for incorporating more objective and accurate methods such as image-based food-recognition systems (Dalakleidi et al., 2022) and/or biomarkers of food intake (Cuparencu et al., 2024), to enhance the precision and objectivity of dietary assessments in this population.

Despite underreporting of EI, some degree of CHO periodisation, adjusted to the physical demands, was evident. The mean CHO intake observed in the present study was higher on MD ($5.0 \pm 1.1 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) compared with MD-1 ($3.5 \pm 1.3 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$), MD+1 ($3.0 \pm 1.0 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) and training day ($3.0 \pm 1.1 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$). Similar patterns of CHO intake have been previously reported among EPL (Anderson et al., 2017b), Dutch Eredivisie players (Brinkmans et al., 2019) and more broadly in the literature (Danielik et al., 2022), with higher CHO intake reported on MD. These findings suggest that players adjust their CHO intake based on the expected differences in workload between training and match days. However, the CHO intakes reported in the present study were at the lower end of the current guidelines (3 to 6 $\text{g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) recommended for in-season training days and the recommended CHO intake on MD-1, MD and MD+1 (6 to 8 $\text{g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) was not achieved (Collins et al., 2021). Even considering the likely underreporting of CHO, most players still fell short of the recommended intake. As previously speculated (Brinkmans et al., 2019, 2024), these inadequate CHO intakes

could be linked to the relatively high protein ($2.1 \pm 0.4 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) and fat intakes ($1.4 \pm 0.1 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$). As shown in Table 6, adherence to the protein and fat intake recommendations from the UEFA consensus statement resulted in five out of seven outfielders failing to meet the CHO intake guidelines of $6\text{-}8 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$ on MD-1, MD and MD+1. Given the constraint imposed by TDEE, modifications to protein and/or fat intakes may be required on these days to accommodate recommended CHO intakes. Additionally, the consistent failure to meet CHO guidelines among professional soccer players, despite the well-documented benefits of high CHO intake for performance and recovery (Baker et al., 2015; Williams and Rollo, 2015; Aguinaga-Ontoso et al., 2023), may be attributed to factors such as the nutrition culture within the sport (Ono et al., 2012; Foo et al., 2025c), unrealistic body composition goals (Jenner et al., 2021), confusion about the role of CHO (McHaffie et al., 2022) and poor advice from coaches and other support staff (Bentley et al., 2019). Thus, further research is needed to explore the enablers and barriers contributing to the suboptimal CHO intake among professional soccer players, as targeted educational and behaviour change strategies have been shown to significantly improve CHO consumption on MD-1, MD and MD+1 (Carter et al., 2024). Indeed, in recent qualitative research from our group in male academy players (Carney et al., 2024) and adult female players (McHaffie et al., 2022), we observed that a combination of factors such as a player's capability (i.e. nutritional knowledge), social opportunity (i.e. culture around fuelling practices and coaches drive to support body composition targets) and physical opportunity (i.e. food provision and time available to eat) can all affect a player's habitual nutritional practices, especially that of CHO intake. While evidence supporting the performance benefits of CHO intake in professional soccer remains limited (Foo et al., 2025b), recent field-based experimental studies suggest that higher CHO availability may be advantageous for soccer performance. Specifically, CHO intakes of $6.5 \text{ g}\cdot\text{kg}$

$\text{BM}^{-1}\cdot\text{day}^{-1}$ on the day before a match and $7.5 \text{ g}\cdot\text{kg} \text{ BM}^{-1}\cdot\text{day}^{-1}$ on match day significantly improved total distance and number of repeated sprint efforts (Kazemi et al., 2023). Moreover, higher CHO intake during recovery between successive matches attenuated the decline in running speed, intense ACC and DEC in the second match (Ermidis et al., 2024). Further research is warranted to assess the feasibility and effectiveness of current CHO guidelines in professional soccer contexts.

Despite the strengths and practical implications of this study, it is important to acknowledge some limitations. First, the DLW method does not allow for assessing day-to-day variations in energy requirements (Westerterp, 2017), nor does it enable the measurement of energy expenditure during individual training sessions or matches. Additionally, the study was conducted on nine players from a single team, which may not fully represent the physical demands or nutritional habits of players from other teams or leagues. Finally, dietary intake was not assessed on all days during the 15-day period, as extending the assessment period might have reduced compliance (Magkos and Yannakoulia, 2003). However, by focusing on dietary intake on MD-1, MD, MD+1 and training days, we captured key dietary intake periods and allowed us to calculate weighted averages for energy and macronutrient intake. Another limitation of the present study is the absence of direct measurements of RMR due to logistical constraint. Recent findings indicate that RMR may increase on MD+1 compared to MD-1 in elite academy soccer players during a competitive week (Carter et al., 2023a). Accordingly, future research should investigate RMR fluctuations across both 1GW and 2GW microcycles among elite soccer players. An additional limitation of the present study is the absence of objective assessment of daily physical activity outside of structured training sessions. Incorporating wearable monitors such as accelerometers and pedometers could provide valuable insights into non-exercise activity (Butte et al., 2012). Finally, the inclusion of an

away match may have influenced background enrichment levels if players consumed local tap water with differing isotope backgrounds; however, this effect is likely negligible given the predominant use of bottled water in elite players and the fixture being held within the same country.

In summary, the direct comparison of TDEE between 1GW and 2GW microcycles among male professional soccer players from EPL was reported for the first time using the DLW method. No significant differences in TDEE were observed between the two microcycles, likely due to the comparable external loads. The underreporting of EI through self-reported methods, as evidenced by the substantial discrepancy with DLW-derived estimates, highlights the ongoing challenges in accurately assessing dietary intake within this population. While patterns of CHO periodisation were evident, with higher intake on MD than on MD-1, MD+1 and training days, players failed to meet CHO recommendations on MD-1, MD and MD+1. While this observation highlights a potential area for improvement, the present study did not examine the consequences of these nutritional practices. Future research should investigate the performance and recovery implications of failing to meet nutritional recommendations in this context. Collectively, these findings suggest that EI should be aligned across 1GW and 2GW microcycles due to comparable TDEE. Despite the evolving physical demands of the modern game, no further increases in TDEE were observed, supporting the continued relevance of current UEFA nutrition guidelines for professional soccer players.

Chapter 5

Energy requirements of injured soccer players: a doubly labelled water case series from the English Premier League

The aim of this Chapter was to evaluate TDEE in professional soccer players during rehabilitation through two case studies involving EPL players: one examining TDEE, EI, and body composition changes during the first two weeks of hamstring injury rehabilitation, and another assessing TDEE and EI over a 15-day period following rectus femoris surgery as the player progressed from PWB to FWB between the third and fourth postoperative weeks.

Paul Fisher and Richard Clark assisted with the data collection for this study. Catherine Hambly and John Speakman conducted doubly labelled water analysis for this study.

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5.1 Abstract

Purpose: Accurate estimation of energy requirements is essential for optimising nutritional strategies during injury rehabilitation in professional soccer. This case series examined TDEE via DLW, EI, and body composition across two rehabilitation phases in EPL players.

Methods: Case Study 1 (22 years-old, 193 cm, 93.7 kg) involved early-stage hamstring rehabilitation, while Case Study 2 (21 years-old, 186 cm, 88.7 kg) captured the transition from PWB to FWB during rectus femoris rehabilitation. EI was measured via RFPM and 24-hour recalls on two non-consecutive days per case. Body composition was measured via Dual-energy X-ray Absorptiometry (DXA) in Case Study 1 at baseline and Day 14.

Results: In Case Study 1, TDEE increased by 1013 kcal·day⁻¹ (Week 1: 3143 kcal·day⁻¹; Week 2: 4156 kcal·day⁻¹), accompanied with an increased DLW-estimated EI (Week 1: 2911 kcal·day⁻¹; Week 2: 4343 kcal·day⁻¹). BM remained stable (+0.10 kg), but fat-free soft-tissue mass (FFSTM) decreased (-0.50 kg), primarily in the trunk and non-injured leg, while FFSTM in the injured leg was preserved (+0.07 kg). In Case Study 2, TDEE increased by 538 kcal·day⁻¹ (PWB :3175 kcal·day⁻¹; FWB: 3713 kcal·day⁻¹) but remained below pre-injury levels (4546 kcal·day⁻¹). BM reduced in both PWB (-0.3 kg) and FWB phases (-1.2 kg). DLW-estimated EI indicated energy deficits in both phases (PWB: 139 kcal·day⁻¹; FWB: 557 kcal·day⁻¹).

Conclusion: These findings highlight that energy requirements of EPL players fluctuate across rehabilitation phases, emphasising the importance of individualised nutritional support during rehabilitation.

5.2 Introduction

Soccer is a high intensity, intermittent sport characterised by repeated explosive actions including sprinting, tackling, jumping and rapid changes of direction, interspersed by lower intensity activity like walking (Bangsbo et al., 2006). The physical demands of the sport predispose players to injuries, predominantly the lower extremities, with an incidence rate of 6.8 per 1000 hours of exposure (López-Valenciano et al., 2020). Elite European soccer teams experience an average of ~50 injuries per season (Ekstrand et al., 2011) and injury rates are projected to increase due to increasingly congested fixtures (Page et al., 2023). Notably, the incidence of hamstring injuries has doubled over the past two decades among elite professional soccer players (Ekstrand et al., 2022). Injuries have substantial implications on performance, with lower injury rates being strongly associated with better league rankings, higher point totals and increased win rates (Hägglund et al., 2013). Financially, EPL teams are estimated to lose an average of £45 million each season due to injury-related performance declines (Eliakim et al., 2020). Given the practical and financial implications of player injuries, implementing effective rehabilitation strategies to support a timely return to play is paramount for elite soccer teams (Rollo et al., 2021a).

Sports nutrition is a fundamental component of the multidisciplinary strategies employed to support recovery and improve rehabilitation outcomes in injured players (Wall et al., 2015; Close et al., 2019b; Smith-Ryan et al., 2020; Smith et al., 2025). During the early phases of rehabilitation, joint immobilisation is commonly required to protect the injured area. However, this often restricts FWB and voluntary muscle contractions, resulting in periods of muscle disuse (Wall et al., 2015). Short term muscle disuse has been shown to significantly suppress myofibrillar protein synthesis, contributing a state of anabolic resistance despite protein ingestion (Wall et al., 2013, 2016). This

physiological response can lead to rapid muscle atrophy, with reductions in FFSTM observed after as little as 5 days (-1.4%) and 14 days (-3.1%) of immobilisation (Wall et al., 2014). Preserving FFSTM during this period is therefore critical to support functional recovery and expedite return to play (van der Horst et al., 2017).

Understanding energy requirements during rehabilitation is therefore the basis for formulating effective nutritional interventions. Although Chapter 4 presented updated TDEE for fit professional soccer players during the in-season period, the energy requirements of injured players remain poorly understood. To date, only one study has quantified TDEE in a professional soccer player during rehabilitation using the DLW method, reporting a value of 3178 kcal·day⁻¹ six weeks after ACL injury (Anderson et al., 2019a). Despite this, energy requirements during other phases of rehabilitation remain largely unexplored. Notably, it has been suggested that TDEE may not decrease as substantially as commonly assumed during early rehabilitation phase, as the physiological demands of tissue healing can elevate energy expenditure by 15-50%, depending on the type and severity of the injury (Frankenfield, 2006). Furthermore, the energetic cost of ambulation with crutches is two- or three-fold greater when compared to normal walking (Waters et al., 1987), indicating that TDEE during partial or non-weight bearing phases may not decline as markedly as often assumed if the player maintains a relatively high level of movement during rehabilitation (Tipton, 2015). Nonetheless, these assumptions remain speculative, as no studies have directly assessed TDEE across different rehabilitation phases in professional soccer players using the DLW method.

With this in mind, the aim of this case series was to evaluate TDEE in professional soccer players during rehabilitation. Specifically, two case studies were conducted on players from the EPL. The first investigated TDEE, EI and changes in body composition over the initial two weeks of rehabilitation following a hamstring injury. The second case evaluated TDEE and EI over a 15-day period in a EPL player recovering from rectus femoris surgery, during which the player progressed from PWB to FWB between the third and fourth postoperative weeks. Findings aim to inform evidence-based nutritional strategies to support optimal recovery during rehabilitation in elite soccer.

5.3 Methods

5.3.1 Presentation of the Participants

Players 1 and 2 were both internationally capped male EPL players. Their physical characteristics are summarised in Table 7. Both players had been full time professional since age 18. Their training regime prior to injury included periodised field-based sessions, two resistance training sessions per week (upper and lower limbs) and 1-2 competitive matches per week. Player 1 suffered a grade 3c proximal intramuscular tendon injury to the right bicep femoris, occurred during a sprinting action in a match. Player 2 suffered a grade 4c retracted tear of the conjoint tendon and proximal musculotendinous junction of the left rectus femoris, occurred during a goal shooting action in training. Following consultation with a specialist, surgery was performed four days after the injury. Player 2 was PWB on the injured limb using elbow crutches for three weeks post-surgery.

Table 7. Physical characteristics of Players 1 and 2.

Position	Player 1	Player 2
Age	22	21
Height (cm)	193	186
Body Mass (kg)	93.7	88.7
English Premier League appearances	39	52
Injury history	One left hamstring injury	Three left hamstring and one quadricep injury
Daily nutritional supplementation protocol	<ul style="list-style-type: none"> • During physiotherapy: 25 g whey protein isolate, 5 g creatine monohydrate • Supplementation: 30 ml of Montmorency Tart Cherry Juice, 2 g omega-3 fatty acids (1000 mg Eicosapentaenoic Acid [EPA], 400 mg Docosahexaenoic Acid [DHA]) and 500 mg curcumin 	<ul style="list-style-type: none"> • During physiotherapy: 15 g hydrolysed collagen, 25 g whey protein isolate, 5 g creatine monohydrate • Supplementation: 30 ml of Montmorency Tart Cherry Juice, 2 g omega-3 fatty acids (1000 mg Eicosapentaenoic Acid [EPA], 400 mg Docosahexaenoic Acid [DHA]), 500 mg Curcumin and 500 mg Vitamin C

5.3.2 Study Design

5.3.2.1 Player 1

An overview of the study design is presented in Figure 12A. Baseline BM and urine samples were collected on the morning of Day 0 of the data collection period (23 days after the onset of injury), followed by DLW dosing. Subsequent BM assessments were conducted on Days 8 and 14, while urine samples were collected on Days 1, 2, 4, 5, 6, 7, 8, 11, 12, 13 and 14 (in line with logistical constraint). Energy and macronutrient intakes were assessed on Days 1 and 11 using the RFPM (Martin et al., 2009) with 24-hour dietary recalls conducted on the following days (Days 2 and 12) to ensure the player did not omit any foods/drinks. EI was also calculated using the DLW method by adjusting TDEE for changes in energy stores over Days 0-14 (Schulz et al., 1992):

$$\text{EI (kcal}\cdot\text{day}^{-1}) = \text{TDEE (kcal}\cdot\text{day}^{-1}) + \text{changes in energy stores (kcal in grams of body fat} \\ + \text{kcal in grams of FFSTM changes)}.$$

For BM loss, 9 kcal·g⁻¹ of fat mass and 1 kcal·g⁻¹ of FFSTM and for BM gain, it is assumed 13.2 kcal·g⁻¹ of fat mass and 2.2 kcal·g⁻¹ of FFSTM (Forbes et al., 1986). Body composition was assessed via DXA (Lunar iDXA. GE Healthcare, Madison, USA) at baseline and on Day 14. All scans were performed at the same time of day (~1 hour within waking) (Nana et al., 2015). The player was fasted overnight and presented to the scanner with the bladder voided and had not undertaken in any strenuous exercise 18 hours before the scanning. He was asked to wear minimal clothing (e.g. underwear) and remove all jewellery and metal objects. Both scans were performed and analysed by the same trained technician with more than five years of experience, with a special emphasis on the consistency in the positioning of the player on the scanning bed. Specifically, the player was centrally aligned with hands mid prone to maintain a constant distance between palms and trunk. The lower limb was stabilised in full extension and in zero degrees of internal rotation using Velcro straps to immobilise the limbs. The scans were analysed automatically by the software. Due the club's scanning schedule, repeat DXA assessments could not be performed and thus device-specific precision errors could not be established. Consequently, precision errors were drawn from published research using the same DXA iLunar model in athletic population (Barlow et al., 2015). Reported root mean squared standard deviations (RMS-SD) of DXA iLunar was 0.32 kg for total FFSTM, 0.40 kg for trunk FFSTM, 0.37 kg for legs FFSTM and 0.14 kg for arms FFSTM. Corresponding RMS-SD values for fat mass were 0.28 kg (total), 0.30 kg (trunk), 0.15 kg (legs) and 0.06 kg (arms) (Barlow et al., 2015). TDEE of Week 1 was compared to Week 2.

5.3.2.2 *Player 2*

An overview of the study design is presented in Figure 12B. Baseline BM and urine samples were collected on the morning of Day 0 (three days after the onset of injury), followed by dosing with DLW. BM and urine sampling then occurred on Days 1, 3, 4, 7, 8, 11, 12, 13, 14 and 15 (in line with logistical constraint). Player 2 spent Days 1-10 in the PWB phase with crutches and transitioned to FWB from Days 11-15. Energy and macronutrient intakes were assessed on Days 1 (PWB) and 11 (FWB) using the RFPM with 24-hour dietary recalls conducted on the following days (Days 2 and 12) to ensure the player did not omit any foods/drinks. EI was also estimated using the DLW method described above (Schulz et al., 1992). As a DXA scan was not performed on Player 2, the changes in energy stores were estimated with the assumption that $\frac{2}{3}$ of change in BM was metabolic and $\frac{1}{3}$ was water and that $\frac{3}{4}$ of the change in metabolic weight was fat mass and $\frac{1}{4}$ was FFSTM (Schulz et al., 1992). This was measured from Day 0 up until the final day (Day 15). TDEE during PWB and FWB phases was compared to the player's TDEE when fully fit, as reported in Chapter 4.

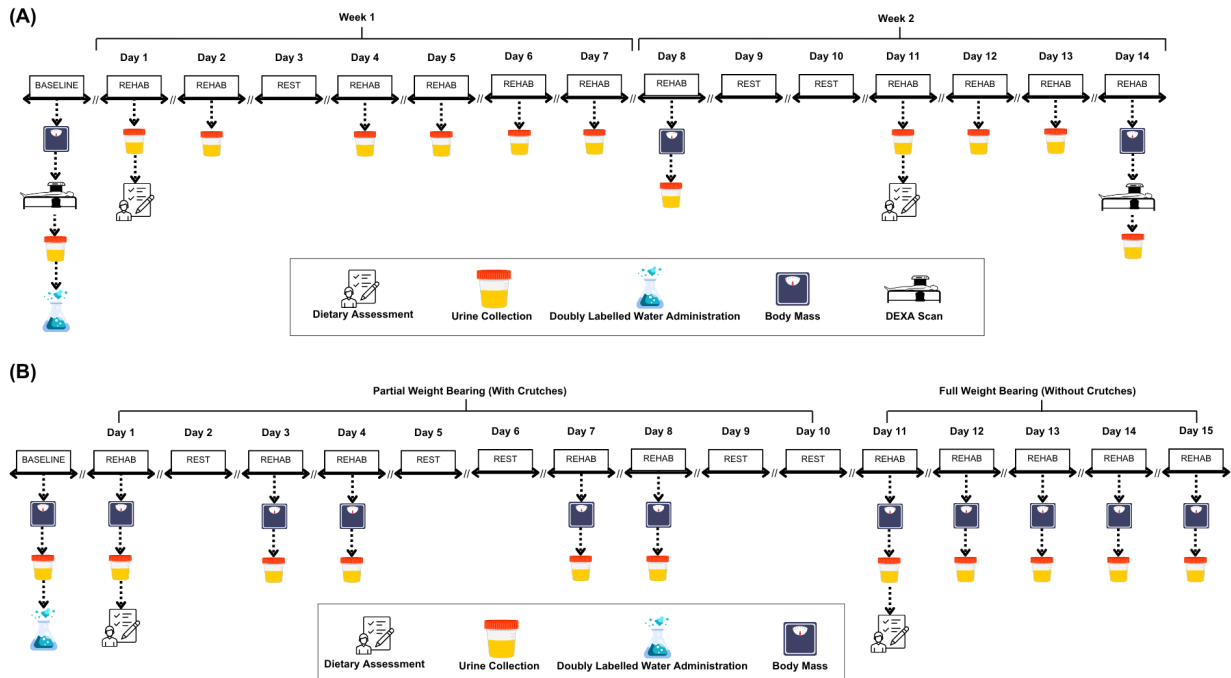


Figure 12. Overview of study design for Player 1 (A) and Player 2 (B).

5.3.3 Measurement of TDEE via DLW

TDEE was measured via the DLW method, previously applied in elite soccer players (Foo et al., 2025a). Baseline urine samples were collected in a 20-mL tube. Following collection of baseline samples, players were orally administered a single bolus dose of DLW containing isotopes deuterium (^2H) and oxygen-18 (^{18}O) in the form of water ($^2\text{H}_2^{18}\text{O}$) with a desired enrichment of 10% ^{18}O and 5% $^2\text{H}_2$ using the calculation:

$$\text{Dose (mL)} = 0.65 (\text{BM, g}) \times \text{DIE/IE}$$

Where 0.65 is the approximate proportion of the body comprised of water, DIE is the desired initial enrichment in the body ($\text{DIE} = 618.923 \times \text{BM (kg)}^{-0.305}$) and IE is the initial dose enrichment (10% 100,000 parts per million dosed according to BM (Speakman et al., 2021). To ensure the whole

dose was administered, both players were observed consuming each bolus dose and each glass vial was refilled with additional water which players were asked to consume. Time of dosing was recorded. Isotopes were purchased from Sercon (Cheshire, UK). For the DLW analysis, urine was encapsulated into capillaries, which were then vacuum distilled (Nagy, 1983) and water from the resulting distillate was used. This water was analysed using a liquid water analyser (Los Gatos Research) (Berman et al., 2012). Samples were run alongside three laboratory standards for each isotope and three International standards (Standard Light Artic Precipitate-2, Standard Mean Ocean Water-2 and Greenland Summit Precipitation) (Craig, 1961; Speakman, 1997) to account for machine day to day variation and correct delta values to parts per million. Daily isotope enrichments were \log_e converted and the elimination constants (k_o and k_d) were calculated by fitting a least squares regression model against sample time. The back extrapolated intercept was used to calculate the isotope dilution spaces (N_o and N_d). Isotope elimination rates and dilution spaces were converted to TDEE using an updated two-pool model equation (Speakman et al., 2021) and a mean calculated food quotient of 0.85 ± 0.2 .

5.3.4 Nutritional supplementation protocols

Table 7 summarises the supplementation strategies provided to both players. During physiotherapy, whey protein ($25 \text{ g}\cdot\text{day}^{-1}$) and creatine monohydrate ($5 \text{ g}\cdot\text{day}^{-1}$) were provided to support myofibrillar protein synthesis (Mitchell et al., 2018) and help preserve FFSTM during rehabilitation (Johnston et al., 2009). Player 2 also received collagen supplementation ($15 \text{ g}\cdot\text{day}^{-1}$) and vitamin C ($500 \text{ mg}\cdot\text{day}^{-1}$) to facilitate collagen synthesis (Shaw et al., 2017; DePhillipo et al., 2018). In addition, omega 3 fatty acids ($2 \text{ g}\cdot\text{day}^{-1}$) (Smith-Ryan et al., 2020) and curcumin (500

mg·day⁻¹) (Fernández-Lázaro et al., 2020) were provided to both players to aid in modulating inflammation.

5.3.5 Rehabilitation exercise programme

Table 8 outlines the rehabilitation exercise programme for Player 1 in Weeks 1 and 2. In Week 1, the player engaged in upper body strength training, upper body cardiovascular exercise and lower body exercises. In Week 2, lower body strength and cardiovascular exercises were introduced alongside the progression of the prior activities, in line with standard club rehabilitation protocols. Table 9 outlines the rehabilitation exercise program during PWB and FWB phases for Player 2. During the PWB phase, the player performed lower body exercises and upper body strength training. In the FWB phase, upper body cardiovascular exercises were introduced alongside the progression of prior activities as part of normal club practice. A typical daily schedule for both players included: breakfast (09:00 a.m.), soft tissue therapy (09:30 a.m.), movement preparation (10:00 a.m.), bike session (10:30 a.m.), upper body strength or cardiovascular (11:00 a.m.), movement skills in water (12:00 p.m.) and lunch (1:00 p.m.).

Table 8. Dietary intake and exercise program performed by Player 1 during the data collection period.

		Week 1	Week 2
Dietary Intake	Energy	2617 kcal (28.2 kcal·kg BM ⁻¹)	3121 kcal (33.3 kcal·kg BM ⁻¹)
	Carbohydrate	229 g (2.4 g·kg BM ⁻¹)	304 g (3.2 g·kg BM ⁻¹)
	Protein	250 g (2.7 g·kg BM ⁻¹)	262 g (2.8 g·kg BM ⁻¹)
	Fat	78 g (0.8 g·kg BM ⁻¹)	95 g (1.0 g·kg BM ⁻¹)
Lower Body Exercise			
Exercise Program	Aim	Lumbo-pelvic control, hamstring isometrics, pool running mechanics	Daily hamstring loading, functional movement circuit, accessory lower body strength, running mechanics, run in pool
	Frequency/Week	5x	5x

Repetition Range	5-10	5-8
Sets/Session	30	46
	6x mobility & lumbo-pelvic exercise (3 sets, 10 reps)	8x mobility & lumbo-pelvic exercises (2 sets, 8 reps)
Exercise Selection	4x isometrics hamstring exercise (3 sets, 5 reps, 8 seconds)	4x glute activation exercises (2 sets, 8 reps)
	Hydrotherapy (20 min functional movement and low intensity running drills)	5x functional movement exercises (2 sets, 8 reps)
		4x isometrics hamstring exercise (3 sets, 5 reps, 8 seconds)
		Hydrotherapy (30 mins running drills and pool run)
Upper Body Strength		
Aim	Strength	Strength
Frequency/Week	1x	2x
Repetition Range	8	6-8
Sets/Session	18	26
Exercise Selection	Lat pull down, bench press, row, shoulder press, hammer curl, chest fly	Lat pull down, medicine ball slam, bench press, supine medicine ball press, hammer curl, chest fly
Cardiovascular		
Aim	Cardiovascular fitness	Cardiovascular fitness
Frequency/Week	1x	3x
Duration	30 min per session	20 min per session
Exercise Selection	Battle ropes, assault bike, seated ski ergometer	Spin Bike
Lower Body Strength		
Aim		Strength
Frequency/Week		2x
Duration		8 20-25
Exercise Selection		X2 concentric hamstring exercises X2 eccentric hamstring exercises Adductor cable, calf raise, leg extension

Table 9. Dietary intake and exercise program performed by Player 2 during the data collection period. OKC = open kinetic chain, CKC = close kinetic chain, DB = dumbbell, SA = single arm, FT = functional trainer.

		Partial Weight Bearing (PWB)	Full Weight Bearing (FWB)
Dietary Intake	Energy	2498 kcal (28.2 kcal·kg BM ⁻¹)	2857 kcal (32.3 kcal·kg BM ⁻¹)
	Carbohydrate	206 g (2.3 g·kg BM ⁻¹)	244 g (2.8 g·kg BM ⁻¹)
	Protein	160 g (1.8 g·kg BM ⁻¹)	210 g (2.4 g·kg BM ⁻¹)
	Fat	115 g (1.3 g·kg BM ⁻¹)	116 g (1.3 g·kg BM ⁻¹)
Lower Body Exercise			
Exercise Program	Aim	Muscle Endurance	Muscle Endurance

Frequency/Week	5x	5x
Repetition Range	12-15	12-15
Sets/Session	24-26	36
Exercise Selection	2x OKC quadriceps exercises 2x OKC exercises for adductors, hamstrings, hip extensors 3x OKC exercises for ankles 1x CKC exercise for calves 2x OKC strength exercises for contralateral side	3x OKC quadriceps exercises 4x CKC quadricep exercises 3x OKC exercises for Adductors, hamstrings, hip extensors 3x OKC exercises for ankles 2x CKC exercises for calves 2x OKC strength exercises for contralateral side
Upper Body Strength		
Aim	Hypertrophy	Hypertrophy
Frequency/Week	3x	3x
Repetition Range	6-10	6-10
Sets/Session	15-24	15-24
Exercise Selection	DB incline bench press SA seated Keiser row Seated lateral raise Seated Keiser fly's DB biceps curl Seated FT triceps extension	DB incline bench press SA bench row Seated land mine press Seated Keiser fly's DB biceps curl Seated FT triceps extension
Upper Body Cardiovascular		
Aim		Cardiovascular Fitness
Frequency/Week		3x
Duration	Not performed for wound protection	30 min per session
Exercise Selection		Battle ropes Assault bike Seated skiing ergometer

5.4 Results

5.4.1 Player 1

Mean TDEE over the data collection period was 3538 kcal·day⁻¹ (37.8 kcal·kg BM⁻¹·day⁻¹). In Week 1, mean TDEE was 3143 kcal·day⁻¹ (33.5 kcal·kg BM⁻¹·day⁻¹), increasing to 4156 kcal·day⁻¹ (44.4 kcal·kg BM⁻¹·day⁻¹) in Week 2. Energy and macronutrient intakes for both weeks are presented in Table 8. Self-reported EI was lower than TDEE by 526 kcal·day⁻¹ in Week 1 and 1035 kcal·day⁻¹ in Week 2. Based on this energy deficit, predicted BM losses were ~1.1 kg in Week 1 and ~3.3 kg in Week 2. However, actual BM decreased by only 0.5 kg in Week 1 (from 93.7 kg on Day 1 to 93.2 kg on Day 8) and increased by 0.6 kg during Week 2 (from 93.2 kg on Day 8 to 93.8 kg on Day 14).

Estimated EI via the DLW method was 2911 kcal·day⁻¹ in Week 1 and 4343 kcal·day⁻¹ in Week 2, values that were 294 kcal·day⁻¹ and 1222 kcal·day⁻¹ higher, respectively, than EI reported via the RFPM. Over the 14-day period, total FFSTM decreased by 0.50 kg, slightly above RMS-SD (0.32 kg). Meaningful reductions were evident in non-injured left leg (-0.49 kg, Figure 13A) and trunk (-0.60 kg, Figure 13C), both exceeding their respective RMS-SD (0.15 kg and 0.42 kg). In contrast, FFSTM increased in the arms (+0.46 kg, Figure 13E), surpassing the RMS-SD (0.14 kg), while the small increase in injured right leg (+0.07 kg, Figure 13A) fell below the RMS-SD (0.37 kg), likely reflecting measurement variability. Total fat mass increased by 0.65 kg, above the RMS-SD (0.28 kg), driven primarily by a 0.52 kg gain in the trunk (Figure 13D), which exceeded the RMS-SD (0.30 kg). Fat mass also increased in non-injured left leg (+0.07 kg); however, this change was smaller than reported RMS-SD (0.37 kg), suggesting it may fall within the expected measurement error rather than reflecting a true physiological change (Figure 13B). Similarly, the reduction of fat mass in both injured right leg (-0.01 kg) and arms (-0.03 kg) was within the RMS-SD (0.15 kg and 0.06 kg, respectively).

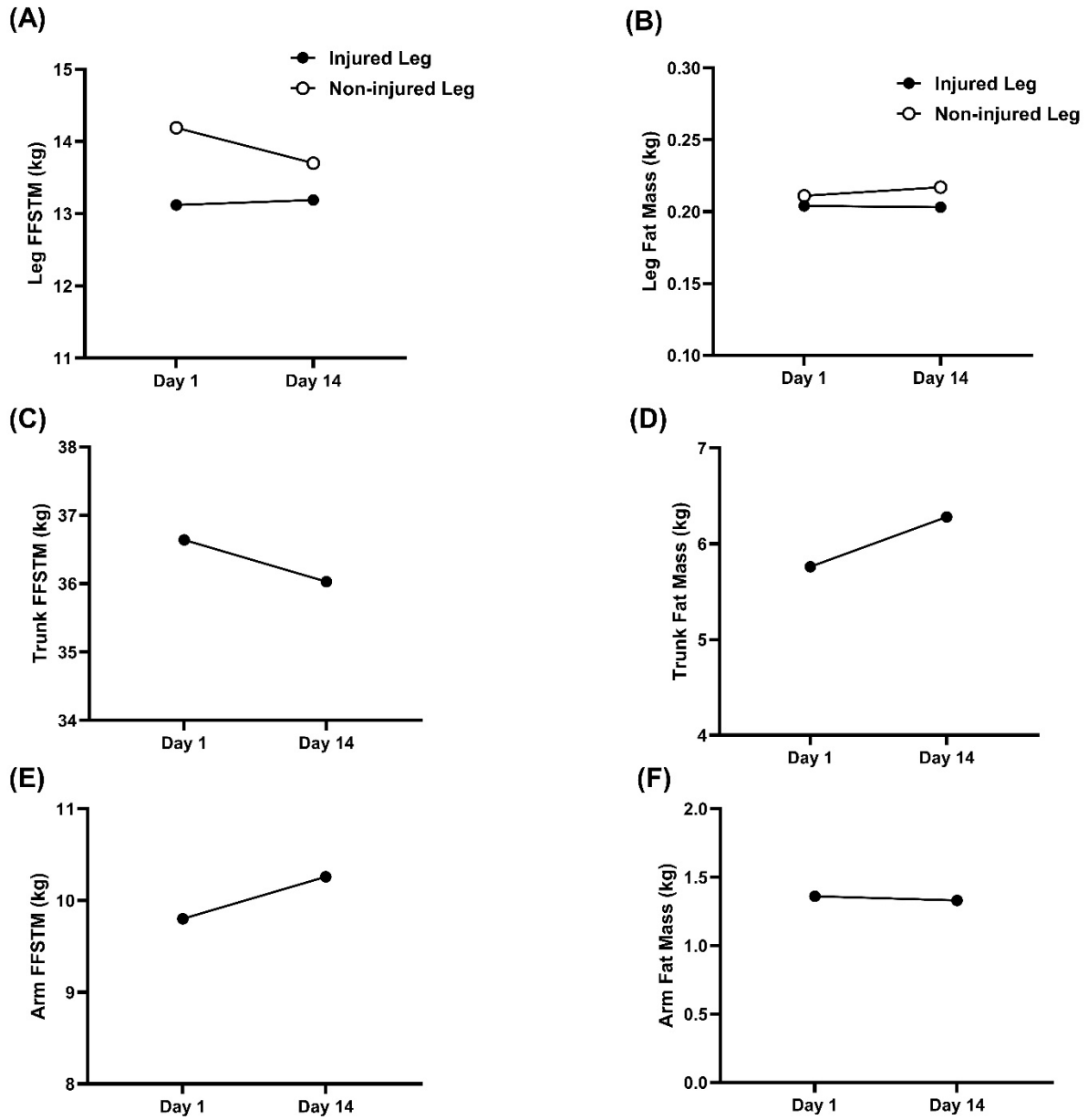


Figure 13. Changes in total (a) leg FFSTM, (b) leg fat mass, (c) trunk FFSTM, (d) trunk fat mass, (e) arm FFSTM and (f) arm fat mass throughout the rehabilitation.

5.4.2 Player 2

Mean TDEE during the PWB phase was $3175 \text{ kcal}\cdot\text{day}^{-1}$ ($35.8 \text{ kcal}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$). Upon transitioning to FWB, mean TDEE increased by $538 \text{ kcal}\cdot\text{day}^{-1}$, reaching $3713 \text{ kcal}\cdot\text{day}^{-1}$ ($42.0 \text{ kcal}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$). Nevertheless, TDEE during rehabilitation remained substantially lower than when the player was at full fitness, where TDEE was $4546 \text{ kcal}\cdot\text{day}^{-1}$ ($51.5 \text{ kcal}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) over a 15-day period in which the player competed in three matches (Figure 14A). The energy and macronutrient intakes during the PWB and FWB phases are detailed in Table 9. Self-reported EI was $677 \text{ kcal}\cdot\text{day}^{-1}$ and $856 \text{ kcal}\cdot\text{day}^{-1}$ lower than TDEE during the PWB and FWB phases, respectively. Based on the observed energy deficit, the player was expected to lose 1.5 kg during PWB and 1.9 kg during FWB. However, BM decreased by only 0.3 kg from Days 1–10 (PWB) and 1.2 kg from Days 11–15 (FWB) (Figure 14B), suggesting potential inaccuracies in self-reported EI. Specifically, EI derived from the DLW method was $3036 \text{ kcal}\cdot\text{day}^{-1}$, exceeding self-reported EI by $538 \text{ kcal}\cdot\text{day}^{-1}$ during the PWB phase. Similarly, a difference of $299 \text{ kcal}\cdot\text{day}^{-1}$ was observed between DLW derived EI ($3156 \text{ kcal}\cdot\text{day}^{-1}$) and self-reported EI during the FWB phase.

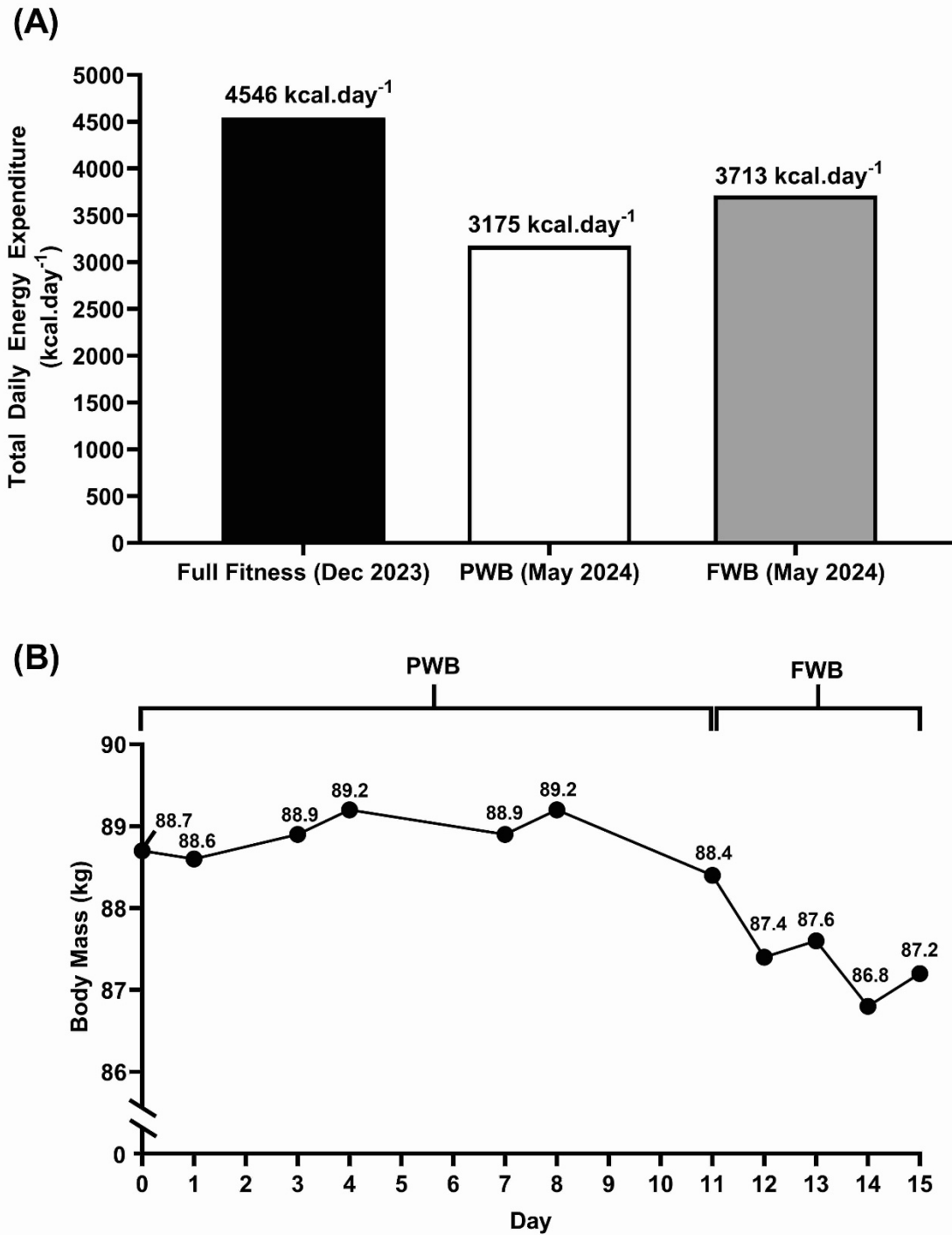


Figure 14. Total daily energy expenditure of the player during full fitness, partial weight bearing and full weight bearing phases (A) and body mass changes observed throughout the rehabilitation process (B).

5.5 Discussion

Using the DLW method and a case series approach, we were able to evaluate TDEE of two professional soccer players undergoing rehabilitation from lower limb injuries. Case Study 1 focused on the early phase of rehabilitation following a hamstring injury, while Case Study 2 examined the transition from PWB to FWB during the third- and fourth-weeks post rectus femoris surgery. A marked increase in TDEE was observed in both cases, with Player 1 demonstrating a rise of $1013 \text{ kcal}\cdot\text{day}^{-1}$ from Week 1 to Week 2, and Player 2 showing a $538 \text{ kcal}\cdot\text{day}^{-1}$ increase during the PWB to FWB transition. These increases likely reflect the progressive elevation in exercise volume and intensity as rehabilitation advanced (Tables 8 and 9). Collectively, these data suggest that TDEE can escalate rapidly during the early rehabilitation phase and during key transition periods, highlighting the need for dynamic adjustment of energy and macronutrient intake to support recovery and mitigate losses in FFSTM.

In Case Study 1, relative TDEE increased markedly from Week 1 ($33.5 \text{ kcal}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) to Week 2 ($44.4 \text{ kcal}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$), reaching values comparable to fit outfield players ($\sim 44.6 \text{ kcal}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) (Anderson et al., 2017b). This substantial rise in TDEE likely reflects the progressive increase in training volume and intensity of lower-body, upper-body and cardiovascular exercises (Table 8), which collectively increase energy demands. Similarly, in case study 2, a notable rise in TDEE was observed as Player 2 transitioned from the PWB phase ($3175 \text{ kcal}\cdot\text{day}^{-1}$) to the FWB phase ($3713 \text{ kcal}\cdot\text{day}^{-1}$). This increase is likely due to the greater exercise volume and intensity (Table 9) as well as increased non-exercise activity thermogenesis from weight bearing mobility (Levine, 2002). However, even during the FWB phase, TDEE remained

~800 kcal·day⁻¹ below pre-injury levels, exceeding reductions observed in prior research (~300 kcal·day⁻¹) (Anderson et al., 2019a). The findings from both case studies highlighted the significant variations of TDEE across different phases of rehabilitation process, driven by changes in exercise volume, intensity and mobility status. Future research should seek to quantify both exercise energy expenditure and RMR to provide a more comprehensive understanding of how energy demands fluctuate across different stages of rehabilitation and to identify the key factors influencing these changes. These fluctuations in TDEE emphasize the importance of continuous monitoring of energy balance throughout rehabilitation. Indeed, inadequate energy availability has been linked to impaired wound healing, which can delay tissue repair and prolong return-to-play timelines (Demling, 2009; Wang and Speakman, 2025). Collectively, these observations highlight the need for personalised nutritional strategies that adapt to the players' changing energy demands throughout rehabilitation.

In Case Study 1, BM remained stable (+0.10 kg), despite a decrease in total FFSTM (-0.50 kg) and an increase in fat mass (+0.65 kg), both of which exceeded the corresponding RMS-SD (0.32 kg and 0.28 kg, respectively). Notably, FFSTM in the injured leg increased slightly (+0.07 kg); however, this change is within the measurement error, as it falls below the RMS-SD (0.37 kg) and is therefore unlikely to represent a true physiological change. In contrast, Anderson et al. (2019a) and Milsom et al. (2014) reported FFSTM losses of 0.90 kg and 1.35 kg, respectively, following six to eight weeks of rehabilitation. The relatively greater preservation of FFSTM in the present case may be attributed to differences in injury type and rehabilitation strategy, as previous studies involved ACL reconstructions requiring extended periods of immobilisation (Wall et al., 2014, 2016). Immobilisation, coupled with reduced EI, likely contributed to accelerated FFSTM loss in

those studies, given the established link between low energy availability and impaired myofibrillar protein synthesis (Areta et al., 2014). In Case Study 1, a modest energy deficit during Week 1 (-232 kcal·day⁻¹), followed by a surplus in Week 2 (+187 kcal·day⁻¹), in combination with a high protein diet (>2.5 g·kg BM⁻¹·day⁻¹), may have helped attenuate anabolic resistance and support maintenance of FFSTM (Wall et al., 2015). However, a greater reduction in FFSTM was observed in the uninjured limb (-0.49 kg), contrasting with previous reports that typically found greater FFSTM losses in the injured limb (Milsom et al., 2014; Anderson et al., 2019a). This may be explained by the fact that the left limb was the player's dominant side, which could have undergone a greater degree of detraining during the injury period (Suarez-Arrones et al., 2019) as it was previously shown that predominant use of one of the lower limbs is associated with increased muscle thickness of dominant leg in young soccer players (Kearns et al., 2001). Further research is warranted to explore the difference in FFSTM between dominant and non-dominant limbs during rehabilitation.

In contrast, Player 2 experienced a 1.2 kg reduction in BM during the FWB phase, which coincided with an energy deficit of 557 kcal·day⁻¹, as determined via the DLW method. This level of energy deficit may compromise recovery by reducing myofibrillar protein synthesis (Areta et al., 2014), slowing wound healing (Demling, 2009; Tipton, 2015; Wang and Speakman, 2025) and accelerating FFSTM loss (Milsom et al., 2014). Despite protein intake aligning with current recommendation (2.4 g·kg BM⁻¹·day⁻¹) (Wall et al., 2015), EI appears inadequate. Increasing CHO intake by ~140 g (~1.6 g·kg BM⁻¹·day⁻¹) may have been necessary to meet the elevated energy demands associated with the transition from the PWB to FWB phase. The present findings reinforce the need to ensure sufficient energy and protein intakes throughout the rehabilitation

process to minimise FFSTM loss. Notably, the transition from PWB to FWB appears to be a critical period of changing energy demands, warranting careful nutritional management. Further research is needed to understand energy requirements across specific rehabilitation phases and injury types, which would aid in the development of tailored nutritional strategies to support recovery and optimise return-to-play outcomes.

A key limitation of this study is its sample size, capturing the energy demands of two players undergoing two specific rehabilitation protocols aligned with the medical department's approach at a single professional soccer club. Future studies should investigate the energy requirements of a wider cohort of players, across diverse rehabilitation strategies and injury types, and from multiple teams. Although self-reported dietary intake data are inherently susceptible to bias, the incorporation of DLW-derived EI estimates strengthens the reliability of the findings. Furthermore, dietary intake was assessed over only two training days in both case studies. Extending the assessment period to include additional days, particularly rest days, would provide a more comprehensive representation of players' dietary intake throughout the rehabilitation period. Moreover, a further limitation of this case series is the absence of hydration status assessment, which may have affected BM measurements and the accuracy of the DXA-derived outcomes (Toomey et al., 2017).

In conclusion, novel data on TDEE and EI in elite EPL soccer players were provided during two distinct phases of rehabilitation: the initial two weeks post hamstring injury and the transition from PWB to FWB during rectus femoris injury rehabilitation. TDEE increased substantially by ~ 1000 kcal \cdot day $^{-1}$ from Week 1 to Week 2 of hamstring injury rehabilitation, reaching levels comparable to those observed in match-fit players. Additionally, the transition from PWB to FWB was

associated with $\sim 500 \text{ kcal}\cdot\text{day}^{-1}$ increase in TDEE. Despite these increases, TDEE during the FWB phase remained $\sim 800 \text{ kcal}\cdot\text{day}^{-1}$ lower than values reported during full fitness.

Chapter 6

An evaluation of dietary practices of English Premier League soccer players using a behavioural change science framework

The aims of this Chapter were (1) to quantify the energy and macronutrient intake and distribution across meals on training days, MD-1, MD and MD+1; and (2) to apply the COM-B model as a framework to explore the factors underpinning the dietary behaviours of EPL male players.

This study is currently under preparation for submission in Journal of Sports Sciences.

6.1 Abstract

Purpose: Despite the importance of nutrition in optimising performance and recovery, professional soccer players often fail to meet recommended intakes. This study aimed to quantify energy and macronutrients intake in male EPL soccer players and to further explore the enablers and barriers influencing dietary behaviours using the COM-B model.

Methods: Ten male players from a single EPL team participated in this study. The energy and macronutrient intake was assessed via RFBM over a 4-day in-season period comprising one training day, MD-1, MD and MD+1. On day 5, a dietary recall and a semi-structured interview were conducted to explore the factors influencing dietary behaviours. Players' responses were coded according to COM-B components and classified as barriers or enablers to positive dietary behaviour at each mealtime. In total, 195 meals were analysed to generate frequencies of COM-B components by mealtime.

Results: Mean relative CHO intake was significantly higher on MD-1 ($4.6 \pm 0.8 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) compared to training days ($3.5 \pm 0.8 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$, $p = 0.019$) and MD+1 ($3.6 \pm 0.5 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$, $p = 0.013$) but no different from MD ($3.9 \pm 1.2 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$, $p = 0.321$). Energy and fat intakes remained consistent across days, while protein intake was significantly lower on MD ($1.6 \pm 0.5 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) than MD-1 ($2.3 \pm 0.5 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$, $p = 0.004$). “Knowledge” (psychological capability) was the main enabler of dietary behaviours on training day, MD-1 and MD+1; however, recommended intakes were still not achieved. In contrast, “beliefs about consequences” (reflective motivation) and “emotion” (automatic motivation) were the dominant barriers at pre-match/during match and post-match, respectively, with players prioritising

perceptions of lightness around competition and experiencing suppressed appetite following matches.

Conclusion: Barriers to fuelling in professional soccer players include reflective motivation (wanting to feel light before and during the match) and automatic motivation (suppressed appetite following the match). Although psychological capability (knowledge of fuelling and recovery) facilitated dietary behaviours on training days, MD-1 and MD+1, it did not translate into optimal dietary intake. These findings highlight the need for targeted behaviour change interventions (over and above education) to increase CHO intake.

6.2 Introduction

In 2020, the UEFA published an expert consensus statement presenting updated evidence-based nutritional guidelines for elite soccer players. These guidelines recommend that daily CHO intake should range from 3 to 8 $\text{g}\cdot\text{kg}^{-1}\text{BM}\cdot\text{day}^{-1}$, with adjustments based on the energetic demands and specific goals of the training sessions and the competitive schedule (Collins et al., 2021). For instance, higher CHO intake (6-8 $\text{g}\cdot\text{kg}^{-1}\text{BM}\cdot\text{day}^{-1}$) is advised on MD-1, MD and MD+1 to optimise muscle glycogen availability for performance and recovery. Conversely, on lower absolute daily loads days such as typical training days during an 1GW microcycle, lower CHO intakes ranging from 3 to 6 $\text{g}\cdot\text{kg}^{-1}\text{BM}\cdot\text{day}^{-1}$ are likely sufficient to support fuelling and recovery needs (Collins et al., 2021). Additionally, current guidelines recommend that soccer players consume 1.6 to 2.2 $\text{g}\cdot\text{kg}^{-1}\text{BM}\cdot\text{day}^{-1}$ of protein, distributed evenly across four or five servings per day, each providing 0.4 $\text{g}\cdot\text{kg}^{-1}\text{BM}$ per serving. Regarding dietary fat, an intake ranging from 20 to 35% of total EI is advised, with an emphasis on limiting the consumption of saturated fats.

Despite the widespread recognition of the importance of nutrition in elite soccer, dietary assessments from elite soccer players (albeit using self-report methods), consistently indicate a mismatch between evidence-based recommendations and players' habitual practices. While dietary protein and fat intake are typically adequate, CHO consumption frequently falls short of recommendations (Steffl et al., 2019; Danielik et al., 2022). A study conducted on EPL soccer players, for example, have reported inadequate CHO intake on MD-1, MD+1 and in the immediate post-match recovery period, thereby likely compromising muscle glycogen resynthesis (Anderson et al., 2017b; a; Burke et al., 2017), particularly in type II muscle fibres (Gunnarsson et al., 2013; Ermidis et al., 2024). Similarly, Chapter 4 of this thesis has highlighted inadequate CHO on MD-1, MD and MD+1 ($<6 \text{ g} \cdot \text{kg BM}^{-1} \cdot \text{day}^{-1}$). Such deficiencies have been linked with reductions in total distance covered and average speed in subsequent matches (Ermidis et al., 2024). Moreover, CHO consumption during match play was recently shown to be below recommended levels (Kasper et al., 2024), despite strong evidence that in-game CHO ingestion enhances soccer-specific performance outcomes, including dribbling speed (Harper et al., 2017), passing accuracy (Rodriguez-Giustiniani et al., 2019) and high intensity intermittent running capacity (Foskett et al., 2008). Collectively, these findings highlight a persistent gap between research and practice, suggesting the need to better understand the nutritional behaviours of elite soccer players and the factors influencing them.

As highlighted in Chapter 3, dietary behaviours of elite soccer players are inherently complex, shaped by cultural norms, situational constraints and individual preferences. In this regard, the COM-B model (Michie et al., 2011) has been applied within professional sport contexts (Costello

et al., 2018; Carter et al., 2024; Thompson et al., 2026) to facilitate the understanding of dietary behaviours of athletes and the development of effective behaviour change interventions. The COM-B model is a meta-theoretical framework that conceptualises behaviour as part of an interacting system, recognising that athletes are embedded within social and physical environments (Michie et al., 2011). According to this model, engagement in a specific behaviour, requires sufficient psychological (e.g. knowledge) and physical capability (e.g. skills), appropriate social (e.g. interpersonal influences and cultural norms) and physical (e.g. time, resources and environments) opportunity and both automatic (e.g. emotion, desires and impulses) and reflective (e.g. self-conscious planning and beliefs) motivation to prioritise that behaviour over competing alternatives. This framework is particularly relevant in professional soccer, where players' dietary behaviours are influenced not only by nutritional knowledge (Noronha et al., 2020), but also by food availability and the prevailing social and cultural norms within the sport (opportunity) (Ono et al., 2012; Foo et al., 2025c), as well as various motivational drivers such as performance and body image (motivation) (McHaffie et al., 2022; Carter et al., 2023b). To further understand these behavioural determinants, the COM-B components can be further elaborated using the Theoretical Domains Framework (TDF), which comprises of 14 domains synthesised from 128 constructs taken from 33 theories of behaviour change (Cane et al., 2012).

Application of the COM-B framework within professional soccer has highlighted a range of context-specific barriers. Among female soccer players, a fear of weight gain associated with increased CHO intake, thus presenting reflective motivation (i.e. negative beliefs about consequences) as a key barrier (McHaffie et al., 2022). These beliefs were further exacerbated by external pressures arising from social media, coaches and the culture surrounding body

composition i.e. social opportunity (McHaffie et al., 2022). In contrast, a study in male youth soccer players has identified physical opportunity as the key barrier to nutritional adherence, including inadequate food provision within training and home environment and limited access to nutritionist support (Carter et al., 2023b). From practitioners' perspectives, barriers to implementing UEFA nutritional guidelines have been linked to restricted physical opportunity (i.e. limited time for players support) and psychological capability (i.e. difficulties in changing players' dietary behaviours) (Costello et al., 2025). Additionally, reflective motivation barriers including doubts regarding practicality of CHO guidelines and scepticism surrounding body composition guidelines has also been reported (Costello et al., 2025). Despite this growing body of literature, there remains a lack of research examining the barriers and enablers underpinning dietary behaviours in male EPL soccer players, particularly through approaches that first measures dietary practices and then explore the underlying reasons and influencing factors. Given the persistent suboptimal adherence to nutritional guidelines among professional soccer players despite advances in nutritional support, there is a clear need to develop a more nuanced and contextually grounded understanding of dietary behaviours within elite soccer.

To better understand the lack of adherence to nutritional guidelines observed in Chapter 4, this study had two primary objectives: (1) to quantify the energy and macronutrient intake and distribution across meals on training days, MD-1, MD and MD+1; and (2) to apply the COM-B model as a framework to explore the factors underpinning the dietary practices of EPL male players. To this end, dietary intake was assessed over four consecutive days during the in-season via the RFPM, followed by dietary recall on the fifth day, which also included a semi structured

interview to explore the players' perspectives on factors influencing their dietary behaviours over the four days.

6.3 Methods

6.3.1 Participants

Ten male soccer players from the first team squad of an EPL soccer club volunteered to take part in this study. Participant characteristics were as follows: age = 23 ± 4 years, height = 188 ± 4 cm, body mass = 84.0 ± 5.0 kg, EPL appearances = 71 ± 97 , total years of competitive participation = 5 ± 4 years. Written informed consent was obtained for all participants. Ethical approval was granted by the Liverpool John Moores University Ethics Committee (REC approval number: 24/SPS/049).

6.3.2 Study Design

In a mixed methods observational design, players' self-reported energy and macronutrient intakes were assessed over a 4-day in-season period, including a training day, MD-1, MD and MD+1, followed by a dietary recall on the fifth day, which also included a semi-structured interview to explore the players' perspectives on factors influencing their dietary behaviours over the four days. During this time, all players continued with their usual training schedules. An example of daily schedule is displayed in Table 10.

Table 10. Example schedule of a professional soccer player on a training day, MD-1, MD and MD+1.

Time	Types of Day				
	Training Day	MD-1	MD	MD+1	
08:30	08:30 – 09:30: Breakfast	08:30 – 09:30: Breakfast	08:30 – 09:30: Breakfast	08:30 – 09:00: Fasted Blood Biomarkers Test	
09:00				09:00 - 09:30: Breakfast	
09:30					
10:00	10:00: Individual Treatment	10:00: Individual Treatment		10:00: Individual Treatment	
10:30	10:30: Pre-activation	10:30: Team Meeting		10:30: Team Meeting	
11:00	10:50: Team Training	11:00 Pre-activation		11:00: Recovery Session (Bike Mobility, Ice Bath, Massage, Pool Mobility, Sauna)	
11:30		11:30: Team Training	11:30: Report to the Stadium		
12:00			12:00 – 13:00: Pre Match Meal		
12:30	12:30: Gym			12:30: Upper Body Gym Session	
13:00	13:00 – 14:30: Lunch	13:00: Individual Recovery (Massage, Ice Bath, Sauna, Pool Mobility)	13:00: Team Meeting	13:00 – 14:30: Lunch	
13:30		13:30 – 14:30: Lunch			
14:00			14:10: Pre-Activation and Warm Up		
14:30	14:30: Media Appearances	14:30: Individual Video Analysis			
15:00					
15:30					
16:00	16:00: Afternoon Snacks	16:00: Afternoon Snacks	15:00-17:00: Match	16:00: Afternoon Snacks	
16:30			17:00: Post Match Recovery Shake		
17:00			17:30: Media Duties/Anti-Doping Test		
18:00			18:00: Post Match Meal		
18:30					
19:00	19:00: Dinner	19:00: Dinner		19:00: Dinner	
19:30					
20:00					
20:30			21:00: Evening Snacks		
21:00					
21:30					
22:00	22:00: Evening Snacks	22:00: Evening Snacks	22:00: Bedtime	22:00 Evening Snacks	
22:30					
23:00	23:00: Bedtime	23:00: Bedtime		23:00: Bedtime	

6.3.3 Quantification of energy and macronutrient intakes

Energy and macronutrient intake was measured via RFPM (Martin et al., 2009) and weighed food inventory. Prior to the data collection, participants were briefed individually about the process of collecting dietary intake using RFPM. The individual briefing session was delivered by the researcher who is accredited by the SENr and has four years of experience working with professional soccer players. Firstly, at breakfast and lunch, the dietary intake was assessed via weighed food inventory, which has been previously used alongside DLW with professional soccer players (Morehen et al., 2022; Chapter 4). As a menu-based system is utilised in the club, the main meals were weighed with a calibrated weighing scale (Model 405, Salter Brecknell Weighing, West Midlands, United Kingdom) before serving to the participants. Participants subsequently used the RFPM to self-report additional food items consumed at mealtimes (e.g. salad, fruits, beverages etc.) and any foods consumed for dinner and snacks. When using the RFPM to assess all food and drink they consume, participants are required to take a photo prior to consumption at 90° angle. Participants will then send a short description of the food within the images to the principal investigator on a smart phone via WhatsApp. The aim of the short description was to provide the principal investigator with as many details as possible (i.e. information on quantities, brands, preparation and cooking methods) to assist with the accuracy of the data analysis. Furthermore, most meals were consumed under the supervision of club nutritionists, including a registered dietitian and a SENr-Practitioner registrant, who provided support to players in accurately documenting meal details and capturing food photographs. Additionally, 24-h recall was performed with all participants on the day after each dietary assessment using the triple-pass method to ensure players did not omit any foods/drinks and to cross-check the two sources of dietary intake information (Capling et al., 2017). Dietary intake was analysed by the principal

investigator using the dietary analysis software (Nutritics v5, Dublin, Ireland), which calculates the energy and macronutrient intake for each participant. The estimated EI was reported in $\text{kcal}\cdot\text{day}^{-1}$ and macronutrient intake was reported in $\text{g}\cdot\text{day}^{-1}$ and $\text{g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$.

6.3.4 Dietary Behaviours Interview

All participants completed a semi structured interview the day after finishing the RFBM. The purpose of this interview was to explore the dietary behaviours observed over the preceding four days. During the interview, participants were shown images from the 4-day RFBM and engaged in semi-structured, open-ended discussions (Gall et al., 2007). Questions were delivered in a conversational and informal manner to encourage voluntary input and detailed responses (Lincoln and Guba, 1985). The interview questions were informed by the study aims and underpinned by the COM-B model. To achieve this, for each player at each mealtime the interview explored: 1) what was consumed (food and drink), 2) where did this occur, 3) who was involved or influenced the provision and 4) the reasons for dietary choice. All interviews were audio-recorded and transcribed verbatim. Data were subsequently analysed using the COM-B model as a framework, with participants' responses coded to the relevant COM-B components and further classified as either enablers or barriers to adherence to nutritional recommendations. To provide a more nuanced understanding of dietary behaviour, the TDF was applied to further elaborate on the COM-B components. This analytical process was conducted on a meal-by-meal basis to account for the contextual differences and meal specific influencing factors. Data are presented as the proportion (%) of responses per meal, attributable to each COM-B component and categorised as either an enabler or barrier. To enhance the rigour, one of the members from the supervisory team, unacquainted with the club and not involved in the interview process, acted as a "critical friend",

who independently checked and challenged data analysis and presentation of selected quotes (Smith, 2018). The role of critical friend is not to seek agreement or consensus but to encourage reflexivity by questioning the interpretations and constructions of knowledge (Cowan & Taylor, 2016). While the researcher's role within the club and personal interest in the topic inevitably introduced subjectivity, this insider perspective was considered advantageous for contextual understanding and rapport building. The involvement of the critical friend, who interrogated and challenged analysis, helped ensure balance between insider insight and analytic rigour (Austin & Sutton, 2014).

6.3.5 Statistical Analysis

All data were initially assessed for normality of distribution using Shapiro-Wilk's test. Differences in daily energy and macronutrient intakes were analysed using one-way repeated measures ANOVA. When there was a significant ($p < 0.05$) effect of "day", Bonferroni post hoc pairwise comparisons were performed to identify which day differed. Ninety-five percent confidence interval (95%CI) for the differences are also presented. All statistical analyses were completed using SPSS (version 29, SPSS, Chicago, IL) where $p < 0.05$ is indicative of statistical significance. Data are presented as mean \pm SD.

6.4 Results

6.4.1 Self-report energy and macronutrient intakes

There were no significant differences in absolute and relative EI between MD-1 (3314 ± 292 kcal·day⁻¹, 40 ± 5 kcal·kg BM⁻¹·day⁻¹), MD (2810 ± 573 kcal·day⁻¹, 34 ± 8 kcal·kg BM⁻¹·day⁻¹),

MD+1 ($2921 \pm 427 \text{ kcal}\cdot\text{day}^{-1}$, $35 \pm 4 \text{ kcal}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) and training day ($2830 \pm 395 \text{ kcal}\cdot\text{day}^{-1}$, $34 \pm 5 \text{ kcal}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) (all $p > 0.05$; Figures 15A & 15B). Total absolute CHO intake was significantly higher on MD-1 ($381 \pm 49 \text{ g}\cdot\text{day}^{-1}$), in comparison to training day ($289 \pm 58 \text{ g}\cdot\text{day}^{-1}$, 95% CI of mean difference = 18 to 167 $\text{g}\cdot\text{day}^{-1}$, $p = 0.014$) and MD+1 ($301 \pm 40 \text{ g}\cdot\text{day}^{-1}$, 95% CI of mean difference = 20 to 140 $\text{g}\cdot\text{day}^{-1}$, $p = 0.009$) but did not significantly differ from MD ($321 \text{ g}\cdot\text{day}^{-1}$, $p = 0.250$) (Figure 15C). Relative to BM, CHO intake was also significantly higher on MD-1 ($4.6 \pm 0.8 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) when compared to training day ($3.5 \pm 0.8 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$, 95% CI of mean difference = 0.2 to 2.1 $\text{g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$, $p = 0.019$) and MD+1 ($3.6 \pm 0.5 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$, 95% CI of mean difference = 0.2 to 1.8 $\text{g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$, $p = 0.013$) but did not significantly differ from MD ($3.9 \pm 1.2 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$, $p = 0.321$) (Figure 15D).

Total absolute protein intake was significantly lower on MD ($136 \pm 40 \text{ g}\cdot\text{day}^{-1}$) when compared to MD-1 ($190 \pm 32 \text{ g}\cdot\text{day}^{-1}$, 95% CI of mean difference = -86 to -21 $\text{g}\cdot\text{day}^{-1}$, $p = 0.002$), but no significant difference was observed when compared to training day ($177 \pm 18 \text{ g}\cdot\text{day}^{-1}$, $p = 0.120$) and MD+1 ($177 \pm 18 \text{ g}\cdot\text{day}^{-1}$, $p = 0.086$) (Figure 15E). Similarly, total relative protein intake was also lower on MD ($1.6 \pm 0.5 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) when compared to MD-1 ($2.3 \pm 0.5 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$, 95% CI of mean difference = -1.1 to -0.2 $\text{g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$, $p = 0.004$) but did not significantly differ from training day ($2.1 \pm 0.1 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$, $p = 0.104$) and MD+1 ($2.1 \pm 0.2 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$, $p = 0.091$) (Figure 15F). There were no significant differences in absolute and relative fat intakes between MD-1 ($116 \pm 20 \text{ g}\cdot\text{day}^{-1}$, $1.4 \pm 0.2 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$), MD ($109 \pm 31 \text{ g}\cdot\text{day}^{-1}$, $1.3 \pm 0.4 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$), MD+1 ($113 \pm 29 \text{ g}\cdot\text{day}^{-1}$, $1.3 \pm 0.3 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) and training day ($109 \pm 27 \text{ g}\cdot\text{day}^{-1}$, $1.3 \pm 0.3 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) (all $p > 0.05$; Figures 15G and 15H).

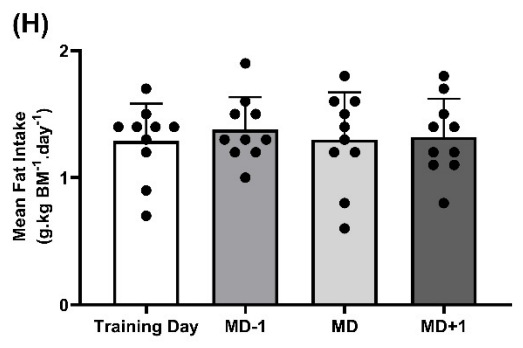
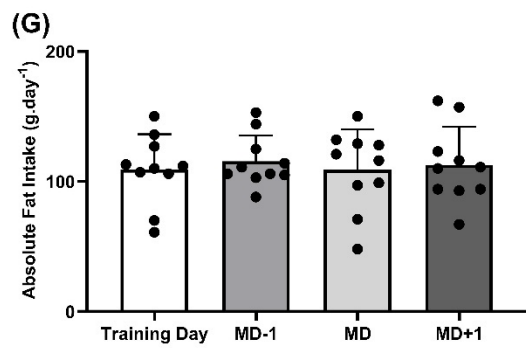
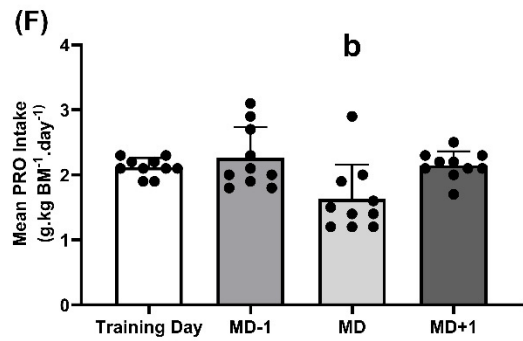
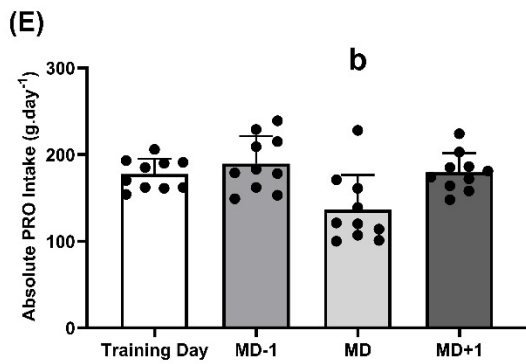
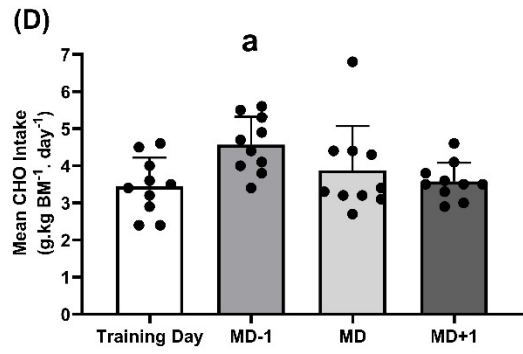
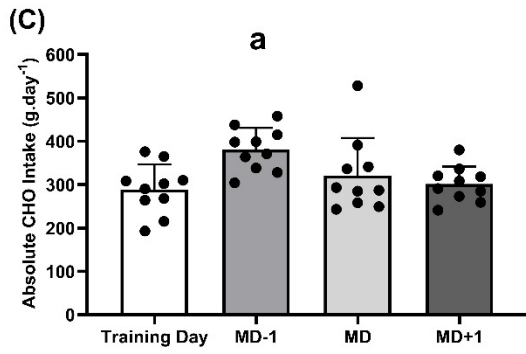
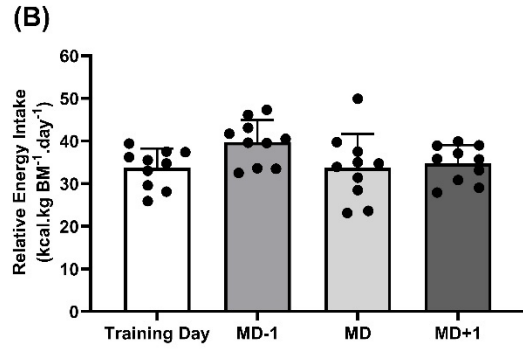
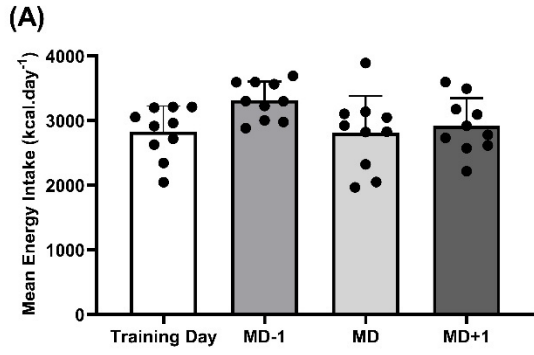


Figure 15. Self-reported mean absolute and relative energy (A & B), absolute and relative carbohydrate (C & D), absolute and relative protein (E & F) and absolute and relative fat (G & H) intakes on MD-1, MD, MD+1 and training day. ^aSignificantly higher on MD-1 than MD+1 and training day ($p < 0.05$). ^bSignificantly lower on MD than MD-1.

6.4.2 Distribution of Macronutrients Across Meals

Overview of macronutrients distribution is presented in Figure 16. The distribution of macronutrients is similar on training days and MD+1, with mean relative CHO intake between 0.8 to 1.0 g·kg BM⁻¹ at main meals (breakfast, lunch and dinner), 0.3 to 0.4 g·kg BM⁻¹ post training, 0.6 g·kg BM⁻¹ at afternoon snacks and 0.2 g·kg BM⁻¹ at evening snacks. On MD-1, higher relative CHO intake between 1.0 to 1.3 g·kg BM⁻¹ was observed at main meals (breakfast, lunch and dinner). Similarly, relative CHO intake was also higher post training (0.4 ± 0.2 g·kg BM⁻¹), afternoon snacks (0.8 ± 0.4 g·kg BM⁻¹) except evening snacks (0.1 ± 0.1 g·kg BM⁻¹). On MD, the mean relative CHO at pre match (0.9 ± 0.3 g·kg BM⁻¹) is lower than the recommended intake of 1 to 4 g·kg BM⁻¹. Similarly, CHO intake during match (24.1 ± 14.9 g·h⁻¹) was lower than the recommended intake of 30 to 60 g·h⁻¹. Immediate post-match CHO intake (0.8 ± 0.6 g·kg BM⁻¹) was also lower than the recommended intake of 1 g·kg BM⁻¹. The subsequent relative CHO intake at post-match recovery meal (PMRM) (0.8 ± 0.4 g·kg BM⁻¹) also fall short of the recommended intake of 1 g·kg BM⁻¹·h⁻¹ for the first four hours following the match.

Relative dietary protein intake was comparable across training days, MD-1 and MD+1, with mean values ranging from 0.4 g·kg BM⁻¹ at breakfast, 0.2 to 0.3 g·kg BM⁻¹ post training, 0.5 to 0.7 g·kg

BM⁻¹ at lunch, 0.2 to 0.3 g·kg BM⁻¹ at afternoon snacks, 0.6 to 0.7 g·kg BM⁻¹ at dinner and 0.2 to 0.3 g·kg BM⁻¹ at evening snacks. On MD, protein intake ranged from 0.2 to 0.6 g·kg BM⁻¹ across breakfast, lunch, pre match, post-match, PMRM and evening snacks, with no protein consumed during match play. Dietary fat intake was higher at main meals including breakfast, lunch, pre match, post-match, PMRM and dinner, ranging from 0.2 to 0.5 g·kg BM⁻¹ across training days, MD-1, MD and MD+1, compared with lower intakes post training, afternoon snacks and evening snacks (0.0 to 0.2 g·kg BM⁻¹).

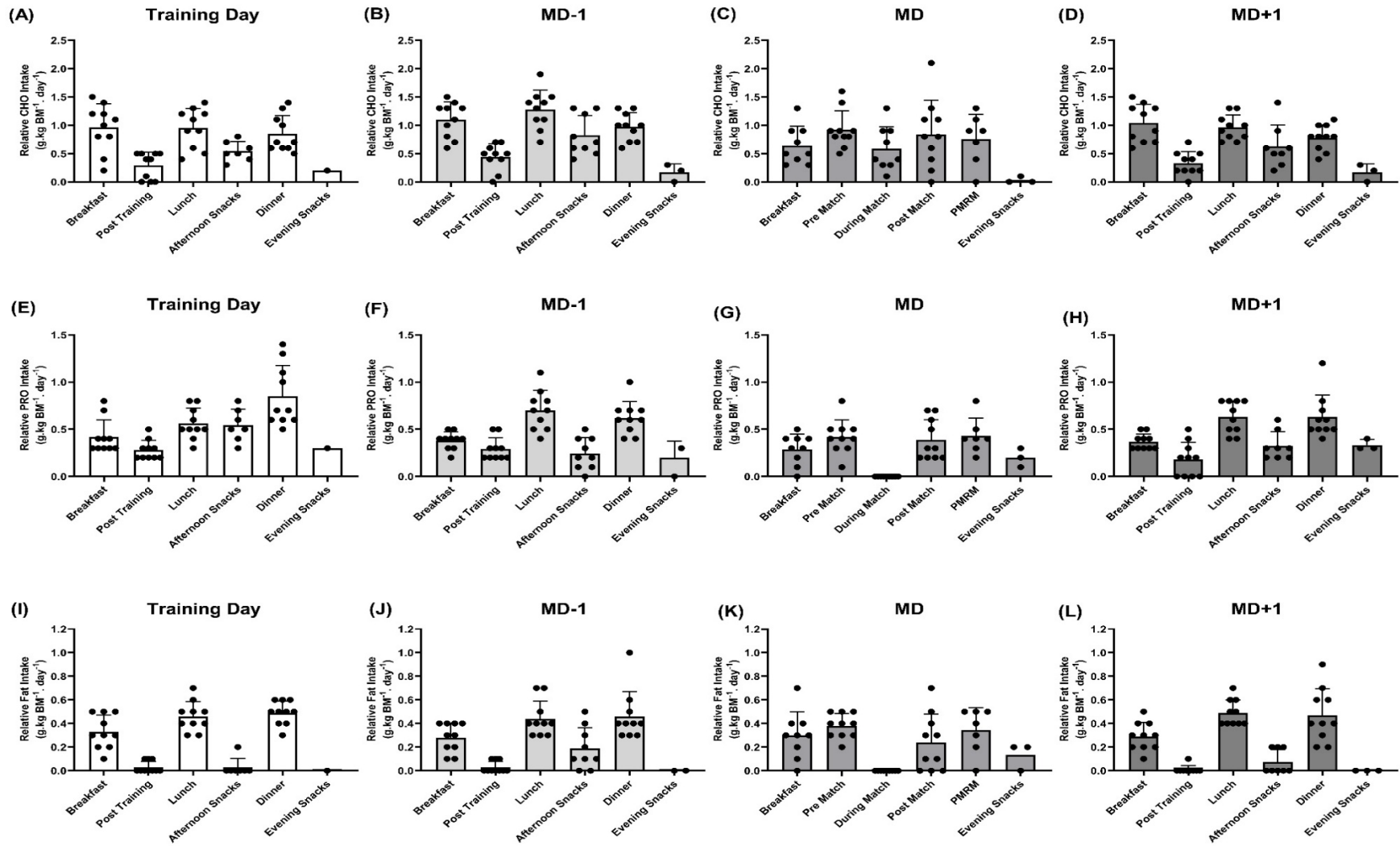


Figure 16. Relative carbohydrate, protein and fat intake meal distribution on training days (A, E, I), MD-1 (B, F, J), MD (C, G, K) and MD+1 (D, H, L).

6.4.3 COM-B Analysis of each mealtime

The COM-B analysis of each mealtime from the perspective of the players is displayed in Tables 11-14. In total, 195 meals were analysed, with the subsequent frequency analysis of COM-B components for each mealtime displayed in Figures 17-20. To provide deeper insight into the enablers and barriers underpinning players' dietary behaviours, illustrative participant quotes are presented below.

Training Day

On training days, reflective motivation (“beliefs about consequences”) emerged as the main barrier at breakfast (60%). The majority of the players preferred foods that were easily digestible in order to preserve a feeling of lightness before training:

[Participant 3] *“I always just have it and that's what I comfortable with, I feel like it doesn't upset my stomach.”*

[Participant 10] *“I always have something that can digest fast before I train so it's easy for me.”*

Following training, the main enabler was psychological capability (“knowledge”) (70%), with most players recognising the importance of protein for post training recovery. For instance, Participant 3 mentioned that *“I think after training, it's important to have protein, it's an important time to have it.”* Similarly, psychological capability (“knowledge”) (60%) was also the main enabler at lunch, with players demonstrating an understanding of CHO periodisation. Participant 7 explained:

“It depends on the training day; it's a pretty hard training day then I will have good amount of carbs and protein. I know how to adapt the amount of carbs basically. That also depends on whether I will play or not in the next couple of days.”

At lunch, automatic motivation (“emotion”) (20%) emerged as a potential barrier, as described by Participant 1, *“I'm picking it depending on how I am feeling.”* In contrast, for afternoon snacks, automatic motivation (“emotion”) (44%) emerged as the main enabler as Participant 7 described that *“I usually have yogurts or protein bar usually because I'm hungry.”* Reflective motivation (“belief about consequences”) (44%) was another enabler at afternoon snacks with Participant 4 stating *“I think it's a good snack in between lunch and dinner.”*

For dinner, social opportunity (“social influences”) (40%) was the main enabler. Players described reliance on others to support appropriate food provision:

[Participant 5] *“The chef will follow the plan provided by the nutritionist.”*

[Participant 9] *“I'll just eat what my dig lady cooks for me, she had a lot of nutritional meeting with nutritionists, so she knew what to cook on different types of day. She always gets it spotted on.”*

At evening snacks, psychological capability (“knowledge”) (100%) was the main enabler with Participant 3 explaining *“It's just another way to get protein before I go to bed.”*

MD-1

On MD-1, psychological capability (“knowledge”) (50%) emerged as the primary enabler at breakfast. Players demonstrated awareness of the need to maximise CHO availability on the day before the match. For instance, Participant 9 stated that *“On MD-1, you want to get as much CHO as you can, obviously during the game you'll burn it all, so it's about CHO loading.”* Similarly, “knowledge” (70%) was the key enabler at post training with Participant 8 mentioning that *“protein shake is a quick way to get protein, it's easy way to get protein. It got creatine in there as well which is good for your body.”* At lunch, psychological capability (“knowledge”) (50%) continued to act as a key enabler, as players acknowledged the importance of increasing CHO intake:

[Participant 8] *“I like to fill out at my lunch on the day before as on game day I don't like to eat as much. The day before I would like to have a bigger portion at lunch.”*

[Participant 9] *“I focus on getting more carbs on MD-1 to prepare me for the game.”*

However, reflective motivation (“beliefs about consequences”) (20%) was identified as a barrier at lunch, with some players preferring familiar foods. As Participant 3 explained, *“I always stick to the foods that I'm comfortable with on MD-1.”* For afternoon snacks, automatic motivation (“emotion”) (56%) emerged as the main driver of dietary behaviour, with Participant 9 noting that *“It makes me feel quite full and I quite enjoyed it as well because it's nice.”* At dinner,

psychological capability (“knowledge”) (60%) again functioned as the main enabler, with players intentionally increasing CHO intake:

[Participant 2] *“At dinner, I will eat a bit more CHO than normal day.”*

[Participant 3] *“I try to get more carbs in towards the night on MD-1.”*

Evening snacks were also driven entirely by psychological capability (“knowledge”) (100%). Participant 3 mentioned that *“I ’ll have an extra snack, whatever I’m feeling to eat a little more energy.”* However, only three players reported consuming evening snacks on MD-1, indicating a potential opportunity to further increase CHO intake.

MD

On MD, reflective motivation (“beliefs about consequences”) (63%) emerged as the primary barrier to breakfast intake. Players commonly restricted food intake to avoid feelings of heaviness during the match:

[Participant 4] *“I try to not eat a lot because then I feel full and I cannot run.”*

[Participant 10] *“I prefer to eat a bit less than normal on MD because I want to feel lighter during the game.”*

This pattern persisted at the pre-match meal, where reflective motivation (“beliefs about consequences”) (60%) remained the main barrier. Players again prioritised feelings of lightness:

[Participant 3] *“I feel like when it gets closer to the game, I want to have less foods to feel a bit lighter when I play.”*

[Participant 8] *“I will have smaller portion at pre match as I like to feel light when I go out to play.”*

During the match, reflective motivation (“beliefs about consequences”) (40%) continued to act as the dominant barrier. Participant 8 stated that *“I like to feel quite light and it's something that I have always done so I don't have a lot during match.”*, while Participant 9 added that *“I don't want to upset my stomach and that's nothing worse than feeling heavy when you're playing.”*

In the immediate post-match period, automatic motivation (“emotion”) (40%) emerged as the main barrier, with participants reporting suppressed appetite immediately post-match:

[Participant 1] *“Normally after the game, I can't really eat straight away, I have to wait for a few hours before I can eat.”*

[Participant 4] *“I don't have appetite especially if I played a full game.”*

Similarly, during the PMRM, automatic motivation (“emotion”) (50%) remained the main barrier. For instance, Participant 5 stated that *“It depends how I feel. If I'm really tired, I struggle to eat.”*

MD+1

On MD+1, psychological capability (“knowledge”) (40%) emerged as the main enabler of dietary practice. Players demonstrated awareness of the need to support recovery through increased intake. For instance, Participant 8 mentioned that *“I’ll add more carbs and protein to help with my recovery.”* Similarly, psychological capability (“knowledge”) (70%) was the main enabler post training:

[Participant 6] *“I will have the cherry drink because it’s good for recovery.”*

[Participant 8] *“I will add additional supplement with the cherry to boost my recovery.”*

At lunch, psychological capability (“knowledge”) (60%) again acted as the primary enabler, with players emphasising the need to replenish energy stores. For example, Participant 9 mentioned that *“it’s about replenishing what lost, so I will eat as much as I can.”* and Participant 10 stated that *“I’ll eat more carbs, protein on MD+1 to replace what I have lost on MD.”* For afternoon snacks, reflective motivation (“beliefs about consequences”) (57%) was the main enabler as suggested by Participant 4, *“I like them and they are good for me.”* For dinner, social opportunity (“social influences”) (50%) was one of the main enablers as described by Participant 7, *“I usually go out to have dinner; just to have some times with the family, that usually will be a restaurant meal.”* Additionally, automatic motivation (“emotion”) (50%) also functioned as an enabler at dinner, as players expressed a desire to enjoy food on MD+1:

[Participant 2] *“On the day after the game, I will eat whatever I want, just for my mind. But it’s not regular. It depends.”*

[Participant 5] *“On the day after the game, I like to enjoy more African foods at dinner.”*

Table 11. COM-B analysis for all the meals on training days.

Location	COM-B	COM-B Construct	TDF Construct	Frequency of Barrier or Enabler	Sample Quotations
BREAKFAST					
Training Ground (n = 10)	Capability	Psychological	Knowledge	Enablers (10%)	“I try to have carbs with bread, healthy fats, protein with Iberico ham. I try to have five portions of fruit and veg throughout the day, so I pick fruits in the morning because of that.”
				Barriers (20%)	“I have two sourdough bread because I feel like I need good amount of carbs for training.”
	Motivation	Automatic	Emotion	Enablers (30%)	“I always have the same breakfast because I like it.”
		Reflective	Beliefs about consequences	Barriers (60%)	“I always just have it and that's what I comfortable with, I feel like it doesn't upset my stomach.”
POST TRAINING					
Training Ground (n = 10)	Capability	Psychological	Knowledge	Enablers (70%)	“I know I need to get 150-200 g of protein, which is about 2 g/kg. Also, I know protein help muscles to recover faster.”
	Opportunity	Physical	Environmental Constructs	Enablers (30%)	“I have the protein shake because it's there for me.”
		Social	Social Influences	Enablers (10%)	“It's good for recovery and I trust the nutritionist.”
	Motivation	Automatic	Emotion	Enablers (10%)	“I'm drinking it to recover and to go again as I might do a bit of gym before I have lunch. When you come in, you're quite hungry as well.”
				Barriers (10%)	“It depends on how I feel after the training session; I only have it when I feel weak after training.”
LUNCH					
Training Ground (n = 10)	Capability	Psychological	Knowledge	Enablers (60%)	“It depends on the training day; it's a pretty hard training day then I will have good amount of carbs and protein. I know how to adapt the amount of carbs basically. That also depends on whether I will play or not in the next couple of days.”
	Motivation	Reflective	Beliefs about consequences	Enablers (20%)	“I enjoyed it and also feel comfortable with the foods, and it doesn't upset my stomach. It got all the nutrients that I need.”
		Automatic	Emotion	Enablers (20%)	“I try to have simple foods, not too many sauces, just olive oil on top.”
				Barriers (20%)	“I'm picking it depending on how I am feeling.”
AFTERNOON SNACKS					
Home (n = 9)	Capability	Psychological	Knowledge	Enablers (33%)	“I have fruits so I've enough fruits for the day, also Greek Yogurt as well because it's low fat and high protein.”
	Opportunity	Social	Social Influences	Enablers (11%)	“When I'm home, my chef will give me the snacks.”
	Motivation	Reflective	Beliefs about consequences	Enablers (44%)	“I like them and they are good for me.”
		Automatic	Emotion	Enablers (44%)	“I usually have yogurts or protein bar because I'm hungry.”
DINNER					
Home (n = 8) Host Family Accommodation (n = 2)	Capability	Psychological	Knowledge	Enablers (30%)	“I always try to have veggies, carbs, healthy fats and protein.”
	Opportunity	Social	Social Influences	Enablers (40%)	“I'll just eat what my dig lady cooks for me, she had a lot of nutritional meeting with nutritionists, so she knew what to cook on different types of day. She always gets it spotted on.”
	Motivation	Automatic	Emotion	Enablers (30%)	“It pretty much always pasta and chicken breast. Tomato pasta or ragu pasta, depends on my mood.”
EVENING SNACKS					

Home (n = 3)	Capability	Psychological	Knowledge	Enablers (100%)	"It's just another way to get protein before I go to bed."
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Table 12. COM-B analysis of meals on MD-1.

Location	COM-B	COM-B Construct	TDF Construct	Frequency of Barrier or Enabler	Sample Quotations
BREAKFAST					
Training Ground (n = 10)	Capability	Psychological	Knowledge	Enablers (50%)	"On MD-1, you want to get as much CHO as you can, obviously during the game you'll burn it all, so it's about CHO loading."
				Enablers (20%)	"It gives me energy and it's healthy as well."
	Reflective	Beliefs about consequences	Barriers (40%)	"I always just have it and that's what I comfortable with, I feel like it doesn't upset my stomach."	
POST TRAINING					
Training Ground (n = 10)	Capability	Psychological	Knowledge	Enablers (70%)	"Protein shake is a quick way to get protein; it's easy way to get protein. It got creatine in there as well which is good for your body."
				Opportunity	Physical
	Social	Social Influences	Enablers (10%)		
	Motivation	Automatic	Emotion	Enablers (10%)	"I'm drinking it to recover and to go again as I might do a bit of gym before I have lunch. When you come in, you're quite hungry as well."
				Barriers (10%)	"It depends on how I feel after the training session; I only have it when I feel weak after training."
LUNCH					
Training Ground (n = 10)	Capability	Psychological	Knowledge	Enablers (50%)	"I focus on getting more carbs on MD-1 to prepare me for the game."
				Motivation	Reflective
	Automatic	Emotion	Enablers (40%)		
			Barriers (10%)	"I'm picking it depending on how I am feeling."	
AFTERNOON SNACKS					
Home (n = 9)	Capability	Psychological	Knowledge	Enablers (11%)	"I will have the fruits with yogurt or protein pudding to stop the hunger. If the training session was hard, I will put extra oats and extra half scoop of protein."
				Opportunity	Social
	Motivation	Reflective	Beliefs about consequences		
				Barriers (11%)	"I always stick to the foods that I'm comfortable with on MD-1."
				Automatic	Emotion
DINNER					
Home (n = 8)	Capability	Psychological	Knowledge	Enablers (60%)	"I try to get more carbs in towards the night on MD-1."
				Barriers (10%)	"I will always have rice or pasta with chicken or meat and some vegetables. I don't think about the portion as much."
Host Family	Opportunity	Social	Social Influences	Enablers (10%)	"Usually the day before the game, they'll cook chicken and pasta for me as I know it goes quite well with me."

Accommodation (n = 2)	Motivation	Reflective	Beliefs about consequences	Enablers (30%)	“I eat more to have the energy and have less fat. I eat food that I digest well, not a lot of flavours.”
EVENING SNACKS					
Home (n = 3)	Capability	Psychological	Knowledge	Enablers (100%)	“Sometimes I have the carb and protein mix drink to increase my carbs.”
	Motivation	Automatic	Emotion	Enablers (33%)	“I 'll have an extra snack, whatever I'm feeling to eat a little more before the energy.”

Table 13. COM-B Analysis on MD.

Location	COM-B	COM-B Construct	TDF Construct	Frequency of Barrier or Enabler	Sample Quotations
BREAKFAST					
Home (n = 5)	Motivation	Reflective	Beliefs about consequences	Enablers (25%)	“I'll always have that for breakfast before every home game, that gives me a bit of sugar and carbs and put me in a right state before the game.”
				Barriers (62.5%)	“I don't try to eat a lot because then I feel full, and I cannot run.”
Host Family (n = 2)	Opportunity	Physical	Environmental Constructs	Barriers (12.5%)	“I usually eat at home but at that time I didn't have anything at home.”
Restaurant (n = 1)					
PRE MATCH					
Stadium (n = 10)	Capability	Psychological	Knowledge	Enablers (20%)	“My mental routine is to try have carbs and protein every time, it can change, sometimes I eat pasta, sometimes I eat rice with chicken. I prefer to have slowly digesting carbs to prevent the peak of my blood glucose.”
		Reflective	Beliefs about consequences	Enablers (20%)	“It makes me feel comfortable and I get the energy I need.”
				Barriers (60%)	“I feel like when it gets closer to the game, I want to have less foods to feel a bit lighter when I play.”
DURING MATCH					
Stadium (n = 10)	Capability	Psychological	Knowledge	Enablers (20%)	“I will have the orange drink; I've the espresso for caffeine and hydrators for hydration.”
	Opportunity	Social	Social Influences	Enablers (10%)	“Because the nutritionist says it's good for me.”
	Motivation	Automatic	Emotion	Barriers (30%)	“I don't normally have too many carbs during the game, that's what I have been used to.”
		Reflective	Beliefs about consequences	Enablers (10%)	“Probably for my mind but I think they're giving me energy also.”
				Barriers (40%)	“I like to feel quite light and it's something that I have always done so I don't have a lot during match.”
POST MATCH					
Stadium (n = 10)	Capability	Psychological	Knowledge	Enablers (10%)	“I think after game, it's important to have protein, it's an important time to have it.”
	Opportunity	Physical	Environmental Constructs	Enablers (10%)	“It's more relaxed. I take the stuff from the lounge and then I go home.”

	Motivation	Social	Social Influences	Enablers (10%)	“I have the protein shake because the nutritionist prepares it for me.”
		Reflective	Beliefs about consequences	Enablers (10%)	“For me, I just eat whatever foods I can to get the energy.”
	Automatic	Emotion	Enablers (20%)	“I'm quite hungry after the game after the game as I didn't eat as much before.”	
			Barriers (40%)	“I don't have appetite especially if I played a full game.”	
POST MATCH RECOVERY MEAL					
Home (n = 5)	Capability	Psychological	Knowledge	Enablers (17%)	“I try to have larger portion of carbs and with some protein.”
Restaurant (n = 1)	Opportunity	Social	Social Influences	Enablers (17%)	“Sometimes I will go to the restaurant to have a good time with my friends or family.”
	Motivation	Automatic	Emotion	Enablers (17%)	“I will have the snacks when my chef makes them.”
Barriers (50%)				“It depends how I feel. If I'm really tired, I struggle to eat.”	

Table 14. COM-B Analysis of MD+1.

Location	COM-B	COM-B Construct	TDF Construct	Frequency of Barrier or Enabler	Sample Quotations	
BREAKFAST						
Training Ground (n = 10)	Capability	Psychological	Knowledge	Enablers (40%)	“I'll add more carbs and protein to help with my recovery.”	
				Barriers (20%)	“I have two sourdough bread because I feel like I need good amount of carbs for training.”	
	Motivation	Reflective	Beliefs about consequences	Emotion	Enablers (20%)	“Because I like it and I don't feel heavy.”
				Enablers (20%)	“It gives me energy and it's healthy as well.”	
				Barriers (30%)	“I don't like to eat too much, porridge makes me feel lighter.”	
POST TRAINING						
Training Ground (n = 10)	Capability	Psychological	Knowledge	Enablers (70%)	“I will add additional supplement with the cherry to boost my recovery.”	
	Opportunity	Physical	Environmental Constructs	Enablers (10%)	“I have the protein shake because it's there for me.”	
	Motivation	Automatic	Emotion	Enablers (10%)	“I'm drinking it to recover and to go again as I might do a bit of gym before I have lunch. When you come in, you're quite hungry as well.”	
				Barriers (10%)	“It depends on how I feel after the training session; I only have it when I feel weak after training.”	
LUNCH						
Training Ground (n = 10)	Capability	Psychological	Knowledge	Enablers (60%)	“I'll eat more carbs, protein on MD+1 to replace what I have lost on MD.”	
	Motivation	Reflective	Beliefs about consequences	Enablers (20%)	“I enjoyed it and also feel comfortable with the foods, and it doesn't upset my stomach. It got all the nutrients that I need.”	
				Barriers (10%)	“I always have rice, red pesto and salmon because it makes me feel comfortable.”	
		Automatic	Emotion	Enablers (30%)	“I have it because I like it.”	
AFTERNOON SNACKS						

Home (n = 7)	Capability	Psychological	Knowledge	Enablers (29%)	“I have fruits so I've enough fruits for the day, also Greek Yogurt as well because it's low fat and high protein.”
	Motivation	Reflective	Beliefs about consequences	Enablers (57%)	“I think it's a good snack to have between lunch and dinner.”
		Automatic	Emotion	Enablers (43%)	“I like them and they are good for me.”
DINNER					
Home (n = 7)	Opportunity	Social	Social influences	Enablers (50%)	“I usually go out to have dinner, just to have some times with the family, that usually will be a restaurant meal.”
Host Family Accommodation (n = 2)		Motivation	Automatic	Emotion	Enablers (50%)
Restaurant (n = 1)					

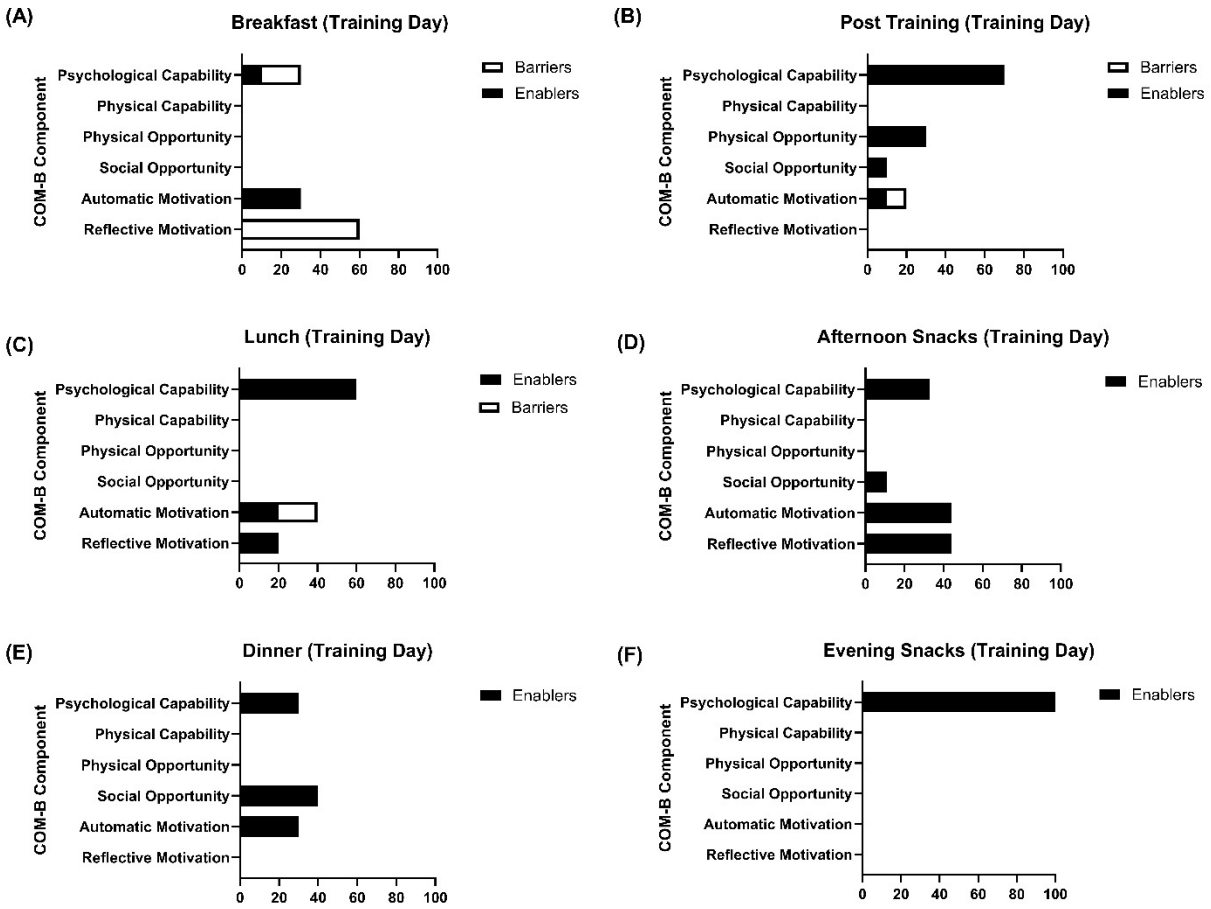


Figure 17. Frequency analysis of each component of COM-B at each mealtime on training days from the perspective of players.

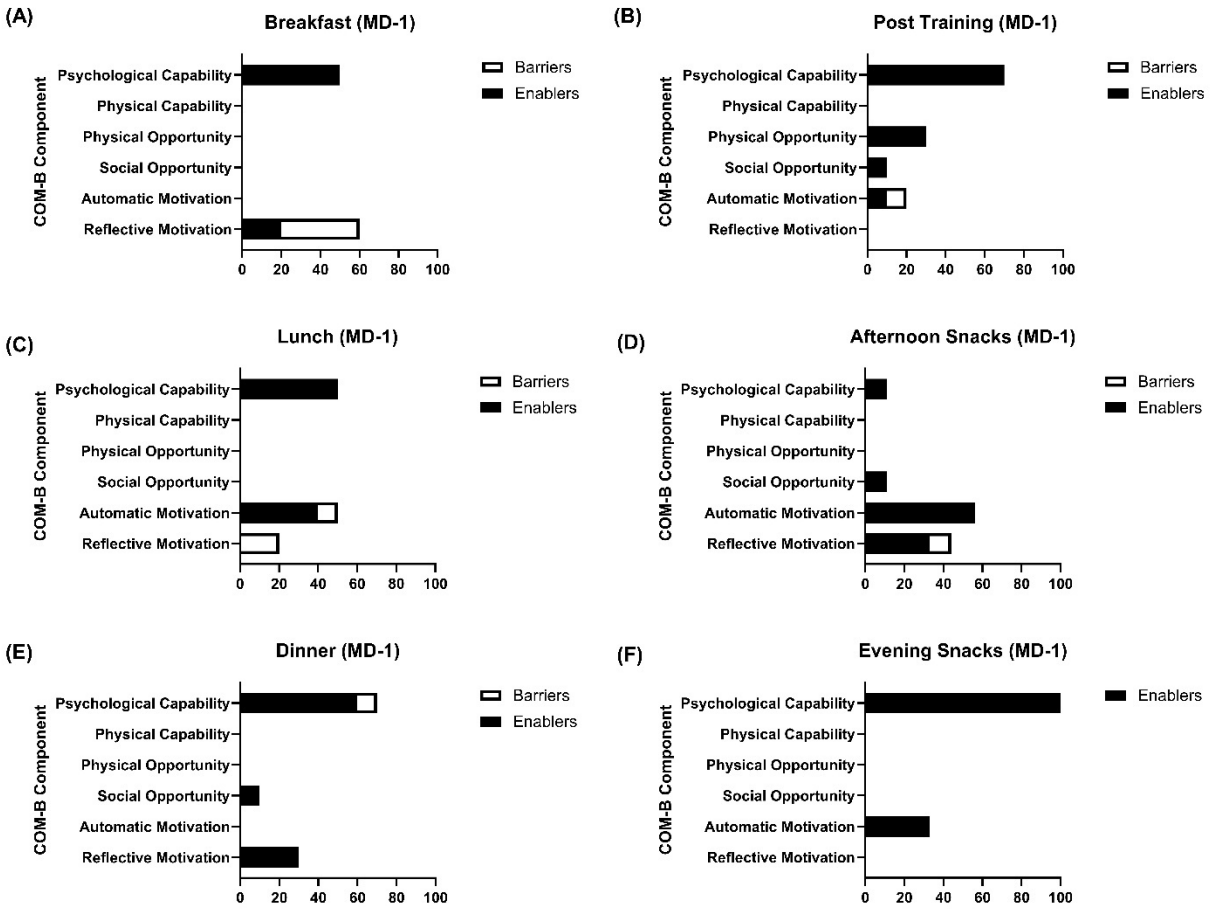


Figure 18. Frequency analysis of each component of COM-B at each mealtime on MD-1 from the perspective of players.

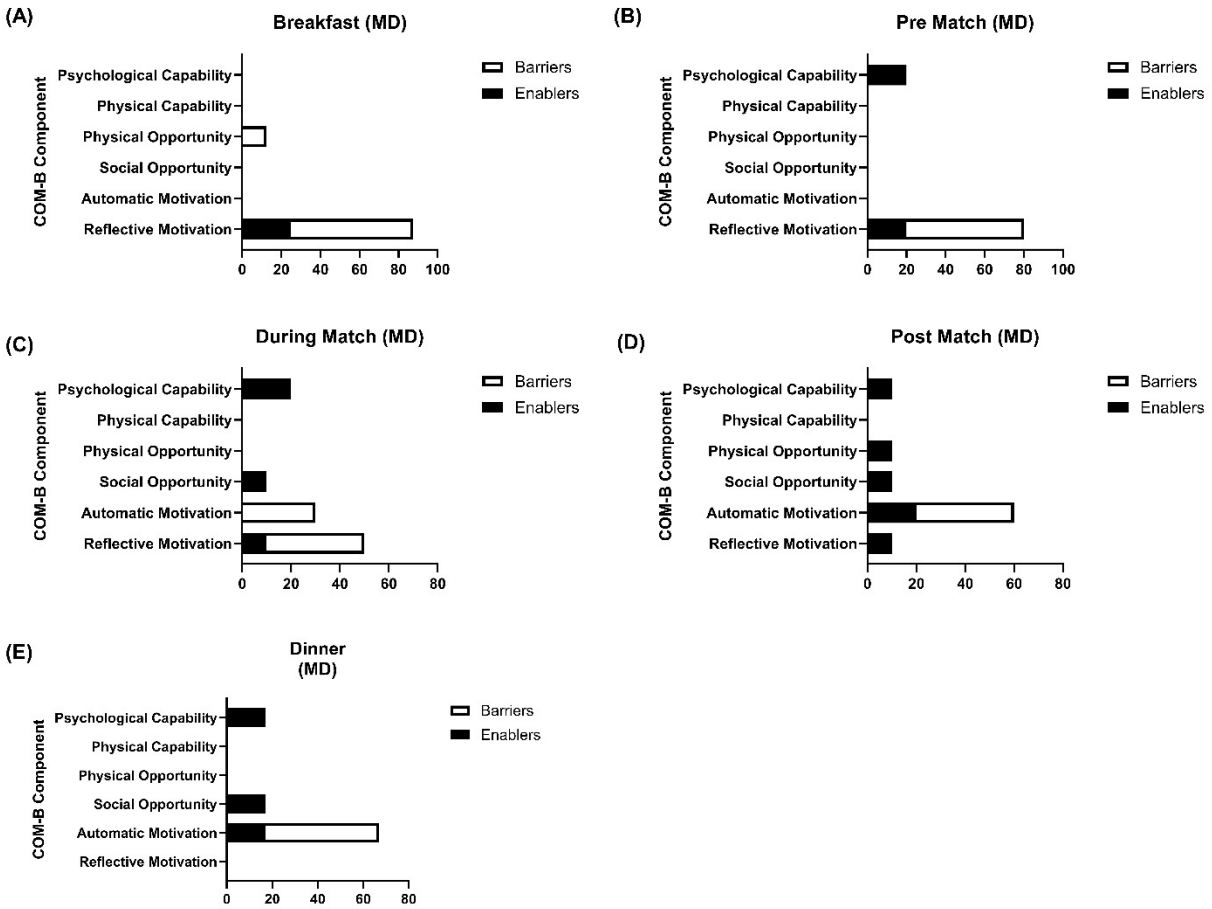


Figure 19. Frequency analysis of each component of COM-B at each mealtime on MD from the perspective of players.

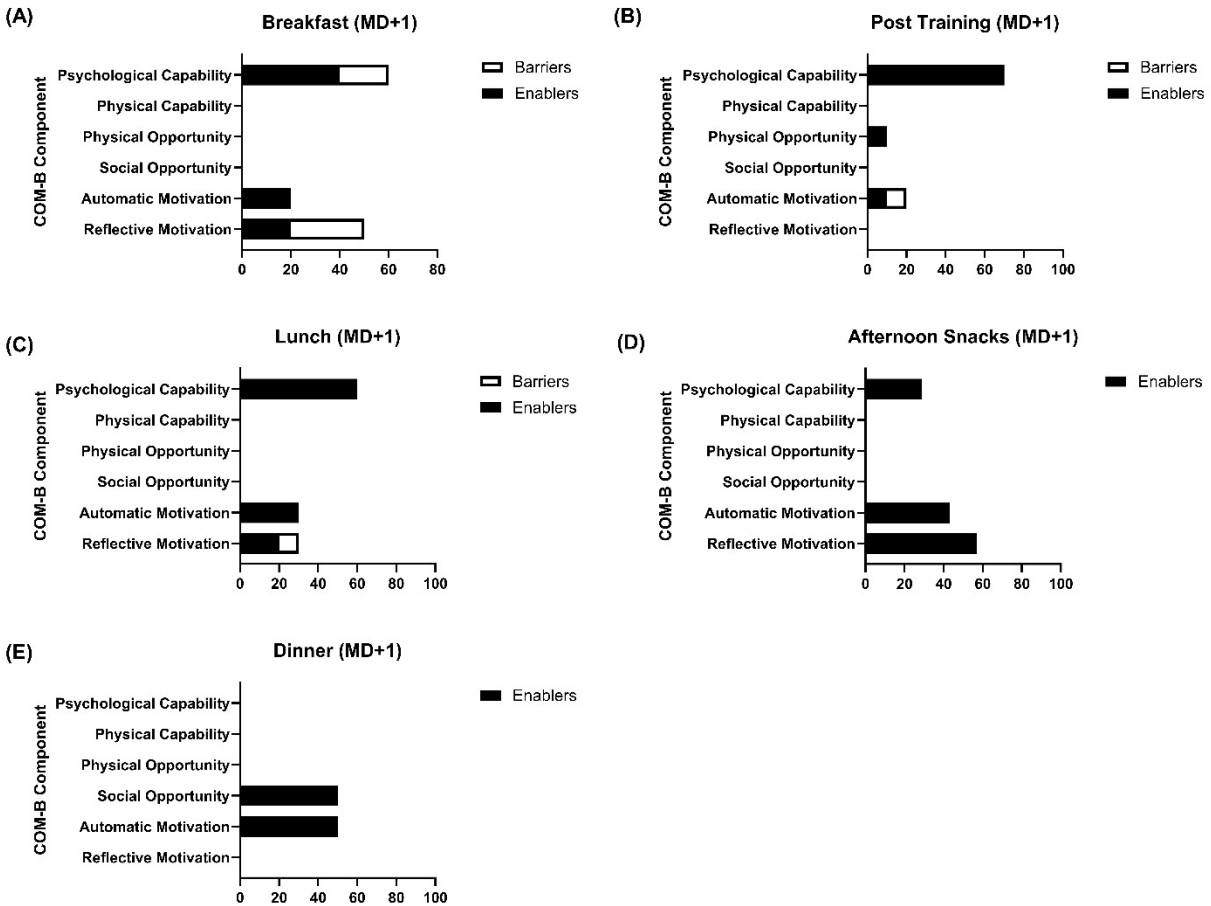


Figure 20. Frequency analysis of each component of COM-B at each mealtime on MD+1 from the perspective of players.

6.5 Discussion

In using a mixed methods approach, the first report to simultaneously evaluate the habitual dietary intakes of male professional soccer players whilst also exploring the potential enablers and barriers that impact their dietary choices and practices **was provided**. Importantly, **the** data demonstrate that the factors affecting players' habitual nutritional practices are distinctly different between training days and match days. Indeed, whereas psychological capability (i.e. knowledge of fuelling etc.) was a key enabler to nutritional behaviours on training days, MD-1 and MD+1, both reflective

(i.e. beliefs about consequences) and automatic motivation (i.e. emotions) were the predominant barrier to fuelling and recovery on match days. These preliminary data provide a conceptual framework for sport nutrition practitioners to better understand the factors affecting players' dietary choices on a meal-by-meal and day-by-day basis.

On the training day, mean CHO intake ($3.5 \pm 0.8 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) was at the lower end of the recommendations of 3 to 6 $\text{g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$, whereas mean protein intake ($2.1 \pm 0.1 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) was aligned with current recommendations of 1.6 to 2.2 $\text{g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$. These findings were consistent with previous findings in EPL players as reported in Chapter 4, which have documented CHO intakes of 3.0 to 4.2 $\text{g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) and PRO intakes around 2.2 $\text{g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$ (Anderson et al., 2017b). The relatively low CHO intake reported may be partly explained by a key barrier identified at breakfast (“beliefs about consequences”), whereby players reported avoiding higher CHO intakes to prevent sensations of heaviness before training. Similar barriers have been reported previously, with athletes describing difficulties tolerating the volume of the foods required to meet CHO recommendations and experiencing gastrointestinal discomfort when doing so (Logue et al., 2021). Consequently, practitioners may consider targeted interventions such as dietary manipulation of fermentable oligo-, di-, and mono-saccharides and polyols (FODMAP) as well as gut training or feeding tolerance adjustments to reduce gastrointestinal symptoms and support higher CHO intakes when required (Costa et al., 2025). In contrast, nutrition knowledge emerged as the primary enabler influencing dietary behaviours post training and at lunch. This aligns with earlier research showing that sports nutrition knowledge influences dietary practices among EPL academy players (Carter et al., 2023b; Carney et al., 2024). At dinner, “social influences” were identified as the main enabler, with key external stakeholders such as partners or

private chefs exerting a substantial influence on food choices. This coincides with previous literature highlighting the role of interpersonal determinants including family members, peers and support staff in shaping athletes' dietary behaviours (Long et al., 2011; Stokes et al., 2018; Jenner et al., 2021; Carter et al., 2023b). Notably, the current findings revealed a contextual discrepancy between enablers influencing players' eating behaviours at the training ground versus outside it. Within the club environment, decisions appeared to be primarily guided by knowledge and professional advice, reflecting the players desire to align with the perceived norms within the professional soccer culture as highlighted in Chapter 3, whereas outside this setting, social influences were more prominent. These findings highlight the importance of environmental context in shaping dietary behaviours. Practitioners should therefore consider the BCT “practical social support” through educating and engaging family members, care givers, partners and personal chefs to foster consistency in nutritional practices.

On MD-1, the players consumed significantly higher CHO intake than training days, MD and MD+1. Nevertheless, mean relative intake ($4.6 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) remained below the recommended 6 to 8 $\text{g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$ (Collins et al., 2021). This shortfall aligns with findings shown in Chapter 4 and previous research conducted in male EPL players (Anderson et al., 2017b), where MD-1 CHO intakes ranged from 3.5 to 4.2 $\text{g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$, suggesting that suboptimal fuelling persists despite the well-established guidelines. Qualitative findings indicated that players generally recognised the importance of CHO for match performance on MD-1 and identified this awareness as an enabler of their dietary behaviours. While this translated into significantly higher CHO intake on MD-1, intakes nonetheless remained below recommendations. This disconnect between knowledge and practice highlights the limitations of education-based sports nutrition

interventions that rely heavily on “information about health consequences” or “instructions on how to perform the behaviour” (Bentley et al., 2020). Without the opportunities for “behavioural rehearsal and practice”, such approaches may fail to convert awareness into consistent dietary action. Evidence supporting the effectiveness of strategies incorporating “persuasion” such as visible nutritionist presence, structured meal-time prompts and digital nudges, in promoting higher CHO intake (Carter et al., 2024), further highlights the need for BCTs beyond education alone. In addition, “restructuring the physical environment” has been previously shown to increase CHO intakes by enhancing the accessibility and availability of CHO-dense foods (Salagaras et al., 2021). Collectively, these findings suggest that professional soccer players recognise the performance benefits of CHO but often lack the practical strategies to meet recommendations. This contrasts with academy players where limited awareness of nutrition has been highlighted (Carney et al., 2024) and with the prevailing CHO fear documented in women’s soccer environment (McHaffie et al., 2022). From a practical perspective, this highlights the need for interventions that move beyond knowledge provision to focus on behaviour change strategies capable of bridging the gap between awareness and optimal fuelling practices.

On MD, mean CHO intake was below current recommendations across all key phases: pre-match ($0.9 \text{ g}\cdot\text{kg BM}^{-1}$ vs. $1\text{--}4 \text{ g}\cdot\text{kg BM}^{-1}$), during match play ($24 \text{ g}\cdot\text{h}^{-1}$ vs. $30\text{--}60 \text{ g}\cdot\text{h}^{-1}$), and post-match ($0.8 \text{ g}\cdot\text{kg BM}^{-1}$ vs. $1 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{h}^{-1}$ during the first 4 h), with similarly low intake at PMRM ($0.8 \text{ g}\cdot\text{kg BM}^{-1}$). Pre-match CHO intake was lower than previously reported in EPL players (~ 1.3 to $1.4 \text{ g}\cdot\text{kg BM}^{-1}$) (Anderson et al., 2017a), whereas CHO intake during match was higher than a recent report from EPL pre-season matches ($17 \pm 11 \text{ g}\cdot\text{h}^{-1}$) (Kasper et al., 2024). Immediate post-match CHO intakes were comparable to earlier findings of $<1 \text{ g}\cdot\text{kg BM}^{-1}$ (Anderson et al., 2017a).

Suboptimal CHO intake during the critical recovery period is likely to compromise muscle glycogen resynthesis, particularly within fast twitch muscle fibres (Ermidis et al., 2024) and may reduce intermittent exercise capacity on the subsequent day (Díaz-Lara et al., 2024). Qualitative analysis identified “beliefs about consequences” as the key barriers to fuelling at pre match and during matches, suggesting that players may deliberately restrict CHO before and during the match to preserve a subjective feeling of lightness. This perception aligns with applied practitioners’ perspectives and highlights that, although current guidelines are physiologically robust, their practical feasibility may be constrained by food volumes required and associated risk of gastrointestinal discomfort (Costello et al., 2025). In this context, BCTs such as “behavioural practice and rehearsal” are likely effective in supporting improved fuelling behaviours. Practical strategies include prioritising low-fibre, energy-dense CHO sources (Foo et al., 2022) and incorporating systemic “gut training” during training and match preparation (Martinez et al., 2023) could help to improve tolerance to higher CHO intakes.

For post-match and PMRM, “emotion” was cited as the primary barrier, with many players reporting suppressed appetite. Similar reports have been observed in Australian Rules football players (Jenner et al., 2021), consistent with the evidence of reduced subjective hunger and suppressed acylated ghrelin following high intensity intermittent exercise (Hu et al., 2023b; a). To mitigate this, providing convenient, palatable and cultural appropriate options post-match has been recommended (Ranchordas et al., 2017). Furthermore, the use of “graded task” may support improvements in pre, during and post match CHO intakes by progressively increasing intake targets to enhance gastrointestinal tolerance over time (Thompson et al., 2026). These findings highlight that optimising MD fuelling in professional players requires practitioners to move

beyond absolute CHO targets and instead implement strategies that balance physiological robustness with contextual feasibility by accounting for player beliefs, comfort and post-match appetite while ensuring sufficient CHO intake to support muscle glycogen resynthesis, recovery and performance.

On MD+1, mean CHO intake ($3.6 \pm 0.5 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) was significantly below the recommended intake of 6 to 8 $\text{g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$ (Collins et al., 2021). Comparable intakes of 3 to 4 $\text{g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$ were previously reported among EPL first team and academy players on MD+1 in Chapter 4 and also previous research (Anderson et al., 2017b; Carter et al., 2023a). Maintaining high CHO availability on the day following the match is critical, particularly during congested periods, as intakes of 9.5 $\text{g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$ have been shown to fully restore muscle glycogen within 72 h after a 90 min soccer game (Krustrup et al., 2011). Furthermore, additional CHO supplementation on days following the match has been associated with the preservation of repeated sprint ability, running speed, intense acceleration and deceleration while attenuating muscle damage and inflammatory responses before and during the subsequent match (Ermidis et al., 2024). Similar to MD-1, “knowledge” was identified as a key enabler of dietary practices on MD+1 at breakfast, post training and lunch. Nevertheless, players still failed to achieve the recommended CHO intake, indicating awareness alone was insufficient to translate guidelines into practice. This suggests a need to enhance players’ practical capability to operationalise recovery nutrition strategies. In this context, incorporating BCTs including “instructions on how to perform behaviour” and “demonstration of behaviour” may be effective in illustrating what appropriate fuelling should look like across MD+1 via educational infographics outlining meal timing, portion sizes, and example food combinations across the day, alongside live or video-based demonstrations

of optimal recovery meals and snacks provided within the training-ground environment (Carter et al., 2024; Thompson et al., 2026). In addition, providing recovery snack bags consisting of CHO-rich foods (“enablement”) has been shown to effectively increase CHO intake on MD+1 (Carter et al., 2024). At dinner, however, “emotion” and “social influences” were the dominant enablers, as reflected in players’ preferences for culturally familiar foods. These findings align with the evidence from Australian Rules football, where interpersonal factors such as the influence of family and peers and mood were also identified as key determinants of dietary behaviour (Jenner et al., 2021). Accordingly, providing “practical social support” by educating and engagement of family members and partners may help players maintain social connectedness while still making nutritional appropriate choices. Furthermore, implementing themed dining days focused on different cultural cuisines may help accommodate player preferences, enhance enjoyment and improve adherence to nutritional recommendations (Ranchordas et al., 2017; Haller et al., 2022). The present findings indicate that although players were aware of the importance of CHO and protein for fuelling and recovery on MD+1, this awareness did not translate to optimal dietary practice, indicating that they lacked the practical knowledge required to meet established guidelines. In addition, recognising and addressing the social and emotional drivers of food choice may be critical to bridging the gap between recommendations and dietary behaviours on MD+1, thereby ensuring nutritional strategies are both evidence-based and contextually effective.

This study has several limitations. Firstly, this study was conducted on ten players from a single EPL soccer team, which may limit the generalisability of findings to other teams and leagues. Furthermore, dietary intakes measured via RFPM are subjected to under-reporting and bias as shown in previous literature in athletic population (Capling et al., 2017; Stables et al., 2021).

Nonetheless, the assessments were strengthened by prior training on data collection and the onsite presence of the researcher at the training ground to assist participants where required. Even when accounting for the estimated underreporting (18%) in this population as seen in Chapter 4 and assuming all unreported energy was derived from CHO, mean CHO would increase by $\sim 1.8 \text{ g} \cdot \text{kg} \text{ BM}^{-1}$; however, players would still not achieve recommended CHO intakes, particularly on MD and MD+1. Finally, the interview was conducted by the lead researcher, who was also the performance nutritionist at the club and this may bias the interviewer's approach and the response from the participants. However, interviewer's fluency in understanding the players' jargon and informal language and the ability to develop rapport with the participants were considered advantageous.

In summary, the assessment of enablers and barriers influencing dietary behaviours of professional soccer players across training days, MD-1, MD and MD+1 was reported for the first time using the COM-B model. On training days, CHO intake was at the lower end of recommendations while PRO intake met guidelines, with dietary behaviours primarily influenced by nutrition knowledge during the day and social influences at dinner. Inadequate CHO intake was also reported on MD-1 and MD+1, despite nutrition knowledge serving as the key enablers for the majority of meals, indicating that awareness of importance of nutrition alone is insufficient to ensure optimal dietary practices. Pre-match and during match CHO consumption was also suboptimal, largely driven by players' desire to maintain a subjective sense of lightness, while post-match and PMRM CHO intakes were limited by suppressed appetite. Overall, these findings highlight the multifaceted nature of dietary behaviours in elite soccer and suggest that effective nutrition interventions must extend beyond education alone to incorporate practical guidance and BCTs and contextual

considerations to bridge the gap between current practice and recommended guidelines. This research approach provides a framework for practitioners operating across different sporting contexts to examine dietary behaviours, acknowledging that the barriers and enablers influencing nutrition are likely to differ according to sport, sex and age.

Chapter 7

The Rules of the Game: towards a theory of practice for performance nutritionists in professional soccer using Bourdieu's concepts of Habitus, Capital and Field

The aim of this Chapter was to qualitatively explore the perspectives of professional players and key stakeholders on their perceptions of what defines a successful performance nutritionist in the EPL.

This study has been published in Sports Medicine.

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7.1 Abstract

Purpose: Performance nutrition is now an established discipline in professional soccer; however, limited knowledge exists on how practitioners can navigate through the unique cultural environment of the men's professional game. Accordingly, we explored the perspectives of players and stakeholders from the EPL on the attributes they perceive to underpin successful performance nutrition practice.

Methods: Guided by an interpretivist paradigm with a critical perspective (recognising that reality is also subjectively and socially constructed), qualitative, face-to-face semi-structured interviews were conducted with purposively sampled EPL stakeholders from August 2024 to December 2024, including players (n = 4), coaches (n = 4), sports scientists (n = 2), physiotherapists (n = 2), chef (n = 1) and medical doctor (n = 1). Data were abductively analysed using thematic analysis informed by Bourdieu's concepts of habitus, capital and field.

Results: Three key themes were identified. It is perceived that (1) Field: Successful performance nutritionists must recognise and adapt to the hierarchical structure, entrenched cultural norms and doxic practices of professional soccer, adapting their strategies to gain support from coaches, players and staff; (2) Capital: Effective performance nutrition practice requires strategic deployment of cultural capital (technical, sports-specific and interdisciplinary knowledge) and social capital (ability to build trust and relationships with key stakeholders) to establish credibility and influence practice; (3) Habitus: The ability to accumulate and mobilise these forms of capital is underpinned by a habitus congruent with elite soccer's culture, characterised by passion, resilience, adaptability and positivity.

Conclusion: These data provide a comprehensive interpretation of the unwritten rules of professional soccer, demonstrating that the perceived success for performance nutritionists in the EPL extends beyond technical expertise, requiring the ability to navigate tacit field rules, strategically mobilise cultural and social capital, and embody a habitus aligned with the values of elite soccer through passion, adaptability, positivity and resilience.

7.2 Introduction

The role of performance nutrition in professional soccer has developed markedly over recent decades. Once regarded with scepticism and largely confined to medical staff providing basic dietary advice (Ono et al., 2012), nutrition support has progressively evolved through part-time consultancy models to the appointment of dedicated specialists embedded within multidisciplinary teams in elite soccer clubs (Wenger, 2021). This professionalisation has been driven by increasing economic investment in the game as reported in Chapter 3 and is supported by a growing body of applied research as seen in Chapter 2, which has elevated the cultural capital of performance nutrition within the professional soccer field. The publication of the UEFA Expert Group Statement on Nutrition in 2021 (Collins et al., 2021) further reflects this evolution, establishing nutrition as a recognised and integral component of elite soccer performance. Nonetheless, while the physiological basis of performance nutrition for soccer is increasingly well defined, much less is known about how performance nutritionists themselves navigate the social, cultural and organisational structures of professional soccer to deliver their practice.

Professional soccer represents a distinctive social arena with its own internal logic, hierarchies of power and deeply embedded cultural norms. Within this field, multiple key stakeholders including

players, coaches, performance and medical staff interact in ways that shape both the opportunities and barriers for performance nutrition practice, with each agent bringing different priorities, values and forms of capital that influence decision-making and the day-to-day work of performance nutritionists (Silva et al., 2023; Costello et al., 2025). Coaches and managers, in particular, often occupy a dominant position, with their authority extending into domains such as nutrition provision and body composition management, thereby exerting a direct influence on how nutrition support is delivered at the club level as reported in Chapter 3. At times, this hierarchical dynamic can create tensions, as nutritionists may feel pressured to adopt practices that conflict with their professional values, potentially undermining their credibility and straining the nutritionist-player relationship (Costello et al., 2025). For instance, the imposition of arbitrary BM or composition targets by coaching staff, a practice widely reported in professional soccer, can encourage harmful dietary behaviours and body image concerns among players (McHaffie et al., 2022). Despite these challenges, there remains a paucity of research examining what it takes for performance nutritionists to be effective within this highly complex and culturally specific environment.

To address these challenges, Bourdieu's theory of practice (Bourdieu, 1990) provides a valuable lens for understanding what underpins the effectiveness of performance nutritionists working in professional soccer. Through the interrelated concepts of habitus, capital and field, it highlights how individual dispositions and resources interact with the structured environment of professional soccer. Habitus reflects the embodied values and practices shaped by prior experiences and education, thus influencing how nutritionists interpret and respond to the challenges of the professional soccer environment (Grenfell, 2014). Capital, including cultural (scientific expertise, qualifications), social (relationships, trust, networks), or symbolic (status, legitimacy, recognition),

shapes their capacity to exert influence within the club hierarchy (Bourdieu, 2002), while field represents the environment itself, defined by power relations, hierarchies and taken-for-granted beliefs (doxa) Although effective practitioners are expected to demonstrate adaptability, empathy, trustworthiness and strong technical expertise (Rosimus, 2021), research suggests that the more decisive attribute is the ability to appreciate the unique culture of the sport and build meaningful relationships with players and coaches (Burns et al., 2024a).

Using the Bourdieu theoretical framework, this Chapter aimed to build on the findings from Chapter 3 to qualitatively explore the perspectives of professional players and key stakeholders on their perceptions of what defines a successful performance nutritionist in the EPL. Drawing on the views of players, coaches, sports science and medical staff and chefs, this study provides novel insights into the qualities, skills and forms of capital that are regarded as most valuable within the distinctive cultural context of elite soccer described in Chapter 3. In doing so, this Chapter aimed to characterise a “theory of practice” that may offer practical guidance for performance nutritionists working in the elite soccer environment.

7.3 Methods

7.3.1 Research philosophy and positionality

This study was underpinned by an interpretivist paradigm, which recognises that for individuals involved in nutrition provision, practice is socially constructed, context dependent and shaped by individual experiences (Bogdan and Biklen, 1998). Aligned with a relativist ontology, this perspective assumes the existence of multiple, coexisting ways of being a nutritionist, shaped by social, cultural and historical contexts of those involved (Denzin et al., 2024). On this basis,

knowledge, is not objectively discovered but is co-constructed through inquisitive interaction. These propositions make interpretivism particularly well suited to explore the nuanced practices of sports nutritionists operating within context specific elite soccer environments. Additionally, the researchers adopted a self-critical perspective on their positionality. While interpretivism seeks to understand how individuals make sense of their world, the critical paradigm extends this by interrogating the power relations and dominant ideologies that shape those meanings (Kincheloe and McLaren, 2011). This criticality recognises the non-neutral role of the researchers, whose positions within the professional soccer context necessitates reflexivity and an awareness of how their own capital and habitus influence the research process. This dual-orientation supports a rich and critical understanding of how performance nutrition is practiced, legitimized and negotiated within the power-laden field of professional soccer. Building upon this philosophical foundation, we conducted a qualitative study to explore the experiences and perceptions of key stakeholders operating within the complex social landscape of elite soccer. Guided by interpretivist and critical perspectives our sampling, data collection and analysis procedures were designed to produce a trustworthy and transparent account of the theory of practice underpinning the perception of what it means to be a successful sports nutritionist within EPL. This study adhered to the SRQR (O'Brien et al., 2014) to ensure rigour, clarity and methodological transparency throughout the research process.

7.3.2 Participants

To develop a comprehensive understanding of the qualities that contribute to the perceived success of a performance nutritionist in professional soccer, a purposive sampling strategy was employed to recruit key stakeholders from a single EPL club. A total of fourteen participants were recruited

and interviewed from August 2024 to December 2024, including coaches (n = 4), players (n = 4), physiotherapists (n = 2), sports scientists (n = 2), medical doctor (n = 1) and club chef (n = 1). This methodology mirrors previous qualitative inquiries into nutrition culture within the professional soccer domain in Chapter 3, where the objective is not to generalise to a wider population (e.g. other leagues, sports) but to gain rich, contextualised insights from a deliberately chosen expert and hard-to-reach sample. While all participants were contracted to a single club at the point of data collection, their narratives reflected cumulative professional experiences across a range of teams and leagues, including the EPL, Serie A, Bundesliga, Ligue 1, Turkish Süper Lig, Australian A-League, Scottish Premiership and Liga Portugal. In line with qualitative research conventions, the sample size was not predetermined but guided by the data analysis process, with recruitment ceasing once a diverse range of perspectives and sufficient thematic depth had been achieved (Sparkes and Smith, 2013; Moser and Korstjens, 2017). Ethical approval was obtained from the Liverpool John Moores University Research Ethics Committee and in accordance with this approval, further participant details are withheld to ensure confidentiality. All participants provided verbal and written informed consent prior to taking part in the interviews.

7.3.3 Procedures

All fourteen participants engaged in semi-structured interviews (mean: 23 min; range 9-48 min), with an “open-ended” approach (Gall et al., 2007), where questions were posed in a conversational and informal manner to encourage voluntary input and detailed responses (Lincoln and Guba, 1985). The questions (see Tables 15 to 17) were informed by the study aims and Bourdieu’s concepts of habitus, capitals, field and doxa practices. For instance, initial questions were neutrally framed such as ‘What are your thoughts on...?’. Subsequently, probing questions were used to

elicit further insights (Jones, 2022). This format of enquiry enabled participants the freedom to express their experiences and opinions and to guide the discussion toward areas they deemed significant (Braun and Clarke, 2013). Consequently, the study's findings extend beyond the scope of participants' current club, providing a comprehensive understanding of their involvement with previous teams across different soccer leagues. To assess the suitability of the interview questions, pilot interviews were conducted with two support staff (one sports scientist and one medical doctor) from the same club. Based on the feedback from the senior co-authors (CJC and JPM) for these pilot interviews, the wording of some questions was revised. Pilot interviews were not included in the analysis. All interviews took place in a private office at the club's training facility and were audio-recorded, then transcribed verbatim. The interviewer was well-versed in the professional soccer subculture, having worked as a performance nutritionist in the industry for the past five years. While this familiarity could potentially bias the interviewer's approach, it was considered advantageous due to their fluency in understanding the key stakeholders' jargon and informal language and their ability to develop rapport with participants (Cook et al., 2014). To prevent leading questions, strategies such as piloting interview questions and utilising open-ended questions were implemented.

Table 15. Interview guide and aims for performance and non-performance staff.

Interview Questions	Prompts	Aims
Domain 1: Participant’s background and experiences working with performance nutritionists		
Q1: Can you provide a brief overview of your career up to this point?	F1: When did you first start in your current position?	A1: To acquire understanding about the prior professional background of participants.
Q2: Can you tell me more about your experience working with a nutritionist?	F2: When did you first started working with a nutritionist? How did you feel?	A2: To understand participants' prior experiences working with performance nutritionists.
Q3: In your experience working with performance nutritionist, how would you describe their role?	F3: What are their duties and responsibilities	A3: To understand participants’ perceived roles and responsibilities of performance nutritionists.
Q4: How has the role of nutritionist evolved over time?	F4: What drives these changes?	A4: To understand shifts in responsibilities, approaches, or areas of focus that nutritionists have undergone
Domain 2: Factors that determine the success of performance nutritionist in football		
Q1 Based on your experience, what qualities and characteristics have you observed in a nutritionist who has had a positive impact within your multidisciplinary team (MDT)?	F1: Can you share an example of successful intervention or strategy that a performance nutritionist has implemented?	A1: To identify specific qualities and characteristics of a nutritionist that contribute to their effectiveness and positive impact within an MDT.
Q2: What specific outcomes or improvements have you observed when working with performance nutritionist?	F2: How has nutrition improved players’ performance and development? Can nutrition make an impact on team selection?	A2: To gather concrete examples of the positive results or changes that have occurred as a result of working with a performance nutritionist.
Q3: Based on your experience what qualities and characteristics have you observed in a nutritionist who has NOT had a positive impact within your MDT?	F3: What challenges have you encountered while working with performance nutritionist? How are they addressed?	A3: To identify and understand the traits or behaviours of a nutritionist that may hinder their effectiveness within an MDT.
Q4: What are your experiences with body composition in football?	F4: Where has this come from? Who is involved? How has body composition influenced selection?	A4: To gather insights on how body composition is managed and perceived in professional football.

Domain 3: Future directions of performance nutritionists		
Q1: How do you think performance nutritionists could improve?	F1: What is missing from their service provision? Skills? Knowledge?	A1: To identify the areas in performance nutrition that participants believe need improvement.
Q2: How do you foresee the role of performance nutritionists changing in the future?	F2: Why do you think that?	A2: To investigate participants' perspectives on the anticipated shifts in the role of nutritionists in the future.

Table 16. Interview guide and aims for coaches.

Interview Questions	Prompts	Aims
Domain 1: Participant's background and experiences working with performance nutritionists		
Q1: In your career so far, can you tell me more about your experience working with nutritionists?	F1: When did you first started working with a nutritionist? How did they make you feel?	A1: To understand participants' prior experiences working with performance nutritionists.
Q2: In your experience working with performance nutritionist, how would you describe their role?	F2: What are their duties and responsibilities	A2: To understand participants' perceived roles and responsibilities of performance nutritionists.
Q3: How has the role of nutritionist evolved over time?	F3: What drives these changes?	A3: To understand shifts in responsibilities, approaches, or areas of focus that nutritionists have undergone
Domain 2: Factors that determine the success of performance nutritionist in football		
Q1: From your experience, what qualities or characteristics have you observed in a nutritionist who has positively influenced the player you coach?	F1: Can you share an example of successful intervention or strategy that a performance nutritionist has implemented?	A1: To identify specific qualities and characteristics of a nutritionist that contribute to their effectiveness and positive impact within an MDT.
Q2: What specific outcomes or improvements have you observed when working with performance nutritionist?	F2: How has nutrition improved players' performance and development? Can nutrition make an impact on team selection?	A2: To gather concrete examples of the positive results or changes that have occurred as a result of working with a performance nutritionist.
Q3: From your experience, what qualities or characteristics have you observed in a nutritionist	F3: What challenges have you encountered while working with performance nutritionist? How are they addressed?	A3: To identify and understand the traits or behaviours of a nutritionist that may hinder their effectiveness within an MDT.

who has NOT positively influenced the player you coach?		
Q4: What are your experiences with body composition in football?	F4: Where has this come from? Who is involved? How has body composition influenced selection?	A4: To gather insights on how body composition is managed and perceived in professional football.
Domain 3: Future directions of performance nutritionists		
Q1: How do you think performance nutritionists could improve?	F1: What is missing from their service provision? Skills? Knowledge?	A1: To identify the areas in performance nutrition that participants believe need improvement.
Q2: How do you foresee the role of performance nutritionists changing in the future?	F2: Why do you think that?	A2: To investigate participants' perspectives on the anticipated shifts in the role of nutritionists in the future.

Table 17. Interview guide and aims for players.

Interview Questions	Prompts	Aims
Domain 1: Participant's background and experiences working with performance nutritionists		
Q1: Have you worked with a nutritionist before?	F1: When did you first started working with a nutritionist?	A1: To understand participants' prior experiences working with performance nutritionists.
Q2: In your experience working with performance nutritionist, how would you describe their role?	F2: What are their duties and responsibilities	A2: To understand participants' perceived roles and responsibilities of performance nutritionists.
Q3: How has the role of nutritionist evolved over time?	F3: What drives these changes?	A3: To understand shifts in responsibilities, approaches, or areas of focus that nutritionists have undergone
Domain 2: Factors that determine the success of performance nutritionist in football		
Q1: From your experience, what qualities or characteristics have you observed in a nutritionist who has had a positive impact whilst working with you?	F1: Can you share an example of successful intervention or strategy that a performance nutritionist has implemented?	A1: To identify specific qualities and characteristics of a nutritionist that contribute to their effectiveness and positive impact within an MDT.

Q2: What specific outcomes or improvements have you observed when working with performance nutritionist?	F2: How has nutrition improved players' performance and development? Can nutrition make an impact on team selection?	A2: To gather concrete examples of the positive results or changes that have occurred as a result of working with a performance nutritionist.
Q3: From your experience, what qualities or characteristics have you observed in a nutritionist who has NOT had a positive impact whilst working with you?	F3: What challenges have you encountered while working with performance nutritionist? How are they addressed?	A3: To identify and understand the traits or behaviours of a nutritionist that may hinder their effectiveness within an MDT.
Q4: What are your experiences with body composition in football?	F4: Where has this come from? Who is involved? How has body composition influenced selection?	A4: To gather insights on how body composition is managed and perceived in professional football.
Domain 3: Future directions of performance nutritionists		
Q1: How do you think performance nutritionists could improve?	F1: What is missing from their service provision? Skills? Knowledge?	A1: To identify the areas in performance nutrition that participants believe need improvement.
Q2: How do you foresee the role of performance nutritionists changing in the future?	F2: Why do you think that?	A2: To investigate participants' perspectives on the anticipated shifts in the role of nutritionists in the future.

7.3.4 Data Analysis

All interviews were transcribed by the researcher. Data were analysed using an abductive approach, combining with inductive and deductive processes, while acknowledging the interpretative creativity involved in applying a theoretical framework to participants' experiences (Sparkes and Smith, 2013). Thematic analysis followed a six-stage process (Braun and Clarke, 2006): (1) familiarisation and immersion of the data through repeated reading and listening during transcription; (2) systematic initial coding process to identify relevant content; (3) reassessment of initial codes to identify patterns and generate preliminary themes aligned with the theoretical framework; (4) review of themes for coherence against the raw data; (5) refinement, definition and naming of themes once consensus was reached; and (6) selection of data excerpts from each theme to present a concise, coherent and engaging narrative that reflects the data's story within and across themes. To enhance rigour, the lead supervisor, unacquainted with the club and not involved in the interview process, acted as a "critical friend", who independently checked and challenged data analysis, theme generation and presentation of selected quotes (Smith, 2018). The role of the critical friend is not to seek agreement or consensus but to encourage reflexivity by questioning interpretations and constructions of knowledge (Cowan and Taylor, 2016). While the researcher's role within the club and personal interest in the topic inevitably introduced subjectivity, this insider perspective was considered advantageous for contextual understanding and rapport building. The involvement of the critical friend, who interrogated and challenged the analysis, helped ensure balance between insider insight and analytic rigour (Austin and Sutton, 2014).

7.3.5 Methodological Trustworthiness and Rigour

To ensure rigour, several measures consistent with qualitative methods and interpretivist paradigms were employed (Smith and McGannon, 2018). These included recruiting a diverse sample, applying a robust theoretical framework and piloting the interview questions. Independent members of the research team, separate from the lead author, provided critical feedback on the interview techniques and data analysis process. Rigour was further reinforced through open discussions among all authors, who acted as critical friends and maintained a reflective stance throughout (Smith and McGannon, 2018). The worthiness of this research topic was justified by addressing the gap in evidence and practice within this population (Anderson et al., 2017b). Furthermore, the results and discussion section outlines three themes, supported by quotations from the data, enabling readers to interpret the findings independently and consider the applicability to their own circumstances (Smith, 2018). To improve the credibility of the manuscript, member reflections were conducted by providing participants with a one-page summary of our interpretations and findings for their feedback (Korstjens and Moser, 2018).

7.4 Results and Discussion

Using a reflexive thematic analysis approach, three themes based on the concepts of field, capital and habitus were identified: (1) Field: a successful performance nutritionist must understand the rules of the game, (2) Capital: a successful performance nutritionist must have sufficient technical knowledge (cultural capital) but also the ability to build relationships (social capital) and (3) Habitus: the success of a nutritionist is dependent on their ability to accumulate capitals and is shaped by their habitus. Together, these themes illustrate how successful performance nutritionists must have the ability to navigate challenges in the field of professional soccer, build and

accumulate different forms of capital and align their habitus to the changing environment of professional soccer. Aligned with Chapter 3, these themes are further critically examined within the discussion section, providing a nuanced exploration of each theme in relation to existing literature. Figure 21 illustrates the interrelationship between the three themes and their collective contribution to developing a theory of practice for performance nutrition in professional soccer.

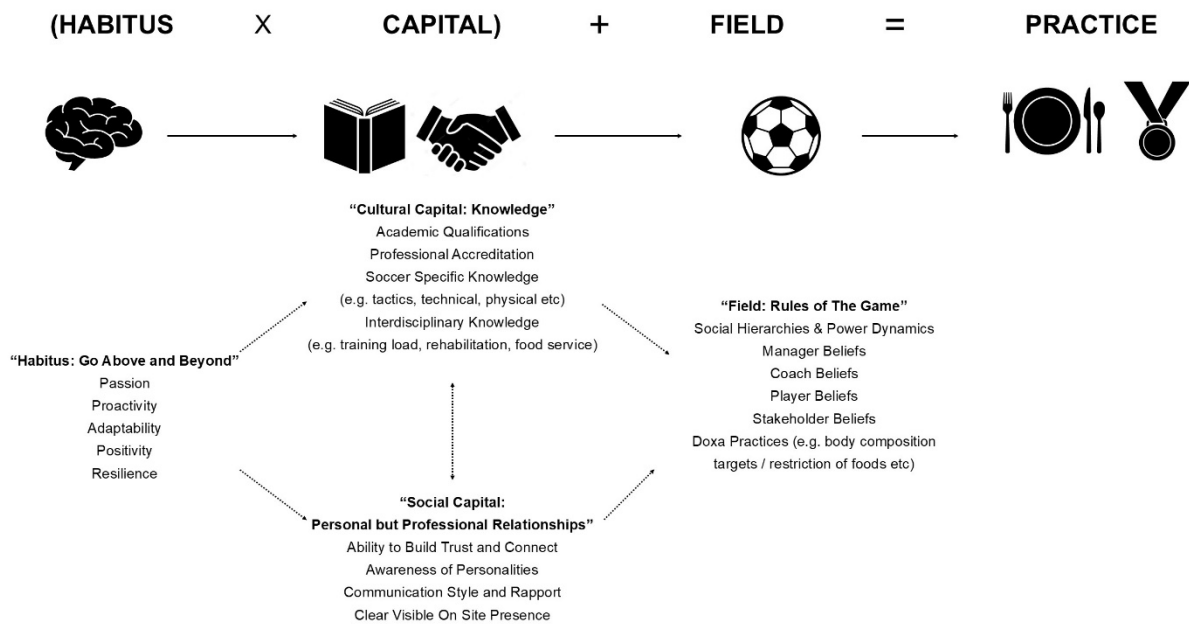


Figure 21. Towards a theory of practice for performance nutrition in professional soccer. How practitioners practice (hence the nature of practice and associated service provision) is dependent on their habitus, accumulated capitals and how they navigate and present themselves within a given field. In this context, a habitus that is characterised by the ability to go above and beyond is more likely to increase the accumulation of both cultural capital and social capitals. In turn, both habitus and capitals can subsequently determine a practitioner’s ability to understand the rules of the game, thereby informing how they navigate the social hierarchies that exist within the field (i.e. survive and thrive). In considering this theory of practice, it is noteworthy that a specific nutritionist may practice differently (and indeed be perceived to have different success) according to whichever

field they are working in. For example, how one practices within a soccer environment may look and feel very different to how they would practice within other team sports (e.g. rugby, basketball etc), endurance sports (e.g. running or cycling etc) or weight sensitive sports (e.g. combat sports, gymnastics etc). Furthermore, to be perceived as successful in each of these sports (according to the relevant athletes, coaches and stakeholders), nutritionists may need therefore to present with a different habitus, accumulated capitals and an appreciation of the rules of the game (i.e. the cultural nuances and social dynamics within a given sporting field).

7.4.1 Field: a successful performance nutritionist must understand the rules of the game

The professional soccer environment operates as a distinct social field, characterised by its own internal logic and established structures of practice (Power, 1999). Within this field, various positions are occupied by key stakeholders, including coaches, players and members of the sports science and medical teams. Across the participants' experiences at various clubs, the professional soccer field is deemed to be inherently hierarchical; Chapter 3 has previously demonstrated that coaches hold a dominant position of influence, with their decisions significantly shaping the dietary practices of professional players. Consequently, for performance nutritionists to be effective within this context, it is essential to first understand the manager's perspective on nutrition. As Participant 14 (coach) explained:

“The first bit of advice is I think you always need to understand where the managers are. So maybe you have a manager that don't value it so then it's harder for you to get really strong. If you have a manager that really values nutrition, then I think it's easier to go really strong because you have the backing of the manager.”

Furthermore, players are widely regarded as the most valuable assets of a club (Matesanz et al., 2018). Beyond their on-field contributions, they are frequently recognised as global icons who significantly contribute to the club's public image and commercial interests (Malagón-Selma et al., 2023). Consequently, interactions between practitioners and players are shaped by the players' elevated status within the club's social hierarchy. Owing to their considerable symbolic capital, it is not uncommon for professional soccer players to exhibit a strong sense of self-assurance or what may be perceived as a heightened ego, which can present challenges when delivering feedback. Adopting rigid or authoritative communication style may be counterproductive, as illustrated by Participant 12 (player):

“I think players have very big ego. All sportsmen do, because that's a little bit what you need in soccer. If you guys talk bad to a player or tell him like “Hey, you have to do this!” then it's going to have the opposite effect because the players will say “No, I will go my way! I will not do what you say, as you are not a soccer player. I will not listen to you, as I am the soccer player” and they will go their way. So, I think it's you got to be very like “Here's something you can try but if you don't want it, then you don't want it”.

Similarly, Participant 2 (physiotherapist) reinforced the importance of practitioners developing a nuanced understanding of the unique cultural dynamics within the field of professional soccer. This participant highlighted the potential challenges that can arise when practitioners fail to appreciate the distinct mindset and social norms embedded within the elite soccer environment:

“I think if that person doesn’t have an understanding of the environment. If that individual, I’m thinking of other staff that I might have seen in this environment that comes from other sporting environments, they tried to make nutritional strategies that worked in other environment that might have involved individual sports and individual athletes. Because of the mindset of a soccer player and an athlete is very different, so I think you have to understand the environment to try to get that buy-in with the players.”

[Participant 1, Chef] *“We basically worked on trying to introduce Mediterranean diet. At that time, we have 19 nationalities and it didn’t appeal to a lot of them. We were between a rock and a hard place, trying to introduce things that not necessarily some of the players would have eaten.”*

Within any social field, the concept of doxa refers to the taken-for-granted beliefs, norms and practices that are deeply embedded within the collective consciousness of its members. These implicit forms of social knowledge function to uphold and reproduce existing power relations, often without being openly questioned (Bourdieu, 1990). In professional soccer, doxic practices are particularly influential, shaping behaviours and expectations across all levels of the sports. A prominent example is the doxic beliefs surrounding the ideal body composition for professional soccer players, an assumption that has become normalised within soccer culture as shown in Chapter 3. This was echoed by Participant 11 (player), who commented on the entrenched nature of body composition monitoring within the sport:

“It [body composition measurement] was ingrained in soccer, it's probably the easiest marker to see whether someone is in shape. I don't know where it comes from, but there probably is an obsession with weight and with body composition within the game. I don't know where it comes from, maybe historically from coaches where in the past they probably didn't have great diagnosis. So, they just decided, okay, the easiest one to jump onto is body fat.”

Practitioners must exercise considerable caution when navigating entrenched doxic practices within professional soccer. While some of these practices may not align with current scientific evidence, attempting to challenge or overturn them in a confrontational manner can prove counterproductive. Abrasive approaches risk undermining the practitioners' credibility and damaging relationships between players and staff, ultimately hindering their efforts to promote meaningful behavioural change. Such unintended consequences can arise when evidence-based recommendations are enforced without sensitivity to the practical and cultural realities of the soccer environment:

[Participant 6, Sports Scientist] *“I think that's really important, that the way not to do it is to be abrasive. Like, for example, people have taken caffeine away in the past to not reduce the sensitivity when it comes to gaming. But in reality, that's probably a bad thing, because you're just going to cause arguments with the players, arguments with the staff, the players are probably going to end up getting caffeine from somewhere anyway. So even though scientifically it's probably the*

right thing to do, I think all the barriers and all the arguments that that causes along the way, it just isn't worth it.”

In summary, the professional soccer environment operates as a hierarchical social field, defined by its own internal logic, power dynamics and entrenched cultural practices. Within this structure, coaches typically occupy dominant positions, exerting considerable influence over team operations and shaping players' dietary behaviours. This aligns with previous research (Costello et al., 2025) which highlights the tendency of coaches to intervene in nutritional practices through imposition of dietary restrictions or prohibitions on certain foods, thereby overriding evidence-based nutritional strategies implemented by practitioners. Consequently, a nuanced understanding of coaches' perspectives on nutrition and the ability to cultivate their support is essential for performance nutritionists seeking to implement effective interventions within elite soccer settings. At the same time, players are widely regarded as the soccer club's most valuable assets, not only due to their on-field contributions but also symbolic capital including commercial value and public profile. Given the elevated status of the players, the communication approach adopted by nutritionists is important. Direct communication styles may provoke resistance and ultimately lead to disengagement from nutritional support. This was reflected in recent research, where professional players identified a lack of individual recognition as a key factor contributing to their disengagement with performance staff (McCall et al., 2023). Moreover, practitioners must navigate the pervasive influence of doxa, the taken-for-granted norms that are deeply embedded within the professional soccer culture. Efforts to challenge or reform these practices, if done insensitively or without cultural awareness, may undermine practitioner credibility and hinder the likelihood of behaviour change. Previous research has emphasized that having high level of

contextual awareness within the sporting environment enables performance support team members to foster meaningful relationships and engage more effectively within their roles (Stewart et al., 2024). As such, the ability to operate effectively within this complex environment requires more than technical expertise; it demands the accumulation and deployment of key forms of capital, which are explored in the following theme.

7.4.2 Capital: A successful performance nutritionist must have sufficient technical knowledge (cultural capital) but also the ability to build relationships (social capital).

Successfully navigating the complex and hierarchical field of professional soccer requires performance nutritionists to possess and strategically employ various forms of capital, a concept defined by Bourdieu as the resources individuals draw upon to maintain their position within a given social field (Bourdieu, 2002). Drawing on insights from a variety of clubs, key stakeholders in the present study identified cultural capital, which encompasses field-specific knowledge, qualifications and understanding of norms embedded within the environment (Power, 1999), as particularly important. For instance, Participant 14 (coach) highlighted that *“sports nutrition knowledge first of all is probably the most important part of the game because you have to have the knowledge to back up the passion.”* In addition to sports nutrition expertise, familiarity with the physical and contextual demands of the sport itself was viewed as critical to establishing practitioner credibility, as articulated by Participant 13 (coach):

“You want to have an understanding of exactly what it takes at that level. And I'm not saying everyone must have played but having an understanding of what fuelling your body really looks like under some stress or under some physical exertion. It's

not the be all and end all, but it would help just so you can then pass on your processes.”

Interdisciplinary knowledge was also identified as a key asset for nutritionists operating within professional soccer clubs. Participants emphasised the value of having a broad understanding of other disciplines to strengthen the delivery of nutritional support. For instance, Participant 4 (sports scientist) explained:

“I think it's good to have a general understanding of all the practices within the club, just to try and help push that nutritional support further. For example, if you are giving the lads a supplement or telling them that they can only have X amount of food. If you can provide that with the context of GPS metrics or strength metrics from the gym to actually show your understanding of why you're putting forward the X plan.”

A lack of interdisciplinary awareness, particularly regarding the physical and tactical demands placed on the players, was perceived as potentially harmful. Misinterpretation of data or failure to account for the broader performance context could result in inappropriate nutritional interventions and lead to player mistrust. Participant 4 (sports scientist) further elaborated:

“The main things I could probably think of when nutritionists don't have a complete understanding of the context of the game or the current situation of the player, whether it's injury or whatever. I think it can be quite dangerous if they receive the

wrong information. For example, if they don't have a true understanding of a GPS report or a gym session and then try to find an intervention based on that. It could have consequences if it's not discussed beforehand. Just off the top of my head I'm thinking if the player's not running a set distance and it gets blamed on, they're not fuelled correctly. Without having an understanding of the tactical element of the game it not being purely physical I think is important.”

Moreover, Participant 5 (physiotherapist) highlighted the need for nutritionists to maintain close alignment with rehabilitation processes, noting:

“Performance nutritionists should have a very strong finger on the pulse of rehabilitation. For example, you have to be very close to the rehabilitation so that can be achieved in a few different ways.”

In a similar manner, interdisciplinary awareness was also valued by non-performance staff. Participant 1 (chef) expressed appreciation for nutritionists who recognise the logistical and operational complexities of food service within a high-performance environment:

“From my side, it's about teaching the team to understand what you need and me explaining to you there are parameters in some respects, not many. Timing is about it and ingredients that are hard to get at certain times in season. What I think would be good for us all to move forward is that we either do a small hour or an hour

trying to explain to my team what you have to go through a day so that they understand.”

Social capital refers to the actual or potential resources accessible through a durable network of institutionalized relationships of mutual recognition and trust (Bourdieu, 2002). Within professional soccer field, the ability to establish strong professional relationships with players was consistently identified by key stakeholders as a crucial asset. For instance, Participant 3 (coach) emphasized the importance of interpersonal competence alongside technical knowledge:

“A lot of people think it’s only the skill that matters but what matters is also the human that is performing the skill and it’s important that we understand the technicality of things. The nutritionist has to know about food, about atoms, about other stuffs. But he/she needs also to know how to communicate. He/she needs to know how to relate with people. He/she should know there’s different types of personalities, how can you get better to one, to others. Some people like a lot of talks, some like less talks, some like harder, some like stricter, some like softer.”

Participant 9 (coach) echoed this sentiment, stating that *“the role in my opinion needs to be someone that can have a relationship with players”*. Similarly, Participant 4 (sports scientist) acknowledged the importance of relationality while warning against becoming overly familiar:

“I think the two most important qualities are ability to build rapport and build good relationships with players. Not so much fanboying and being too friendly with them

but being able to develop a relationship where they trust you, but you can also challenge them and push them to be better.”

These insights highlight the balance required in performance support roles, developing trust and connection without compromising authority or professionalism. In line with this, maintaining a high level of professional integrity was highly valued by key stakeholders. Participant 7 (doctor) outlines how attempts to please players at the expense of professional standards could undermine medical credibility:

“There have been colleagues in the past that were guilty of trying to please the players and that really undermines that person and their ethos as a medical team, particularly individuals, sneaking players, sugary foods for instance and it's just, it really is undermining and it's a bad practice. It's unprofessional because it's sneaky behaviour and you can't function as an entity like that.”

In summary, the effective delivery of nutrition support within the complex and hierarchical field of professional soccer requires the strategic application of multiple forms of capital. Of particular importance is cultural capital, encompassing sports nutrition knowledge and a nuanced understanding of both sports and soccer expertise. Stakeholders identified these attributes as essential for performance nutritionists to establish credibility within the field. Indeed, possessing the requisite knowledge and skill set is recognised as fundamental requirements for members of performance support team (Stewart et al., 2024) whereas a lack of scientific rigour and failure to adopt evidence-based practices were previously identified as hallmarks for ineffective

practitioners (Rosimus, 2021). Moreover, interdisciplinary knowledge spanning sports science, rehabilitation and food service operations was regarded as critical for facilitating effective collaboration between performance nutritionists and other members of multidisciplinary support team. The importance of such integration is reinforced in a recent commentary, which cautions that siloed nutrition practice, responding only to the queries of individual practitioners, can be detrimental to collective team functioning and performance outcomes (Wenger, 2021). Understanding other people's roles and responsibilities is therefore an antecedent for collaborative, interdisciplinary teamwork (Stewart et al., 2024). From an applied educational standpoint, these findings highlight the need for programmes accredited by professional bodies (such as SENr or the Chartered Association of Sport and Exercise Sciences (CASES)) to transcend a focus on narrow technical competencies. There may be value in integrating relevant disciplines (e.g. sports science, physiology, psychology and physiotherapy) and applying sports nutrition within multidisciplinary settings, thereby better equipping practitioners to navigate the complexities of elite sport environments, albeit how this integration occurs needs further consideration.

Equally vital was the development of social capital through the cultivation of strong professional relationships. Stakeholders strongly emphasized the importance of interpersonal skills, effective communication and ability to build rapport with the players and staff. This aligns with previous findings, which suggest that while it is relatively common to find practitioners with high levels of technical expertise, it is far less common to find those who also possess a deep appreciation for the sports' unique culture and are capable of building relationship with players and coaches (Burns et al., 2024a). Indeed, the ability to assess, adapt and align to the environment was identified as a key attribute for good practice delivery in sports science and medicine support (Alfano and Collins,

2021). Furthermore, other research has highlighted the importance of embedding within the broader support team, particularly for practitioners who have yet to establish strong rapport with players as a means of enhancing recognition and impact (Logue et al., 2021). Maintaining professional boundaries and integrity was also regarded as essential, as efforts to overly accommodate players could compromise both credibility and cohesion within the medical and performance team. Effective practice in sports science and medicine were characterised by providing support within one's scope of expertise and professional boundaries, which was viewed as fundamental in building trust among stakeholders (Alfano and Collins, 2021). In contrast, poor relationship with colleagues has previously been identified as a hallmark of an ineffective performance nutrition practice (Rosimus, 2021). Together, these insights underline the multifaceted capitals required of nutritionists to integrate effectively within elite soccer environments and the accumulation of these capitals are likely dependent on the habitus of the performance nutritionists.

7.4.3 Habitus: The success of a nutritionist is dependent on their ability to accumulate capitals and is shaped by their habitus.

Habitus refers to the embodied dispositions shaped by an individual's past experiences and social structures, which influence their perceptions, actions and decisions within a given field (Bourdieu, 1990). It represents the internalised ways of thinking, feeling and behaving that guide practice by shaping what individuals perceive as possible or appropriate (Grenfell, 2014). In this sense, a practitioner's actions are influenced not only by their current position within the professional soccer field but also by their social trajectory, which frames their capacity to recognise and respond to opportunities (Grenfell, 2014). Accordingly, for performance nutritionists, possessing a habitus

aligned with the norms and expectations of professional soccer was considered essential for acquiring the forms of capital that are deemed necessary to gain credibility and effectively navigate this complex environment.

Reflecting the broader cultural influences encountered throughout their careers, participants consistently emphasized the value attributed to passion and proactive engagement. For example, Participant 14 (coach) noted that *“the best nutritionists I’ve worked under are really passionate about their players being in the right condition or getting the right nutrients and the right food.”* Similarly, Participant 8 (player) described his willingness to work with nutritionists who show genuine interest in his well-being and health:

“When you feel like somebody’s passionate about what they’re doing, you want to work with them, you want to because you know they will go above and beyond to make sure, not even just for you but for themselves, to be the best that they can be.”

Conversely, Participant 9 (coach) identified a lack of initiative as a negative trait, criticizing nutritionists who *“lack that engagement with the players. Not proactive and not giving them information and providing them with the stuff. Because if you expect them to do it, they won’t do it. You have to be on them.”*

Adaptability and flexibility emerged as essential attributes when working with key stakeholders in elite soccer environments. The ability to adjust one’s approach to accommodate preferences, personalities and needs of others was consistently highlighted as central to building and sustaining

productive relationships with both staff and players. Participant 5 (physiotherapist) stressed the importance of avoiding a rigid or uncompromising stance, particularly within a high-performance setting characterised by strong personalities:

“I think someone that isn't flexible, someone that has got very strong, unflexible views will end up having a problem. It's an environment where you've got a lot of alpha males. So, if you're too strong in your opinions and too inflexible, I think that could end up spoiling the relationships that you could build with staff and players.”

Similarly, Participant 10 (player) emphasized the importance of adapting the nutritional plan based on feedback of the players, noting that dietary plans must be tailored to the unique preferences and tolerances of each player:

“Let's say it is when the nutritionist doesn't listen to the player and the feedback that the player gives. Because like I said, everyone is different so if a player doesn't or cannot eat one type of a meal. But if a nutritionist doesn't listen, basically saying that no, it's good for you so you have to. Well, one thing will happen. The player won't eat it, so he won't have the same results. So, like I said, it's important to be able to personalise every single meal and every single diet of the player.”

Participant 11 (player) echoed this sentiment, cautioning against a “one-size-fits-all” approach, (Mifsud et al., 2025) which he described as potentially “*completely unattainable for some players.*” Participant 2 (physiotherapist) further reinforced this theme, highlighting that relationship-

building depends on the ability to find solutions that balance performance goals with individual preferences:

“How do you as an individual help that player believe what you’re doing is in their best interest and also make it tangible for them? So, if you turn around and told me that I can no longer eat my favourite food ever, then automatically I’m switched off. If you tell me, “Your favourite food is really not good for you and these reasons why”, we can find a way to work it in for you - maybe you can have it once a fortnight as a treat, based on these other things happening. Then, all the sudden, I’m a bit more interested. Especially if you then give me alternatives that I also like.”

When individualising support where the players’ specific needs are essential, it may also place additional time (perhaps unrealistic) demands on practitioners. These demands can contribute to the risk of occupational fatigue, which is reflected in a recent survey showing that 42% of the medical and performance support staff working in the professional soccer were at risk of burnout (Mifsud et al., 2025). In elite sport, occupational burnout has been associated with disengagement, reduced motivation, heightened emotional responses, withdrawal, impaired concentration and diminished disciplines, all of which can adversely affect support staff performance (Russell et al., 2019). Consequently, resilience emerged as a critical attribute for practitioners. As participant 7 (medical doctor) reflected, *“I think you have to be very resilient, the season’s long, there’s ups and downs, there’s travelling, long hours, so I think you’ve got a lot of resilience and with that being a good team member.”* The capacity to manage mental fatigue and maintain a positive

outlook was also highlighted by Participant 12 (player), who valued the influence of a practitioner's demeanour on the wider group:

“If I see you coming in every day happy to be here and doing your best, it helps everyone. But if you're sad, angry and don't want to be here, that is the worst thing. You can be as smart as you want, but if you have bad energy, it affects everything. It is important to be part of the group, to help people and be there for them.”

In summary, the perceived effectiveness of performance nutritionists in elite soccer appears closely linked to their habitus, which refers to the internal dispositions shaped by prior experiences and social structures that align with the cultural norms of the professional game. Passion and proactive engagement were consistently valued by players and staff, while disengagement and lack of initiative were perceived negatively. This aligns with previous research demonstrating that professional soccer players place high importance on genuine passion and effort from the performance staff (McCall et al., 2023). Players value practitioners who demonstrate authentic care and prioritise their best interests (McCall et al., 2023). Such compassion can elicit positive emotions and support healthy psychophysiological functioning, increasing players' openness to opportunities and facilitating more favourable performance outcomes (Boyatzis et al., 2013). Coaches similarly identified a willingness to go above and beyond as a key marker of practitioner effectiveness (Burns et al., 2024a). Yet, this expectation reflects the broader doxa of soccer, where credibility is earned not only through expertise but through visible dedication. While such disposition can build trust and symbolic capital, they also risk normalising working long hours and burnout, highlighting the delicate balance practitioners must strike between cultural alignment,

professional authority and sustainable practice. Furthermore, adaptability and flexibility also emerged as critical attributes, enabling practitioners to tailor nutritional strategies to the unique preferences, personalities and needs of stakeholders, thereby avoiding the pitfalls of a one-size-fits-all approach. This relational adaptability was underpinned by the capacity to balance performance goals with individual preferences, fostering greater adherence and rapport. Indeed, based on previous research, 80% of the respondents identified the ability to flex (adapt) communication styles as the most important trait of performance nutritionists (Rosimus, 2021), while versatility in navigating fast-paced environments and managing diverse and challenging personalities is also highly valued among performance support staff (Stewart et al., 2024). Moreover, resilience was identified as essential for sustaining performance in a demanding environment characterised by long seasons, travel and high pressure. The ability to manage mental fatigue and maintaining a positive, energising presence was considered integral not only to personal effectiveness but also to enhancing the collective environment.

Within elite sport, the demands of long working hours, high workload and frequent travel have consistently been identified as significant organisational stressors (Arnold et al., 2019). Such pressures can give rise to frustration and negative emotional responses, which, if left unmanaged, may extend beyond the individual and permeate the broader support team (Arnold et al., 2019). This spillover effect has the potential to create additional stress for colleagues, diminish morale and ultimately compromise the overall quality of work within the organisation (Arnold et al., 2019). Conversely, maintaining a positive presence is highly valued by elite athletes, as it not only prevents the transfer of stress onto them but also offers an important source of emotional support (Burns et al., 2024b). However, positioning constant positivity and resilience as expectations risks

normalising unsustainable work practices and conflicts with the standard 37-hour workweek outlined by human resources in professional soccer. Within the cultural doxa of soccer where working “above and beyond” is valued, such expectations can obscure structural issues including unsociable hours and inadequate organisational support, by placing the burden on individuals to absorb excessive workload and emotional strain. While this accrues symbolic capital for those perceived as highly dedicated, it simultaneously heightens the risk of burnout and undermines the long-term sustainability of practitioner well-being and service quality. Consequently, it is critical to consider how those with greater capital and influence (e.g. sporting directors, performance directors, head of departments etc), together with governing and regulatory bodies can enact systemic changes to challenge this entrenched culture and safeguard practitioner welfare.

7.5 Practical Implications and Future Research Directions

Drawing on Bourdieu’s concepts of habitus, capital and field, this study identified the written and unwritten rules shaping the success of performance nutritionists in professional soccer from the perspectives of the key stakeholders (Figure 21). The written rule centres on building strong technical foundations via academic qualifications and accreditation through professional bodies. Within the UK, this is typically achieved through registration with the SENr pathway: completing a relevant undergraduate degree (e.g. nutrition, dietetics or sports and exercise science), followed by an SENr-accredited postgraduate degree for Graduate Registration and ultimately progressing to Practitioner Registration through applied experience and a competency-based portfolio (Rosimus, 2021).

The unwritten rules, however, extend beyond qualifications and technical expertise, requiring practitioners to navigate the social field of elite soccer by understanding the existing power dynamics, mobilising cultural and social capital, building trust with stakeholders and embodying a habitus aligned with the values of passion, adaptability, positivity and resilience. To prepare for this, neophyte nutritionists should be encouraged to deliberately cultivate interpersonal skills, particularly the ability to build trust and credibility with players, coaches and wider multidisciplinary staff. Internships and structured work placements provide valuable platforms for developing these competences (Sleap and Reed, 2006), especially when supported by experienced and appropriately qualified supervisors who can scaffold practice and help acquire the essential social capital for effective practice (Malone, 2017). Beyond entry-level training, hybrid models that embed practitioners within professional sport organisations such as research-practitioner roles (Jones et al., 2019) and professional doctorate programmes (Bartlett and Drust, 2021), offer promising pathways to advance scientific knowledge while strengthening applied impact. Crucially, when transitioning into new sporting environments, performance nutritionists must recognise and adapt to prevailing power dynamics, informal hierarchies and doxic practices, tailoring interventions aligned with the realities of the club environment.

While neophyte nutritionists must navigate both written and unwritten rules to accumulate symbolic capital, these dynamics can sometimes reinforce established practices. Entering the field with limited capital, junior practitioners may feel hesitant to question prevailing norms such as body composition targets that have been debated in the literature (Costello et al. 2025) for fear of losing credibility or affecting employment. Although, not reported by participants in this study, it is possible to see how such conditions may silence critical voices and perpetuate practices that

diverge from best practice recommendations (Mathisen et al., 2023). Furthermore, the emphasis of the habitus traits such as unwavering positivity and consistently working “above and beyond” is often regarded as a pre-requisite and may even be perceived as a means of accruing capital in the field. From a critical perspective, sustaining such workloads over time is unrealistic, which may in turn create pressures that affect well-being and service quality (Mifsud et al., 2025). These challenges are not unique to nutritionists; evidence of burnout and compromised mental health has also been reported among wider performance support staff, coaches and managers in elite soccer settings (Frost et al., 2024; Mifsud et al., 2025). Given that these insights reflect the experiences of players across a variety of clubs, addressing these cultural issues likely require organisational interventions rather than placing responsibility solely with the individual. Those with greater institutional and symbolic capital (e.g. sporting directors, performance directors etc.) may be positioned as cultural architects capable of reshaping norms and beliefs within the field while mitigating the hierarchical pressures. Practical strategies may include implementing realistic workload expectations, providing adequate support and resources and fostering a culture that values work-life balance (Binaebi Gloria Bello et al., 2024). The effectiveness of these approaches is closely linked to sufficient staffing as performance nutrition departments are often limited in resources (Carney et al., 2023). Governing bodies like SENr and the EPL may influence nutrition culture by establishing minimum standards, monitoring compliance and prioritising well-being alongside with performance. While deeply entrenched norms in elite sport mean changes are likely to be gradual, sustained systemic support could progressively promote sustainable practices that prioritise practitioner welfare and strengthen the long-term effectiveness of performance nutrition provision.

While the insights presented here are derived from stakeholders at a single EPL club and thus may have limited generalisability, the themes identified drew upon their gamut of experiences and provide actionable considerations for both practitioners and institutions. Indeed, the stakeholders had previously played or coached across multiple other leagues including EPL, Serie A, Bundesliga, Ligue 1, Turkish Süper Lig, Australian A-League, Scottish Premiership and Liga Portugal, bringing with them a breadth of diverse perspectives. Furthermore, all interviews were conducted by the club nutritionist. This insider position provided positive contributions in terms of access and a shared terminology/language but may have influenced participants' openness due to the pre-existing professional relationships between the interviewer and interviewees. To mitigate potential bias, neutral and open questions were asked, whilst critical friends were incorporated into the data analysis process to support reflexive considerations. Together these processes enhance the trustworthiness of the findings. To strengthen this evidence base, future research should extend this work by engaging key stakeholders from multiple clubs, leagues and sports to establish a broader understanding of performance nutrition practice. Whilst this work has identified the importance of practitioners' developing cultural and social capital alongside the performance habitus, there is now a need to explore how nutritionists can develop micropolitical, intrapersonal and interpersonal knowledge and skills to work effectively with stakeholders (e.g., management, medical team and players). This work could involve advancing professional accreditation, devising educational interventions (e.g., experiential learning), implementing mentoring programmes and the development of applied case studies to support nutritionists develop as contextually influential professionals rather than technicians. Nevertheless, the findings presented here provide a practical lens through which readers can reflect and assess if the findings resonate with their experiences, the specific setting they operate in and the people they interact with (Smith and McGannon, 2018).

7.6 Conclusion

This study identified three interrelated themes that characterise the attributes of successful performance nutritionist within the EPL from the perspectives of key stakeholders. First, the professional soccer environment operates as a hierarchical social field, shaped by the authority of coaches and managers, the elevated status of the players and entrenched cultural norms and beliefs. To be effective within this setting, performance nutritionists must recognise and adapt to these implicit “rules of the game” through the strategic use of capitals, including cultural capital (technical, sports specific and interdisciplinary knowledge) and social capital (ability to build relationship and trust with key stakeholders, while maintaining high level of professional integrity). The capacity to accumulate and mobilise these forms of capital is underpinned by a habitus characterised by passion, adaptability, resilience and positivity, which resonates with the cultural expectations of professional soccer. Yet, these implicit “rules of the game” can constrain autonomy by reinforcing the doxic authority of coaches and valorising a habitus of overwork, which could be associated with burnout and reduced service quality. Sustaining practitioner effectiveness in the professional soccer field therefore requires not only technical and interpersonal skill development but also structural support from leaders in the club and governing bodies to reshape field norms and nutrition culture to advance practitioner welfare and the long-term impact of performance nutrition support.

Chapter 8

Synthesis of Findings

The aim of this Chapter is to provide a summary of the findings from this thesis in relation to the original aims and objectives outlined in Chapter 1. A general discussion is then presented, which focuses on how the data derived from this thesis has furthered the understanding of the nutrition culture, nutritional requirements and dietary practices of professional soccer players. Collectively, this body of work also arrives at the presentation of a theory of practice for performance nutritionists practicing in the elite soccer environment. Finally, the practical implications, limitations and recommendations for future research will also be outlined.

8.1 Achievement of thesis aims and objectives

The overall aim of this thesis was to advance performance nutrition guidelines and practice in professional soccer by improving understanding of the research and cultural landscape, refining knowledge of players' nutritional requirements and developing a theory of practice to support practitioners in elite soccer. It was hoped that the data derived from this thesis would assist towards the formulation of evidence-based nutritional guidelines that support the performance and recovery of EPL soccer players and improve the current practice of performance nutritionists working in the EPL. This aim was achieved through a scoping review (Chapter 2) and a series of field-based qualitative, quantitative and mixed method studies conducted in Chapters 3 to 7. An overview of each specific objective is provided below.

Objective 1: To conduct a scoping review and research audit of the literature (both reviews and original research) with relevance to soccer-specific guidelines for CHO intake. This objective was achieved through the completion of Study 1 (Chapter 2).

Using a scoping review approach, this study identified 258 studies related to CHO research in soccer. The audit demonstrated a predominance of laboratory-based experimental studies and field-based observational studies. Notably, observational studies mainly included developmental and professional soccer players whereas experimental studies primarily conducted with recreationally active and collegiate/university soccer players. This imbalance highlights the need for more field-based experimental studies involving professional and world class soccer players to enhance the translational applicability of CHO recommendations for this population. Additionally, narrative reviews represented a substantial portion of CHO literature in soccer and were frequently

published in higher IF journals and received greater Altmetric attention than original research. This trend may incentivize researchers to publish reviews over original studies and may limit the advancement of evidence-based CHO guidelines in soccer.

Objective 2: To qualitatively explore professional soccer players' perspectives of the nutrition culture within the EPL based on Bourdieu's concepts of habitus, capital and field. This objective was achieved through the completion of Study 2 (Chapter 3).

Through reflexive thematic analysis of semi-structured interviews with professional soccer players (5 British and 5 Migrant) from a single EPL club, five key themes emerged. Players' dietary practices are primarily shaped by their habitus, influenced by their familial, ethnic and religious background. Upon entering professional soccer field, these practices are further affected by economic capital, which determined access to high quality nutrition provision, as well as social influences from coaches, teammates and online influences. Furthermore, the deeply ingrained beliefs surrounding ideal body composition standards, often reinforced by the coaches, create biases in players' evaluation, where those failing to meet perceived standards were labelled as "unprofessional" or "lazy" and such perceptions could contribute to public criticism and stress, thereby fostering unhealthy dietary practices. These findings uncover the complex nature of nutrition culture within male professional soccer, highlighting the importance for practitioners to understand and engage with the existing nutrition culture within their specific context to facilitate effective delivery of nutrition intervention.

Objective 3: To determine the TDEE, dietary intake and external load of male EPL players during 1GW and 2GW microcycles. This aim was achieved through the completion of study 3 (Chapter 4).

Using a cross-sectional study design, this study found no significant differences in TDEE between 1GW and 2GW microcycles among EPL soccer players during in-season period, likely reflecting the comparable external training and match load. The observed TDEE values aligned closely with previous literature, therefore supporting the applicability of current UEFA nutrition guidelines to this cohort. However, CHO intake was shown to be below recommended levels on MD-1, MD and MD+1, indicating a persistent gap between recommendations and players' dietary practices.

Objective 4: To examine the TDEE and EI in elite EPL soccer players during two distinct phases of rehabilitation: the initial two weeks post hamstring injury and the transition from partial to full weight bearing during rectus femoris injury rehabilitation. This aim was achieved via the completion of Study 4 (Chapter 5).

Given that Study 3 focus on fit professional soccer players, Study 4 adopted case studies design to quantify the TDEE and EI in EPL soccer players undergoing rehabilitation. TDEE increased significantly from week 1 to week 2 of hamstring injury and during the transition from PWB to FWB during rectus femoris injury. These findings demonstrate that energy requirements can fluctuate considerably across different phases of rehabilitation, highlighting the importance of providing personalised nutrition support throughout the rehabilitation process.

Objective 5: To quantify the energy and macronutrient intake and distribution across meals on training days, MD-1, MD and MD+1; and to apply the COM-B model as a framework to explore the factors underpinning the dietary behaviours of EPL male players. This aim was achieved aim the completion of Study 5 (Chapter 6).

To better understand the lack of adherence to the nutritional guidelines observed in Study 3 (Chapter 4), this study explored the enablers and barriers of dietary practices of EPL soccer players on training days, MD-1, MD and MD+1. On training days, MD-1 and MD+1, “knowledge” was highlighted as the key enabler of dietary behaviours; however, this awareness of the importance of fuelling and recovery alone did not translate into optimal dietary behaviours. Furthermore, suboptimal CHO intakes were observed before and during the matches, particularly due to the prioritisation of the feeling of lightness. Moreover, inadequate CHO intake was also reported immediately post-match, mainly due to suppressed appetite following high intensity match play.

Objective 6: To qualitatively explore the perspectives of professional players and key stakeholders on their perceptions of what defines a successful performance nutritionist in the EPL. This aim was achieved via the completion of study 6 (Chapter 7).

After examining the nutritional requirements and practices of professional soccer players (Studies 3, 4 and 5) and the broader nutrition culture within professional soccer (Study 2), the present study sought to develop a theory of practice for performance nutritionists working in the EPL. The findings suggest that a habitus characterised by passion, adaptability, resilience, and positivity supports the accumulation of key forms of capital including cultural (e.g., technical expertise, sport-specific understanding, and interdisciplinary knowledge) and social (e.g., the ability to build

relationships and trust with stakeholders). Together, these capitals enable practitioners to interpret the “rules of the game” and effectively navigate the social hierarchies embedded within the field.

8.2 General discussion of findings

8.2.1 Audit of the CHO Literature in Soccer

The importance of CHO availability for soccer performance was first demonstrated in 1973, with evidence showing that players who commenced the match with higher muscle glycogen covered greater total distance and performed more sprints (Saltin, 1973). In the same year, Muckle et al. (1973) provided the first applied evidence that pre-match CHO ingestion improved match outcomes including goals scored, goals conceded and total shots attempted. These seminal studies established the foundation for soccer specific CHO guidelines and catalysed the growth of CHO-focused research in soccer (De Oliveira et al., 2025). Building on this early evidence, CHO guidelines have evolved considerably. Initial recommendations in 1994 advised consuming 55-65% of daily energy from CHO on training days and increases to 7 to 10 g·kg⁻¹BM·day⁻¹ CHO on MD-1 to maximise muscle glycogen stores (Clark, 1994). Updated guidelines in 2006 proposed 5 to 7 g·kg⁻¹BM·day⁻¹ CHO on moderate training days and up to 12 g·kg⁻¹BM·day⁻¹ CHO during intense training or match preparation (Burke et al., 2006). The most recent UEFA expert consensus recommends a range of 3 to 8 g·kg⁻¹BM·day⁻¹, with CHO periodised based on training demands, fixture schedule and individual performance objectives (Collins et al., 2021).

Despite these recommendations, it is unclear whether they are underpinned by evidence with strong translational relevance to elite soccer, particularly randomised controlled trials conducted

with elite players in ecologically valid settings (Close et al., 2019a; Jonvik et al., 2022). For instance, only ~4% of studies on performance supplements (1272 participants) involved world-class or elite athletes (Smith et al., 2022b), while 21 out of 937 investigations (~2%) examining acute CHO manipulation strategies (Kuikman et al., 2023b) and 27 out of 281 investigations (~10%) evaluating chronic CHO approaches (Kuikman et al., 2023a), included athletes of this calibre. Findings from **the** audit (Study 1) align with these observations, indicating that only ~10% of CHO-related experimental studies in soccer involved professional soccer players. Moreover, ~75% of experimental studies were conducted in laboratory settings, limiting ecological validity and consequently their translational applicability to real-world environments (Close et al., 2019a). Narrative reviews also represented a substantial proportion of the soccer specific CHO literature (~26%), reflecting a broader trend toward increased review-based articles in sports nutrition (Jonvik et al., 2022). Additionally, female soccer players remain underrepresented, accounting for only 16% of total participants were female and just 12% of the studies exclusively conducted in female soccer players. This imbalance echoes findings from a recent audit highlighting the limited evidence base underpinning CHO-based fuelling strategies for female soccer players (McManus et al., 2025). Collectively, Study 1 highlights substantial gaps within the current CHO literature in soccer and emphasizes the need for more field-based experimental research involving professional and world class soccer players in order to advance the evidence-based practice in this area.

8.2.2 Nutrition Culture in Professional Soccer

Nutrition culture in professional soccer was first explored by Ono et al. (2012). Drawing on the concept of habitus, the authors demonstrated that the players' eating habits are largely shaped by their upbringing, with players tending to perceive their own dietary practices as being normal, right

and superior. This study also highlighted that the managers frequently held negative perceptions of sports nutrition and that many professional soccer clubs at that time did not employ sports nutritionists (Ono et al., 2012). Since then, the field of sports nutrition has become increasingly professionalised, with managers now recognising the importance of nutrition for both health and performance (Wenger, 2021). Consequently, performance nutritionists are now commonly embedded within MDT in professional soccer environments (Meyer, 2021). Given this evolution, it is therefore important to examine nutrition culture within the contemporary professional soccer context.

Study 2 (Chapter 3) examined nutrition culture in the EPL from the perspectives of professional soccer players. Drawing on the concepts of Bourdieu Theory, players' dietary practices were influenced profoundly by their habitus, informed by their familial, ethnic and religious background. Alignment between a player's habitus and dominant professional soccer norms was perceived as important for success, with misalignment often linked to struggles to adapt to the soccer specific diet. Nutrition provision has improved substantially over the past decade, largely driven by the increased economic capital. Increased clubs' revenue (Deloitte Football Money League, 2024) and player wages (Sporting Intelligence, 2024) have enabled more personalised food provision across multiple meal occasions and greater access to private chefs. However, economic capital was unevenly distributed, with first team players prioritised over academy players. Managers and coaches emerged as dominant figures within the professional soccer field, possessing substantial social capital that enables them to influence players' dietary practices, consistent with previous research (Bentley et al., 2019). Players who struggle to conform to these expectations may be disadvantaged within the field's hierarchy. A clear example is the doxic belief

surrounding body composition, whereby players are expected to meet arbitrary targets, often set by managers, which is also illustrated in recent study (Costello et al., 2025). Those who fail to meet these standards may be labelled unprofessional or lazy, while those who conform to the perceived ideal body type may be favoured, reinforcing stereotypes and limiting for players outside normative body composition. As nutrition culture in professional soccer continues to evolve, it is imperative that practitioners develop a nuanced understanding of the multifaceted nutrition culture within their specific sporting context before implementing nutritional interventions.

8.2.3 Total Daily Energy Expenditure

The literature audit conducted in Study 1 (Chapter 2) revealed that current UEFA CHO guidelines for professional soccer players (Collins et al., 2021) are underpinned by limited evidence derived from professional and world class players. To develop accurate CHO recommendations, it is essential to establish the energy requirements of this population. The DLW method is considered as the gold standard for assessing TDEE in free living individuals for a period of 7-14 days (Westerterp, 2017). The first DLW-based assessment of TDEE in professional soccer players was published in 2002, reporting a mean of 3532 ± 408 kcal in a cohort of Japanese professional soccer players (Ebine et al., 2002). However, these findings may not be directly applicable to European leagues, particularly the EPL, which is widely regarded as one of the most physically demanding and competitive league globally (Morgans et al., 2025b). Energy requirements of EPL soccer players were first examined in 2015/16 season by Anderson et al. (2017b) over seven days during a 2GW microcycle and reported a mean TDEE of 3566 ± 585 kcal in six EPL players, comparable to the values observed in the Japanese cohort. In the same season, Brinkmans et al. (2019) assessed

41 professional soccer players from three Eredivisie clubs over a 14-day period (average of 2 ± 1 matches) and reported a lower absolute TDEE values ($3285 \pm 354 \text{ kcal}\cdot\text{day}^{-1}$).

Over the past decade, the physical demands of soccer games have evolved exponentially. The modern game is faster and more intense, driven by widespread adoption of pressing, counter-pressing and counter attacking strategies (Nassis et al., 2020). Correspondingly, from the 2014/15 to 2018/19 EPL seasons, accumulative HSR and sprint distances increased by $\sim 12\%$ and 15% , respectively (Allen et al., 2024). Similar trends have been observed in Spanish First Division (La Liga), where both high-intensity running distances and number of sprints increased between 2015/16 to 2018/19 seasons (Pons et al., 2021), with further increases in total distance covered, HSR distance and the frequency of HSR efforts observed between the 2019/20 and 2022/23 seasons in La Liga (García-Calvo et al., 2025). In light of these evolving physical demands, Study 3 (Chapter 4) aimed to provide an updated evaluation of the TDEE of EPL players. Using the DLW method, TDEE was assessed in nine players over a 15-day period comprising a 1GW microcycle followed by a 2GW microcycle. The reported mean TDEE of $3551 \pm 507 \text{ kcal}\cdot\text{day}^{-1}$ was comparable to Anderson et al. (2017b). Importantly, this study provides the first measurement of TDEE during a 1GW microcycle ($3554 \pm 963 \text{ kcal}\cdot\text{day}^{-1}$), which did not differ significantly from 2GW microcycle ($3467 \pm 821 \text{ kcal}\cdot\text{day}^{-1}$). The absence of significant differences is likely attributable to the similar accumulative total, HSR and sprint distances recorded across microcycles. Despite the recent advancements in external load at the elite level, **the** findings did not discover a corresponding increase in TDEE of EPL players. These results therefore support the continued applicability of current UEFA nutrition guidelines for professional soccer players.

8.2.4 Energy and Macronutrients Intake

Following the exploration of professional soccer players' energy requirements (Study 3, Chapter 4), it is equally important to examine their nutritional practices. The first quantification of dietary intake in UK professional soccer players, conducted in 1997, reported mean EI of 2629 to 3059 kcal·day⁻¹, alongside CHO (4.4 to 5.0 g·kg⁻¹BM·day⁻¹), PRO (1.3 g·kg⁻¹BM·day⁻¹) and fat intakes (1.2 to 1.5 g·kg⁻¹BM·day⁻¹) (Maughan, 1997). Two decades later, dietary assessments of EPL soccer players demonstrated a marked increase in PRO intake (~2.5 g·kg⁻¹BM·day⁻¹) and evidence of CHO periodisation, with higher CHO consumption on match days (6.4 ± 2.2 g·kg⁻¹BM·day⁻¹) compared with training days (4.2 ± 1.4 g·kg⁻¹BM·day⁻¹) (Anderson et al. 2017b). However, these CHO intakes remained below the recommended levels (6 to 8 g·kg⁻¹BM·day⁻¹) required to optimise muscle glycogen resynthesis during congested fixture period (Gunnarsson et al., 2013). Consistent with this, a recent systematic review reported that 6 of out 15 studies failed to reach UEFA CHO recommendations of 4 to 8 g·kg⁻¹BM·day⁻¹ (Danielik et al., 2022). CHO intake during match play also appears inadequate, averaging 17 ± 11 g·h⁻¹ among EPL players, substantially lower than the UEFA guidelines of 30 to 60 g·h⁻¹ (Kasper et al. 2024). Similarly, immediate post-match CHO intake was also shown to be insufficient, with reported values of <1 g·kg⁻¹BM (Anderson et al. 2017a), falling short of the recommended 1 g·kg⁻¹BM·h⁻¹ for the first 4 hours post-match (Collins et al. 2021).

Studies 3 (Chapter 4) & 5 (Chapter 6) provided an updated assessment of the nutritional practices of EPL soccer players across training days, MD-1, MD and MD+1. Mean EI values were 2975 ± 292 kcal·day⁻¹ in Study 3 and 2969 ± 233 kcal·day⁻¹ in Study 5. These intakes exceeded those

previously reported in Eredivisie players ($2658 \pm 693 \text{ kcal}\cdot\text{day}^{-1}$, Brinkmans et al., 2019) but were lower than those observed in an earlier investigation of EPL players ($3186 \pm 367 \text{ kcal}\cdot\text{day}^{-1}$) (Anderson et al., 2017b). Notably, Study 3 was the first to estimate EI in EPL players using the DLW method. After adjusting for the changes in energy stores, players were found to underreport EI by $724 \pm 722 \text{ kcal}\cdot\text{day}^{-1}$, corresponding to 21% discrepancy (18% error). This magnitude of underreporting aligns with the findings in female soccer players (25% difference; 22% error; McHaffie et al., 2024) and with the underestimation typically observed in studies comparing self-reported EI with TDEE assessed via DLW (Capling et al., 2017). In Study 3, relative CHO intake was significantly higher on MD ($5.0 \pm 1.1 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$), exceeding intakes on MD-1 ($3.5 \pm 1.3 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$), MD+1 ($3.0 \pm 1.0 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) and training days ($3.0 \pm 1.1 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$). In contrast, Study 5 observed a higher CHO intake on MD-1 ($4.6 \pm 0.8 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) when compared to training day ($3.5 \pm 0.8 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$), MD+1 ($3.6 \pm 0.5 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) but did not differ significantly from MD ($3.9 \pm 1.2 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$). Across both studies, players did not meet the recommended CHO targets on MD-1, MD and MD+1 (6 to 8 $\text{g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) and intakes on training days were at the lower end of current guidelines (3 to 6 $\text{g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$). Study 5 further identified in-match CHO intakes ($24.1 \pm 14.9 \text{ g}\cdot\text{h}^{-1}$), similar to (Kasper et al., 2024), as well as inadequate immediate post-match ($0.8 \pm 0.6 \text{ g}\cdot\text{kg BM}^{-1}$) and PMRM CHO intakes ($0.8 \pm 0.4 \text{ g}\cdot\text{kg BM}^{-1}$), both below the recommended intake of $1 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{h}^{-1}$ for the first four hours following the match. In contrast, dietary PRO intakes were adequate in Study 3 ($2.1 \pm 0.4 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) and Study 5 ($2.0 \pm 0.2 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) as were fat intakes (Study 3: $1.4 \pm 0.1 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$; Study 5: $1.3 \pm 0.2 \text{ g}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$). Collectively, these findings indicate that although energy, protein and fat intakes were adequate, players consistently failed to consume sufficient CHO on MD-1, MD+1, during the match and the immediate post-match recovery period.

Consequently, despite advances in CHO research in soccer (Chapter 3), professional players' nutritional practices continue to fall short, highlighting a persistent gap between evidence and applied practice.

8.2.5 Enablers and Barriers to Dietary Intake

It was established in Studies 3 & 5 that professional soccer players frequently failed to meet recommended CHO intakes. However, many sports nutrition interventions have been ineffective in facilitating positive behaviour change due to the lack of theoretically informed BCTs that target the context-specific enablers and barriers influencing dietary behaviours (Bentley et al., 2020). Indeed, interventions incorporating BCTs grounded in the COM-B model (Michie et al., 2011) have shown to be effective in improving body composition in a youth rugby league player (Costello et al., 2018) and increasing CHO intake on MD-1, MD and MD+1 in youth professional soccer players (Carter et al., 2024). Therefore, identifying the enablers and barriers underpinning nutritional practices is a critical prerequisite for designing effective nutritional interventions. For instance, negative beliefs about the role of CHO, social media pressures and practices around body composition assessment were highlighted as key drivers of underfuelling among female soccer players (McHaffie et al., 2022) whereas limited knowledge, demanding lifestyles, inadequate food provision and lack of support from sports nutritionists were the key barriers to optimal nutritional practices in male academy soccer players (Carter et al., 2023b; Carney et al., 2024; Cole et al., 2025). From EPL practitioners' perspectives, limited influence over players' dietary behaviours, scepticism regarding CHO and body composition recommendations and reduced autonomy in delivering nutritional support were the barriers to the implementation of UEFA nutritional

guidelines (Costello et al., 2025). However, the specific enablers and barriers affecting EPL players' adherence to nutritional guidelines have yet to be examined from the players' own perspectives.

Study 5 (Chapter 6) examined, for the first time, the enablers and barriers influencing EPL players' dietary behaviours at each mealtime. Psychological capability, specifically "knowledge", emerged as the primary enabler across most meals on training days including breakfast, post training, lunch and evening snacks and on MD-1 at breakfast, post training, dinner and evening snacks. Yet, despite recognising the importance of fuelling on these days, players still failed to meet the recommended CHO intakes as shown in Studies 3 & 5. On MD, "beliefs about consequences" was the main barrier at breakfast, pre match and during the match. Players often prioritised a "feeling of lightness" over adequate CHO intake, which aligns with practitioners' concerns that current guidelines may be limited by the large food volumes required and the risk of gastrointestinal discomfort (Costello et al., 2025). "Emotion" was the main barrier immediately post-match period and during PMRM, with players reporting suppressed appetite after completion of high intensity match play. Similar findings have been reported in Australian Rules football players (Jenner et al., 2021) and are consistent with evidence of reduced hunger and suppressed acylated ghrelin following high intensity intermittent exercise (Hu et al., 2023a; b). Similarly, players also acknowledged the importance of fuelling and recovery on MD+1, particularly at breakfast, post training and lunch, while mood and social influences such as family and peers acted as key enablers at dinner. In conclusion, Study 5 highlights the multifaceted determinants of dietary behaviours in elite soccer and indicates that effective nutrition interventions must go beyond education alone to

incorporate practical strategies, BCTs and contextual considerations to bridge the gap between current practice and recommended guidelines.

8.2.6 Energy Expenditure and Dietary Intake of Injured Players

Professional players sustain an average of two injuries per season, meaning a 25-player squad can expect around 50 injuries annually (Ekstrand et al., 2011). As physical demands of the game continue to rise (Allen et al., 2024), injury incidence, especially hamstring injury, has increased substantially over the past two decades (Ekstrand et al., 2022) and it is likely to continue rising with growing fixture congestion (Page et al., 2023). Given the strong link between players' availability and team performance (Hägglund et al., 2013) and the financial impact of injury-related underperformance (Eliakim et al., 2020), implementing effective rehabilitation strategies are essential. Sports nutrition is a core element of multidisciplinary rehabilitation (Rollo et al., 2021a), yet evidence on TDEE and dietary intake during rehabilitation is scarce. Only one study has quantified TDEE using the DLW method, reporting $3178 \text{ kcal}\cdot\text{day}^{-1}$ at week 6 of ACL injuries (Anderson et al., 2019a). Defining energy requirements during rehabilitation is critical as sustained energy deficits can lead to significant FFSTM losses as show in an EPL recovering from an ACL injury (Milsom et al., 2014).

In Chapter 5 of this thesis, TDEE and dietary intakes of two professional soccer players were quantified across two distinct rehabilitation phases: the first two weeks following a hamstring injury and the transition from PWB to FWB during rectus femoris injury rehabilitation. Following hamstring injury, TDEE increased by $1013 \text{ kcal}\cdot\text{day}^{-1}$ from Week 1 ($3143 \text{ kcal}\cdot\text{day}^{-1}$, $33.5 \text{ kcal}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) to Week 2 ($4156 \text{ kcal}\cdot\text{day}^{-1}$, $44.4 \text{ kcal}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) post hamstring injury. Similarly,

TDEE increased by $538 \text{ kcal}\cdot\text{day}^{-1}$ when transitioning from PWB ($3175 \text{ kcal}\cdot\text{day}^{-1}$, $35.8 \text{ kcal}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$) to FWB ($3713 \text{ kcal}\cdot\text{day}^{-1}$, $42.0 \text{ kcal}\cdot\text{kg BM}^{-1}\cdot\text{day}^{-1}$). EI, estimated via the DLW method, was adequate in Player 1, who showed a modest energy deficit in Week 1 ($-232 \text{ kcal}\cdot\text{day}^{-1}$) followed by a slight energy surplus in Week 2 ($+187 \text{ kcal}\cdot\text{day}^{-1}$). In contrast, Player 2 remained in negative energy balance during both the PWB ($-139 \text{ kcal}\cdot\text{day}^{-1}$) and FWB ($557 \text{ kcal}\cdot\text{day}^{-1}$) phases. Consequently, Player 1 maintained BM ($+0.10 \text{ kg}$) in the initial two weeks post hamstring injury, despite a slight decrease in FFSTM (-0.50 kg) and an increase in total FM ($+0.65 \text{ kg}$). Conversely, Player 2 experienced a reduction in BM during both PWB (-0.30 kg) and FWB (-1.20 kg) phases. Collectively, TDEE can fluctuate substantially across rehabilitation phases, highlighting the importance of adjusting EI to minimise energy deficits in order to preserve FFSTM and support an optimal return to play.

8.2.7 Theory of Practice for Performance Nutritionists

Following the examination of the nutritional requirements and practices of professional soccer players (Chapters 4 to 6), it is evident that many players continue to fall short of established nutritional guidelines. This highlights the critical role of performance nutritionists in facilitating meaningful dietary behaviour change within professional soccer. However, as highlighted in Chapter 3, professional soccer operates as a multi-faceted social arena with its own unique logic. Consequently, performance nutritionists must be able to effectively navigate this environment in order to implement and sustain optimal nutritional interventions. Indeed, it was previously suggested that although effective practitioners are expected to demonstrate adaptability, empathy, trustworthiness and strong technical expertise (Rosimus, 2021), the ability to appreciate the unique culture of the sport and build meaningful relationships with players and coaches are the more

decisive attribute (Burns et al., 2024b). Despite the recent evolution of the profession, from part-time consultancy roles to fully embedded, full time positions (Wenger, 2021), it remains unclear what factors enable performance nutritionists to be effective within this highly complex professional soccer context.

Study 7 (Chapter 8) explored the perspectives of professional soccer players and key stakeholders on what constitutes a successful performance nutritionist in the EPL. Guided by Bourdieu's theory of practice framework, the findings demonstrate that applied performance nutrition practice is shaped by practitioners' habitus, their accumulated forms of capitals and their ability to navigate and position themselves within a given field. In professional soccer, a habitus characterised by passion, proactivity, adaptability, positivity and resilience was highly valued. This aligns with previous research indicating that players value practitioners who prioritise their best interests (McCall et al., 2023), while coaches emphasise a willingness to go above and beyond as key attributes of practitioners effectiveness (Burns et al., 2024a). Practitioners who embody these dispositions are more likely to accumulate the key capitals, particularly cultural capital ("knowledge") and social capital ("relationship building"). While technical knowledge is recognised as fundamental requirement for performance support staff (Stewart et al., 2024), the ability to build effective relationships with both players and coaches is comparatively rare and more valued in the field (Burns et al., 2024a). Together, habitus and capital shape practitioners' understanding of the rules of the game, influencing how they navigate the social hierarchies and doxic practices within the field. For instance, the doxic authority of coaches, the elevated status of players and entrenched beliefs around body composition were all shown to shape nutrition practice and practitioner autonomy. Importantly, this study highlights that perceptions of successful

performance nutritionists are field specific. A nutritionist may therefore practise and be perceived as effective differently across sporting context. As such, to be considered successful in a particular sport, practitioners may need to adopt context specific habitus, accumulate relevant capitals and develop a nuanced understanding of the cultural and social dynamics of the field they are working in.

8.3 Limitations

The studies presented in this thesis have produced novel data that has advanced the understanding of nutritional culture, nutritional requirements and dietary practices of professional soccer players as well as the theory of practice underpinning performance nutritionists' work. Nevertheless, these studies are not without their limitations, several of which are common across the thesis. Firstly, the research was conducted exclusively with male players and therefore the findings cannot be directly applied to professional female soccer players. Additionally, all data were collected from a single EPL team, which may limit the representativeness of the findings for other EPL clubs or professional soccer teams globally. Differences in coaching, training and nutritional philosophies, as well as differences in infrastructure, staffing, funding, resources and organisational cultures may influence club operations and consequently players' nutritional requirements, practices and the broader nutrition culture. Furthermore, the absence of experimental trials in this thesis, despite the scoping review highlighting the need for more intervention-based research, represents an additional limitation. There were also several limitations that were specific to each study within this thesis.

8.3.1 Study 1 (Chapter 2)

The electronic literature search was restricted to PubMed due to its strong coverage of sports science and nutrition research. However, this restriction may have limited the breadth of the evidence base, as relevant studies indexed in other databases such as Web of Science, Scopus, Embase, Cochrane, SportDiscus and Google Scholar may not have been identified.

8.3.2 Studies 2 & 6 (Chapters 3 & 7)

All interviews were conducted by the researcher who also held the role of club nutritionist. This insider position may have shaped the interview dynamic, potentially influencing participants' willingness to disclose information and the nature of their responses due to the pre-existing professional relationships. To address potential bias associated with this dual role, critical friends were integrated into the data analysis process (Smith and McGannon, 2018).

8.3.3 Studies 3, 4 and 5 (Chapters 4, 5 and 6)

Dietary assessments are inherently prone to error, including underreporting and inability to accurately capture habitual, longer-term intake (Burke et al., 2001). The RFPM used in these studies has been shown to alter usual dietary behaviour and is susceptible to errors such as food omission, inaccurate portion size estimation, underreporting of foods perceived as “unhealthy” and overreporting of foods considered nutritious (Capling et al., 2017). Furthermore, evidence suggests that even trained professionals are not immune to such errors, with both experienced and inexperienced sports nutritionists underestimating total daily CHO intake by 54 g and 66 g, respectively, when assessed over two days (Stables et al., 2021). To partially address these

limitations, a retrospective dietary recall method was used alongside RFPM to enhance the accuracy of dietary assessment (Capling et al., 2017). Data quality was further strengthened by the presence of researchers at the training ground and stadium, allowing real-time clarification and participant support when required. Nevertheless, some degree of reporting bias is likely to persist. Therefore, to aid the interpretation of the actual EI, EI was additionally estimated via the DLW method, which accounts for changes in body energy stores (Schulz et al., 1992) and provides an objective benchmark against which reported intake could be interpreted (McHaffie et al., 2024).

8.3.4 Studies 3 & 4 (Chapters 4 & 5)

Although the DLW technique is widely regarded as the gold standard method for assessing TDEE under free-living conditions, it provides only an estimate of mean TDEE over the measurement period. As such, it does not permit the quantification of day-to-day fluctuations in energy requirements (Westertep, 2017), nor does it allow for the measurement of energy expenditure during individual training sessions or competitive matches. Additional limitations include the absence of direct measurements of RMR, which necessitated the use of predictive equations and may have introduced error at the individual level (O'Neill et al., 2023). Furthermore, daily physical activity outside of structured training sessions was not objectively assessed, limiting insight into the contribution of non-training activities to overall TDEE (Chung et al., 2018; Goshozono et al., 2024).

8.4 Recommendations for further research

Building on the findings of this thesis, further research is needed to deepen understanding of the nutrition culture, nutritional requirements and dietary practices of professional soccer players, as well as to clarify how performance nutritionists should effectively operate within applied professional settings. Some of the questions remain unanswered may be addressed via the following research recommendations:

1. Design and implement field-based CHO intervention studies involving professional and world-class soccer players to address gaps in the existing literature and enhance the ecological validity of current UEFA nutritional recommendations for this population.
2. Replicate Study 2 across professional male players from multiple clubs and professional soccer leagues to capture a broader and more diverse range of perspectives on nutrition culture.
3. Investigate positional differences in TDEE among EPL players using the DLW method, considering the positional variations in training and match external loads (Morgans et al., 2025a; b), to inform the development of position specific nutritional guidelines.
4. Design and implement intervention studies informed by the enablers and barriers identified in Study 5 to improve the dietary practices of professional soccer players, particularly the consistently low carbohydrate intakes observed on MD-1, MD, and MD+1. Such interventions would build on approaches previously applied in academy soccer players and evaluate their effectiveness within an elite professional context (Carter et al., 2024).
5. Investigate within-player changes in TDEE across the different phases of rehabilitation to better characterise fluctuations in energy requirements and support more precise, phase-specific nutritional strategies throughout the rehabilitation process.

6. Replicate Study 6 by engaging key stakeholders from multiple clubs and professional soccer leagues to capture a broader and more diverse set of perspectives on the attributes, competencies, and practices that define a successful performance nutritionist.

8.5 Summary

In summary, this thesis provides novel insights on the current research landscape of CHO and soccer, the nutrition culture, nutritional requirements and dietary practices of EPL players and the theory of practice underpinning effective performance nutritionists. The scoping review of CHO literature revealed a research landscape dominated by laboratory-based experimental studies conducted in recreational active and collegiate populations, alongside a paucity of field-based experimental studies in professional players, thereby limiting the translational relevance of current nutritional guidelines. Complementing this evidence gap, qualitative exploration of nutrition culture demonstrated that players' dietary practices are strongly shaped by habitus and reinforced through social influences from coaches, managers, teammates and social media (social capital), access to financial resources (economic capital) and the presence of taken-for-granted doxic practices exist within the professional soccer field. Despite the substantial evolution in external demands of elite soccer, TDEE in EPL players was comparable to previous literature and did not differ between 1GW and 2GW microcycles, supporting the continued applicability of existing nutritional guidelines. However, CHO intakes were consistently below recommendations on MD-1, MD and MD+1. Further analysis of the dietary behaviours indicated that, although players recognised the importance of fuelling and recovery on MD-1 and MD+1, awareness alone was insufficient to ensure guideline adherence. On MD, suboptimal pre- and during match CHO intake was largely driven by players' desire to maintain a subjective sense of lightness, while post-match and PMRM CHO intakes were constrained by suppressed appetite. To further bridge the gap

between research and practice, additional findings demonstrated that energy requirements can fluctuate markedly during rehabilitation, particularly when transitioning between phases. Finally, the translation of these findings into applied practice is underpinned by the habitus of performance nutritionists and their accumulation of cultural (knowledge) and social capital (ability to build relationship with key stakeholders), enabling them to navigate the multi-faceted elite soccer field effectively. Taken together, this thesis bridges research and practice by contextualising current research and cultural landscape in soccer, providing contemporary applied data amid the evolving demands of professional soccer and consolidating a framework for effective performance nutrition practice in elite soccer settings.

Chapter 9

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