FROM PAPER TO PODIUM: APPLYING LABORATORY BASED SPORT NUTRITION RESEARCH INTO APPLIED PRACTICE

ANDREAS M. KASPER

A PhD via Publication thesis submitted to Liverpool John Moores University in partial fulfilment of the Doctor in Philosophy degree.

November, 2022

AUTHORS DECLERATION

I declare that the work in this thesis was carried out in accordance with the regulations of Liverpool John Moores University. Apart from the help and advice acknowledged, the work within was solely completed and carried out by the author.

Any views expressed in this thesis are those of the author and in no way represent those of Liverpool John Moores University and the School of Sport and Exercise Science.

This thesis has not been presented to any other University for examination either in the United Kingdom or overseas. No portion of the work referred to in this research project has been submitted in support of an application for another degree or qualification of this or any other university or institute of learning.

Copyright in text of this research project rests with the author. The ownership of any intellectual property rights, which may be described in this research project, is vested in Liverpool John Moores University and may not be made available for use to any third parties without the written permission of the University.

Signed 

Andreas M. Kasper

Date **20/11/22**

ABSTRACT:

Sport nutrition is a fast growing discipline within sport science with many sports teams now employing a Sport Nutritionist on either a full or part time basis. Despite this growth in the discipline, and a resultant abundance of sport nutrition literature, often the literature can be inappropriately implemented in practice or, even worse, ignored. This is particularly dangerous in sport nutrition given the risks to health, performance and the anti-doping risks inherent in the sport nutrition discipline.

To help the Sport Nutritionist in practice we initially developed a framework termed 'Paper to Podium (Chapter 1). This framework then provides the basis of the thesis by presenting operational guidance for practitioners to critically evaluate the translational potential of sport nutrition research to practice and provide a time efficient protocol for practitioners to appraise research and inform practice. Once the framework had been developed, this thesis via publication splits into two main themes based upon two major roles of the Sport Nutritionist in applied practice.

The first theme, presented in Chapter 2, is based around current tools for measuring energy intake, energy expenditure and body composition and resulted in 4 publications. The first publication demonstrates that the practical ways in which applied practitioners often estimate energy intake are not necessarily a valid or reliable measure in practice, despite the experience of the practitioner or the simplicity of the meal. The publication was particularly timely given the growing use of the 'Snap-n-Send' method in the applied setting. The second manuscript focussed upon the estimation of energy expenditure in free living athletes. Here, a joint measure of heart

rate and accelerometery was utilised to assess the energy requirements of golfers, as previous research had failed to do this accurately. We found that prior literature significantly over-estimated the energy expended across a round of golf suggesting a MET value in excess of that reported during jogging. Kasper et al., (2022) highlighted the importance of using the most appropriate measurement tool in as close to real conditions as possible, as well as highlighting the dangers associated with poor measurement techniques and is already being used to prescribe dietary interventions to elite professional golfers. The third publication focussed upon the assessment of body composition within an applied model using a weight-making athlete. We observed large discrepancies in body composition data dependent on the selected assessment method. Specifically, we found that some methods (e.g. DXA) were more effected than others (skinfold thickness) during acute and chronic weight loss and rapid regain. Observations led to the fourth publication in this chapter, which involved a review of the available methods for measuring body composition in practice including novel insights from DXA scans on professional athletes. Publications derived from Theme 1 had a number of practical implications, such as informing Career Progress Development (CPD) sessions in sporting organisations for their practitioners, direct changes to practitioner planning of nutritional interventions, and changes to the body composition collection practices, especially for larger athletes or those where ideal operating conditions could not be controlled.

Having assessed and appraised some of the field field-based tools available to nutrition practitioners, theme 2 provides guidance on supplementation practices and procedures for applied practitioners (Chapter 3) and resulted in a further 5 publications. Advice surrounding supplementation is required by nutritionists daily,

however due to the stigma surrounding supplementation, a growing 'food-only' approach is being advocated by many organisations, where supplementation is deemed somewhat taboo. The first publication provides a commentary to introduce a 'food-first but not food-only' framework for advising supplements to athletes and forms the basis of the resultant papers in this chapter. The second publication investigated a common practice reportedly used by team sport athletes to avoid bloating, as well as well as weight-making athletes aiming to 'train-low'. Close et al., (2019) used the 'Paper to Podium' Framework to design an ecological model to test the hypothesis that carbohydrate mouth rinse combined with caffeine reduced the decrements to performance that athletes may experience when restricting carbohydrates or fluids. The third publication investigates another practice that many athletes commonly participate in, oral nicotine use (e.g. snus). As such, we felt the need to produce a short review with the aim of educating athletes and support staff as to the current landscape of oral tobacco use in sport. We highlight the lack of data on snus and that the data available suggests detrimental effects to health and performance and therefore should not be advised in practice. Contrary to snus, cannabidiol (CBD) is a supplement that has a number of proposed benefits, however, although observed first-hand by authors, it was important to first review its prevalence within sport. The fourth article presented within this theme assesses the prevalence, awareness of inadvertent doping, and rationale for CBD use in rugby. Kasper et al. (2020) found that players supplemented with CBD in a quest for pain relief despite the apparent risk of inadvertent doping. As the World Anti-Doping Association (WADA) prohibits all cannabinoids other than CBD, we thought it pertinent to understand the effects of the whole cannabinoid profile on performance. The final publication of the thesis concentrates on reviewing the existing evidence for the physiological effects of

cannabis, tetrahydrocannabinol (THC) and CBD on sporting performance. The manuscripts presented in Theme 2 have been used in a number of keynote conference addresses educating academics and practitioners, adopted by organisations to form the basis of position stands, and applied directly within the elite sporting environment.

Having set the goal of answering some of the key questions that arise daily within applied practice, I can reflect that this novel approach to conducting a PhD allowed me to focus on answering these key sport-nutrition questions, whilst also guiding other practitioner's, researcher's and student's practice. Taken together, the publications presented within the current thesis have helped shape applied practice, educate practitioners and academics, and have had direct impact within the real-world of elite sport in a number of ways highlighted throughout. There is a need for 'fast' research and Researcher-Practitioners based predominantly in applied environments as these publications can often help bridge the gap between science and practice.

CONTENTS:

FIGURES:

ACKNOWLEDGEMENTS:

Conducting this research within the applied environment has had its challenges, however the process has been extremely rewarding and developed me as a scientist and person on several levels. It has challenged me both intellectually and emotionally but has been an experience I will not forget. I owe my gratitude to a number of people who have helped me through this process.

I would like to firstly thank my supervisors, Claire Stewart, Graeme Close and James Morton. Their support and guidance have been invaluable. They have helped mould me as a scientist, academic and practitioner. I would also like to thank the department of Sport and Exercise Science at Liverpool John Moores University for allowing me to follow an untraditional PhD route and support me through this process.

Next, I would like to thank the additional collaborators found within. I am grateful for their support and expertise. I am also incredibly grateful to the long list of coaches and practitioners who gave me the opportunity and/or helped me hone my understanding of applied practice over the past decade in elite sport: John McKeown, Steve Tashjian, Matthew Taberner (Everton FC); Chris Neville, Chris Rush, Liam Mason (Blackburn Rovers Football Club); Ian Taplin, Tom Farrow (Wasps and Arête), Scott Drawer, Neil Taylor, Robin Eager, Tim Hall, Mark Bitcon (England Rugby Union); Steve McNamara, Richard Hunwicks (England Rugby League and Catalans Dragons); Jon Kelly (Toronto Wolfpack); Steve Haines (Derby County Football Club); Frank Lampard, Jody Morris, Chris Jones, Adam Burrows (Derby County Football Club and Chelsea Football Club); Petr Cech, Thomas Tuchel, Tim Harkness, Chris Searle, Anthony

Barry, Will Tullett, Matt Birnie (Chelsea Football Club); James Collins (INTRA Performance Group); Ben Ashworth (AC Sparta Prague); Scott Parker, Ally Harris, Marco Cesarini, Lewis MacMilan (Fulham Football Club); Brian O'Leary, Rob Palmer (London Irish Rugby Union); Rick Swaby, John Kirkpatrick (Sale Sharks Rugby Union); and more recently Eddie Howe, Dan Hodges, Nick Grantham, John Fitzpatrick, James Allan, Paul Catterson (Newcastle United Football Club).

Finally, I would like to dedicate this to my family, including those no longer with us, who have supported me in more ways than can be quantified over the duration of my education. I hope you realise how much I appreciate you and all you have done for me.

CHAPTER 1

INTRODUCTION: TRANSLATING RESEARCH TO PRACTICE

Publications resulted from this chapter:

Close, G. L., Kasper, A. M., & Morton, J. P. (2019). From Paper to Podium: Quantifying the Translational Potential of Performance Nutrition Research. *Sports Medicine*, *49* (Supplement 1), 25–37. https://doi.org/10.1007/s40279-018-1005-2

Impact Factor: 11.136

Quartile: Q1

Altimetric: 212

Citations: 25

1.1 INTRODUCTION TO THESIS

The submission of this thesis is for a PhD via publication. The focus is on nutrition and elite sport. I will set the scene and will be writing in part, in the first-person narrative, for clarity. I am a Sport Nutritionist working within the world of elite sport, where the focus of my work is to help the team I am supporting to out-perform the opposition, where the measured outcome is 'winning'. I have worked within this realm since the final year of my undergraduate degree programme in Sport Science (as an Assistant Sports Scientist, Everton Football Club, 2013-2014). Now almost 10 years later, my practice has developed extensively, and I am working at the top level of football and rugby union. However, my journey since finishing my MSc degree programme in Sport Nutrition (2015) has been somewhat diverse.

Sport nutrition is a fast-growing discipline within sport science, with many elite sports teams now employing a Sport Nutritionist on either a full- or part-time basis, however there is yet to be an accepted working definition of what exactly a Sport Nutritionist's role within the multidisciplinary team is. Implicit in the responsibilities of a Sport Nutritionist is the need to protect the athlete's health and performance by preventing the harmful practices that many athletes follow. However, nutrition is still an area that is not particularly well regulated, and it is not a pre-requisite that teams hire accredited practitioners, despite some of the potential pitfalls to athlete health and risks of inadvertent doping if poor advice is provided / protocols followed (Burke et al., 2019, Garthe & Maughan, 2018; Maughan et al., 2018). As such, nutrition practice and the academic qualifications of practitioners is extremely varied between teams, some who may not have studied nutrition *per se* at an academic institute and may not have an

appreciation of good working practices (including testing of energy intake, energy expenditure, body composition and biochemical markers). Indeed, this is also true of some of the nutritionists that athletes may work with privately.

Nutrition is a relatively new discipline compared with other areas of sport science. Somewhat unique to the field of sport nutrition, is that many roles encompass part-time consultancy as opposed to full time employment roles. Due to this, there are two primary types of applied Sport Nutritionists (Figure 1): 1) research-based applied practitioners working in a safe and ethical way, underpinned by scientific evidence, found full-time within the applied environment, and 2) the 'Researcher-Practitioner' often based within a university as well as applied practice, who also works in a safe and ethical way, underpinned by scientific evidence, but spends time reviewing and conducting research projects that directly influence applied practice. The research conducted by the 'Researcher-Practitioner' may take various forms and should enable the answering of a performance question. Broadly speaking, there are two main types of research important within elite sport: 1) experimental research, e.g., 'what are the outcomes of consuming this food/product on repeated high-intensity running capacity in a situation specific cohort under ecological conditions?'; and 2) review of the current research to enable the development of novel interventions, based on wider study. In both of these suggested scenarios, for the progression of sport nutrition as a discipline, it is important to publish the findings where possible. Often practitioners sit between these applied practitioner roles or academic research roles, with few dual role practitioners within the field. Part of the role of a Researcher-Practitioner is to publish, in peer-reviewed literature, on issues experienced/observed in daily practice to solve

problems. This is undertaken in an attempt to upskill other practitioners on issues seen in daily practice and to answer pertinent questions using reliable and valid measures.

In my experience, sporting organisations often collect data without appreciation as to the reliability or validity of measures being taken, such as morning counter movement jumps in inappropriate footwear, subjective wellness questions not filled out accurately and weight measures taken with little standardisation. It is crucial that multidisciplinary teams choose tests that are not only ecologically valid and can be used in an applied environment, but also robust and reliable.

I began my career as a traditional academic based student, however this transitioned to a more applied focus. My PhD study targeted translating physiological and nutritional practices from research into team sports performance. I had started working part-time at Blackburn Rovers Football Club (2014-2018) during my postgraduate studies. Alongside this, I began to consult for several other organisations (England Rugby League, 2015-2020; England Rugby Union, 2015-Current). These roles allowed me to spend additional time applying nutrition in practice outside of my postgraduate study. Since this period, I have spent time working with other high performing teams (Catalans Dragons, 2017-2021; Chelsea Football Club, 2019-2022; Derby County, 2018-2019; Fulham Football Club, 2018-2020; London Irish Rugby Union, 2019-2022; Sale Sharks Rugby Union, 2021-2022; AC Sparta Prague 2020-2022; Newcastle United Football Club 2022-Current) and individual athletes in sports such as boxing, golf, mixed martial arts, and motor racing. Through these experiences and roles, I have been in an ideal place to not only see the questions that arise on a

daily basis, but also design studies around answering the pertinent questions that athletes and members of the multidisciplinary team actually have in practice.

Although somewhat removed from the practical world of sport nutrition, my initial research interest focussed on the mechanisms by which muscle growth and therefore strength were regulated, 'from molecule to man', however during this period several observations were made. I was finding that teams were applying research far in advance of any significant results being presented, based on research that was far removed from their own situations, and sometimes basing practice on research with poorly selected and controlled methodologies. I was also finding that some athletes were following advice/self-selecting practices that were likely detrimental not only to performance but also to their health. Some practices include the use of CBD and snus, as well as the restriction of dietary supplements altogether (e.g., 'Food-First'). As a result of these observations and my own interests, my research switched to undertaking investigations relevant to applied practice. Therefore, we have researched and published data as it has been produced, in order to provide guidance and data for practitioners who field questions from athletes daily. At this point, I began to transition from studying lab-based procedures to field based applied techniques and practices and I began to critically appraise the literature available in order to 'plug holes' observed within my own practice. I am very passionate about furthering the sport nutrition profession in order to improve safe practice and optimise performance. I believe I am well placed to do so, as a result of my experiences and understanding of the issues commonly observed in the world of elite sport. This thesis will therefore explore some of the key themes that have arisen over my tenure as a Nutritionist Researcher-Practitioner in elite sport. The aims of the current thesis are threefold:

1) To provide a framework for researchers and practitioners when translating research to practice.
2) To assess and appraise some of the field-based tools available to nutrition practitioners.
3) To provide guidance on supplementation practices and procedures for applied practitioners.

Initially, I will introduce the idea of an operational framework for practitioners to critically appraise and evaluate the translational potential of research to their chosen sporting area (Close et al., 2019). The second chapter will draw upon some of the 'gaps' within the literature experienced by myself, whereby we investigated and published research to improve practice. This literature surrounds the assessment tools that are regularly implemented by Sport Nutritionists in the field: 1) assessment of energy intake (Stables et al., 2021); 2) assessment of energy expenditure (Kasper et al., 2022); 3) assessment of body composition (Kasper et al., 2019; Kasper et al., 2021). The third chapter will focus upon and propose a framework to guide practitioners when choosing to use supplements with their athletes (Close et al., 2021), as well as answer additional questions that have arisen during my own practice, surrounding 1) training 'low' (e.g. with low carbohydrate availability and/or energy) / mouth rinsing carbohydrate and caffeine, and its effects on performance (Kasper et al., 2016); 2) the use of oral nicotine within sport (Kasper & Close, 2021); 3) the use of cannabidiol within rugby union (Kasper et al., 2020); and 4) the current understanding of the effects of cannabis and its constituents on athletic performance

(Burr et al., 2020). This thesis will include a commentary/reflection that has been observed first hand within the world of sport.

The overarching objective is to provide a foundation for less experienced practitioners and provide a guide on safe working practices within sport. Alongside this, a commentary of the published papers that have stemmed from questions encountered whilst working at the cutting edge of sport will be provided. The research presented within this thesis has led to direct changes to individual practitioner practices and organisational position stands, as well as being used by sporting and academic organisations as an educational tool to lead practice and learning (discussed further within ‘Reflections From Practice’).

Figure 1.1. A visual representation of the dual Researcher-Practitioner role.

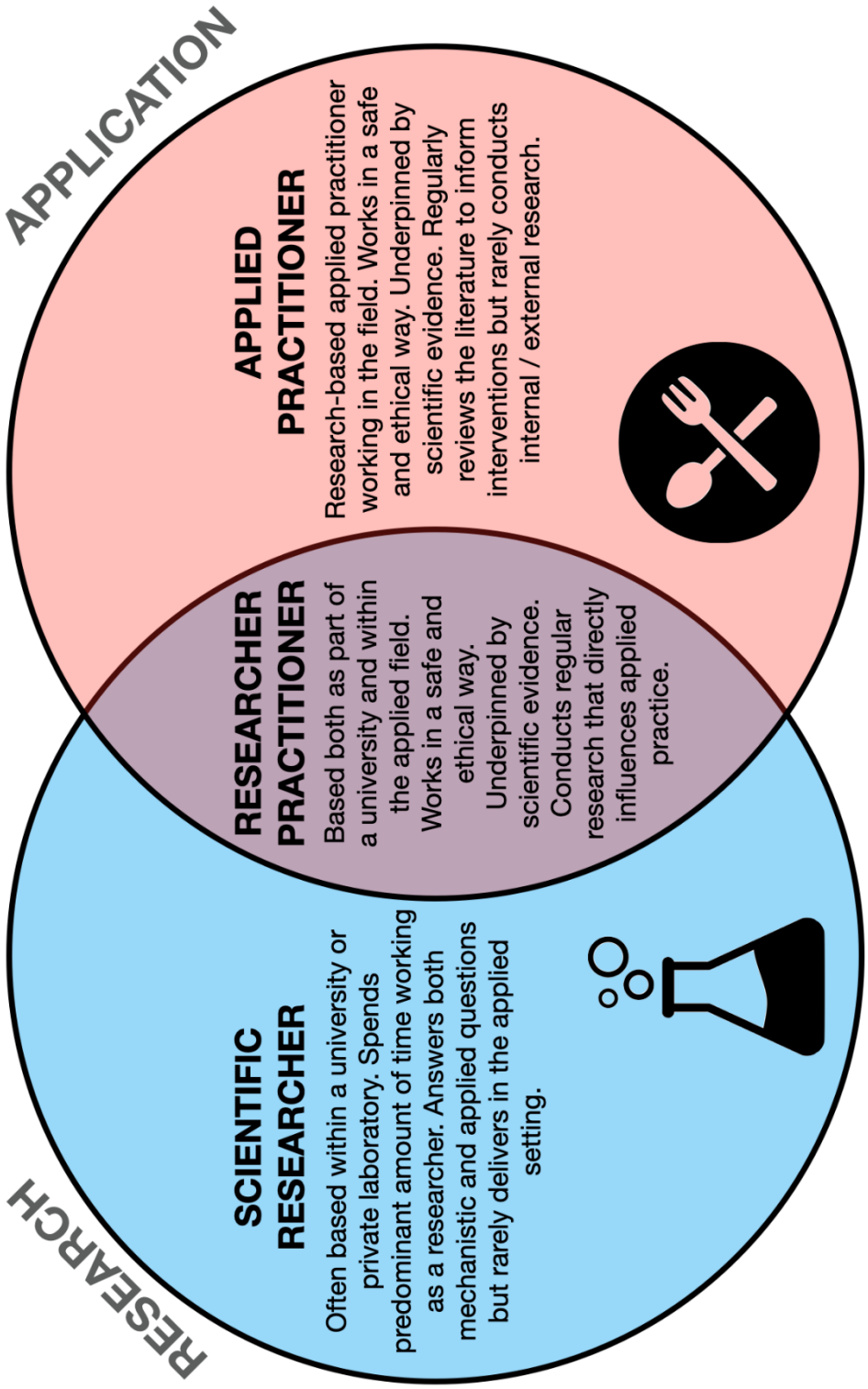
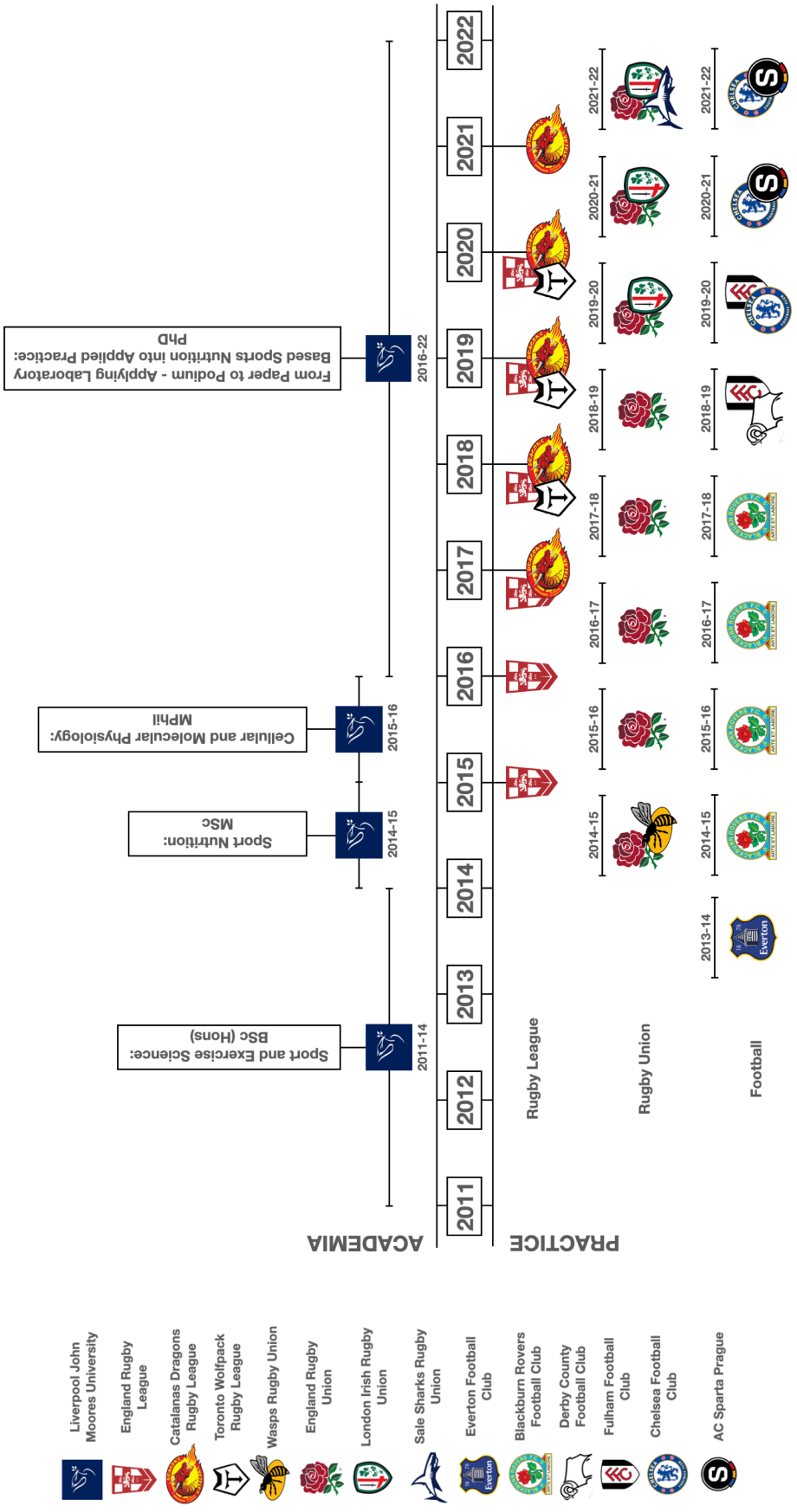


Figure 1.2. A visual representation of my career path thus far.



1.2 PROLOGUE TO CHAPTER 1 AND RATIONALE FOR 'FROM PAPER TO PODIUM: QUANTIFYING THE TRANSLATIONAL POTENTIAL OF PERFORMANCE NUTRITION RESEARCH'

Whilst the goal for both applied-practitioners and Researcher-Practitioners is to ensure research-informed practice, in the world of elite sport, elite athletes and coaches pursue winning margins. There is often not time to wait for the perfect randomised controlled trial or detailed meta-analyses to be published in the world of 'fast' practitioners and 'slow' researchers (Coutts, 2016; Mujika, 2017). Research is focussed on informing sporting performance now. Indeed, performance questions must be answered, and conclusions drawn using the best available literature, despite published scientific research being sometimes disjointed from (e.g., *in vitro* focus with no gold-standard lab practice or way of mimicking field-based exercise), or behind the world of applied sport. Indeed, research is often removed from the sporting situation that practitioners are attempting to translate findings to. The objective of this particular article was to present an operational framework for practitioners to critically evaluate the translational potential of research to practice and provide a time efficient protocol for practitioners to appraise research and ultimately inform their practice. This may also act as a time efficient tool to prompt critical evaluation of research papers and may improve practitioner's confidence to innovate and generate performance improving interventions.

Close, G. L., Kasper, A. M., & Morton, J. P. (2019). From Paper to Podium: Quantifying the Translational Potential of Performance Nutrition Research. *Sports Medicine*, *49* (Supplement 1), 25–37. https://doi.org/10.1007/s40279-018-1005-2

REFLECTION FROM PRACTICE:

Working within the elite sports environment I have often found that practitioners *in-post*, including both nutritionists and non-nutritionists, quote the findings of research papers based on an infographic, 280-character tweet and abstract. This failure to adequately critique and appraise the research, which may be presented in poorly peer-reviewed and low-quality journals, leads to unnecessary time spent discussing and considering interventions, which may not be appropriate and often do not work. As such, we came up with a framework that we found useful both as researchers and applied practitioners for helping objectively review research. In addition, we have used this with both young practitioners and students as a learning tool. Authors presented the framework to practitioners based with The English Institute of Sport and this has since been adopted by the organisation when considering new nutritional interventions / critiquing the available literature. In addition, Liverpool John Moores University and University of Newcastle now utilises this as an educational tool for BSc and MSc Sport Nutrition students, with those completing the course moving on to many key roles across elite sport. In addition, the Paper-2-Podium Matrix has also helped myself and other academics when designing applied research. As such, a checklist of considerations for research design can be found within the appendix (see appendix 1).

CHAPTER 2

APPLICATION OF FIELD BASED NUTRITION TOOLS PRACTICES:

TOOLS IN THE TOOLBOX

Publications resulted from this chapter:

Stables, R. G., Kasper, A. M., Sparks, S. A., Morton, J. P., & Close, G. L. (2021). An Assessment of the Validity of the Remote Food Photography Method (Termed Snap-N-Send) in Experienced and Inexperienced Sport Nutritionists. *International Journal of Sport Nutrition and Exercise Metabolism*, *31*(2), 125–134. https://doi.org/10.1123/ijsnem.2020-0216

Impact Factor: 3.884

Quartile: Q1

Altimetric: 35

Citations: 4

Kasper, A.M., O'Donnell, A., Langan-Evans, C., Jones, A., Lindsay, A., Murray, A., & Close, G.L. (2022). Assessment of Energy Expenditure During Tournament Golf: The Effects of Bag Carrying, Electric or Manual Trolleys. *European Journal of Sports Sciences.* Online Ahead of Print. https://doi.org/10.1080/17461391.2022.2036817

Impact Factor: 4.050

Quartile: Q1

Altimetric: 23

Citations: Recently published: 0

Kasper, A. M., Langan-Evans, C., Hudson, J. F., Brownlee, T. E., Harper, L. D., Naughton, R. J., Morton, J. P., & Close, G. L. (2021). Come Back Skinfolds, All Is Forgiven: A Narrative Review of the Efficacy of Common Body Composition Methods in Applied Sports Practice. *Nutrients*, *13*(4), 1075. https://doi.org/10.3390/nu13041075

Impact Factor: 5.717

Quartile: Q1

Altimetric: 99

Citations: 36

Kasper, A. M., Crighton, B., Langan-Evans, C., Riley, P., Sharma, A., Close, G. L., & Morton, J. P. (2019). Case Study: Extreme Weight Making Causes Relative Energy Deficiency, Dehydration, and Acute Kidney Injury in a Male Mixed Martial Arts Athlete. *International Journal of Sport Nutrition and Exercise Metabolism*, *29*(3), 331–338. https://doi.org/10.1123/ijsnem.2018-0029

Impact Factor: 3.884

Quartile: Q1

Altimetric: 124

Citations: 34

2.1 PROLOGUE TO CHAPTER 2

Although the exact scope of practice for nutritionists working within sport is something that has yet to be fully defined, the Sport and Exercise Nutrition register (SENr) and British Dietetic Association (BDA) accept that for Sport and Exercise Nutritionists, this includes:

1) '*Supporting excellence in sport performance as well as in physical activity, sport, and exercise health'*
2) '*Application of scientific knowledge with understanding of the social and psychological aspects of motivation and human behaviours*.
3) *'Proficiency in communication and education about their subject in order to be able to give and formulate advice that is appropriate and relevant to an individual or group'* (SENr, 2022).

However, to be able to fully apply scientific knowledge to practice, where research does not fully answer questions or does not necessarily replicate what happens within the 'real-world', applied research is required to 'bridge the gap'. From my own daily practice, key areas in the sport nutrition arena, which are often poorly undertaken, relate to accuracy, reliability, and validity of key assessment tools used. Key approaches in sport nutrition include methods for determining body composition, energy intake, and energy expenditure. Indeed, the manipulation of energy balance to achieve physiological change is an important aspect of sport nutrition that requires in-depth understanding of metabolism, measurement tools of dietary intake and expenditure, and food composition. However, when utilising assessment tools in

practice, practitioners need to be critical of and be able to appraise the available literature on current methods, in order to make informed decisions as to the best suitable technique in a given situation.

2.2 RATIONALE FOR 'AN ASSESSMENT OF THE VALIDITY OF THE REMOTE FOOD PHOTOGRAPHY METHOD (TERMED SNAP-N-SEND) IN EXPERIENCED AND INEXPERIENCED SPORT NUTRITIONISTS'

A fundamental goal of a Sport Nutritionist is to assess energy intake, however there is no gold standard way in which this can be done practically. We assessed the validity of the Remote Food Photography Method (RFPM) (Martin et al., 2009) as a way of estimating energy intake by both experienced and fully accredited and non-experienced or graduate accredited practitioners. This validation process provided novel insight into a widely accepted method used within practical nutrition settings and highlighted considerations practitioners must be aware of when utilising this method. The research stemmed from observations of using this technique in practice and challenging the accuracy of this method in a real-world context. In brief, images of a plate of food are taken by athletes, sent to the nutritionist, who calculates the energy content of the image and makes estimations as to the macronutrient and micronutrient content. To facilitate this study and to address the question relating to the validity of the method, we included 'simple' and 'complex' plates to be photographed. Significant discrepancies were observed, not only with the estimated energy and macronutrient content, but also with the inter- and intra-differences observed between practitioners. This raises questions as to the use of this methodology in applied sport and highlights some of the considerations for its use and interpretation in the applied and research setting.

Stables, R. G., Kasper, A. M., Sparks, S. A., Morton, J. P., & Close, G. L. (2021). An Assessment of the Validity of the Remote Food Photography Method (Termed Snap-N-Send) in Experienced and Inexperienced Sport Nutritionists. *International Journal of Sport Nutrition and Exercise Metabolism*, *31*(2), 125–134. https://doi.org/10.1123/ijsnem.2020-0216

REFLECTION FROM PRACTICE:

Within rugby league, I worked with an athlete who was struggling to reach their weight target set by the multidisciplinary team. Following a 1-1 consultation, it was apparent that his behaviours of eating (e.g., frequency and total energy intake) may have been the problem. Following discussing the use of the remote food photography method to study his eating patterns, the player requested an in-depth analysis of his daily macronutrient and overall energy intake. He was under the impression that this could be done accurately and quickly from previous experiences with nutritionists at other teams. I had to explain to him the limitations of the method when drawing such conclusions and instead spoke about this being a good indicator for general behaviours but not necessarily accurate enough for more in-depth conclusions on energy and macronutrient intake. We discussed other methods to estimate grams of carbohydrate, fat, protein, and kcals (e.g., a weighed food diary) ingested, however this was not something he wanted to do as it would not be practical for him and very time consuming. My takeaway message from this specific encounter was that perhaps both practitioners and athletes need to understand more about the methods they are using and often the most accurate methods are not particularly practical and vice-versa. Best practice is often the one that best fits the particular situation. For example, the remote food photography method, combined with a detailed food diary/description of the images, may be the best way of assessing dietary intake when dealing with athletes remotely. This study informed a CPD presentation that was given to The English Institute of Sport's nutrition team to inform their practice.

2.3 RATIONALE FOR 'ASSESSMENT OF ENERGY EXPENDITURE DURING TOURNAMENT GOLF: THE EFFECTS OF BAG CARRYING, ELECTRIC OR MANUAL TROLLEYS'

Having made observations relating to the validity of the 'snap-n-send' method and the issues athletes face when considering available resources for assessing nutritional intake, we decided to assess a method of estimating energy expenditure. For the purposes of this, we focussed on golf. We found large discrepancies within the literature as to what the energy expenditure of a round of golf was, with many published findings using a variety of methods such as different modes of transport around the course, different populations and different equipment used to estimate energy expenditure (Murray et al., 2017). Indeed, we found that many of the methods used were outdated or flawed (e.g., commercially available Global Positioning System watches) as they did not calculate activity energy expenditure, many used pedometer / step measures alone, with some reporting its MET value as higher than jogging (Murray et al., 2017). Although activity expenditure data is available for other sports, we used a joint heart rate and accelerometer measure to calculate, for the first time, the energy expenditure required for a round of golf using a variety of different transportation modes, including carrying the golf bag, using a manual push trolley, and using a follow electric trolley. It is important that athletes and practitioners have an appreciation for energy balance (both intake and expenditure) for daily activity (including recreational activity). Practitioners should also utilise the best technique used in a given context and should consider the ecological validity of a technique prior to implementation. Applied "fast' research should focus on answering questions that are pertinent to the sport and athletes.

Kasper, A.M., O'Donnell, A., Langan-Evans, C., Jones, A., Lindsay, A., Murray, A., & Close, G.L. (2022). Assessment of Energy Expenditure During Tournament Golf: The Effects of Bag Carrying, Electric or Manual Trolleys. *European Journal of Sports Sciences.* Online Ahead of Print. https://doi.org/10.1080/17461391.2022.2036817

REFLECTION FROM PRACTICE:

In preparation of working with a golfer and the need to examine energy expenditure, I consulted the literature to determine current practice and discovered a large range of "answers", with none of the measures taken/provided matching the context of this particular golfer. Indeed, several papers were based on dated methods and many using poor methodology to assess energy expenditure. Following discussions with a co-author, we identified a need for a player specific assessment. As the project progressed, I reflected on the question and the data we were collecting and have since realised that this was not only important to the elite golfer, but also important to other athletes that play golf recreationally. I work with a number of athletes who choose to play golf on their days away from the club. When planning for these individuals, it is important to understand how athletes spend their days off, what activities they do and how this may impact their energy requirements for the day. A rest day may seem like a low energy day but may in fact be a medium – high expenditure day if activities such as golf are played. Therefore, our research was not only important to estimate energy expenditure for those athletes that compete in golf, but also additional activity energy expenditure for those that play recreationally. In addition, the research supports the use of Acti-Heart as a practical, whole-body measure of activity energy expenditure (as opposed to hip based accelerometery alone). These data have had a direct implication for how nutritional interventions are designed and has provided key information on diet prescription for DP World Tour, PGA European Tour and Ryder Cup golfers and has been presented at the World Tour Golf Congress. Interventions have surrounded daily portion control, fuelling during practice and competition rounds, and general advice/education resources.

2.4 RATIONALE FOR 'CASE STUDY: EXTREME WEIGHT MAKING CAUSES RELATIVE ENERGY DEFICIENCY, DEHYDRATION, AND ACUTE KIDNEY INJURY IN A MALE MIXED MARTIAL ARTS ATHLETE'

Although skinfold scores and DXA may have been previously considered the most appropriate tools for measurement of body composition in practical environments, there are questions as to the control of participants when collecting these (see Section 2.5). Extreme levels of dehydration in combat sports athletes allowed us to investigate the effects of hydration and feeding status on measures of body composition, manipulated through applied practice within the current case study. In addition, the level of error identified within the Remote Food Photography Method publication means that assessment of energy intake within case study literature (Costello et al., 2017; Costello et al., 2019) should be approached with necessary caution. Within practice, it is often the case that athletes prefer to purchase food from pre-packaged meal companies, where the macronutrient status is pre-estimated, and this may actually be the preferred methods for practitioners as opposed to spending arduous amounts of time calculating / estimating energy intake. The athlete within the current study made no attempt to understand energy expenditure of training sessions and therefore had no appreciation for energy balance. The poor practice experienced in the fight week, specifically the extreme weight making practices within the 24 hrs leading to the weigh in led to adverse health issues. Based on what we have learnt within this chapter, practitioners may better select and utilise appropriate field-based tools to assess energy intake (such as RFPM/Snap-n-Send with appropriate additional detail), expenditure (such as Actiheart® vs. commercial GPS watches) and body composition (such as bioelectrical impedance vs. skinfold thickness vs. DXA) for

athletes vulnerable to extreme practices in order to compete (e.g., weight restricting athletes).

Kasper, A. M., Crighton, B., Langan-Evans, C., Riley, P., Sharma, A., Close, G. L., & Morton, J. P. (2019). Case Study: Extreme Weight Making Causes Relative Energy Deficiency, Dehydration, and Acute Kidney Injury in a Male Mixed Martial Arts Athlete. *International Journal of Sport Nutrition and Exercise Metabolism*, *29*(3), 331–338. https://doi.org/10.1123/ijsnem.2018-0029

REFLECTION FROM PRACTICE:

Reflecting on our observations throughout the case study and from the other published research included in this thesis, it is important that accurate assessment of not only energy intake, expenditure, and body composition, but also blood biochemical markers to protect athlete health and wellbeing is conducted regularly. The aim of this case study was to observe the current weight making practices in sport, whilst simultaneously understanding the changes in biochemistry and physiology that may occur during this stressful period for these athletes. We observed extreme energy deficiency and dehydration, specifically in the 24 h period prior to the weigh in, that led to acute kidney injury. We also observed physiologically impossible changes in body composition when severe acute dehydration and glycogen manipulation occurred. Practitioners need to realise that the 'real-world' of elite sport is not what occurs within a controlled laboratory study and cannot always be replicated. Often appropriate tools for tracking change must be selected with the situation they are being utilised in mind. Whilst we often know the reliability and validity of what happens within the laboratory, it is difficult to understand this in a 'real-world' context, where there are many variables that cannot be controlled. This highlights the importance for practitioners and researchers to collect real, ecologically valid data and that the practitioner's choice of tool needs to fit the situation. For example, it is meaningless to use DXA technology to assess body composition in a weight making sport due to the aforementioned factors (such as glycogen content, body water etc.). This is especially apparent during their final week of weight cutting. Whilst N=1 studies are not as rigorous as randomised controlled trials, they are essential within the Paper to Podium framework to further our understanding of sport.

2.5 RATIONALE FOR 'COME BACK SKINFOLDS, ALL IS FORGIVEN: A NARRATIVE REVIEW OF THE EFFICACY OF COMMON BODY COMPOSITION METHODS IN APPLIED SPORTS PRACTICE'

From a performance perspective it is not only important for nutrition practitioners to understand the energy balance of the athletes they work with (e.g., energy intake and expenditure), but also to track and monitor interventions effectively. Indeed, understanding both energy intake as well as expenditure is extremely important when manipulating body composition in athletes, however there is still a question as to how best to practically monitor body composition in the applied setting. Field-based methodologies for measuring body composition require critical appraisal to allow practitioners to make informed decisions on their choice of tools. As such, we provided insight into the different available methods for body composition assessment, along with original data evidencing the limitations of Dual Energy X-Ray Absorption (DXA) method, often stated as the gold-standard. Body composition assessment in practice is a routine activity for athletes, usually measured multiple times over a competitive season / training and competition period. There is however debate as to which are the best methods within practice and as such, teams and athletes use a number of methods within their testing battery to estimate or measure body composition. Methods are often selected dependent upon what the practitioners are most comfortable using, together with considerations relating to the expense, portability, and invasiveness of the measures, without rigorous appraisal of the validity, accuracy, and precision, within their specific situations. The data presented within this paper is

novel as no author has previously investigated how the size of an athlete may practically affect a DXA scan (page 11 of the manuscript). These data have direct practical implications for larger athletes (both tall and wide) who struggle to fit on the bed. This article also highlights *Lower, Middle,* and *Upper* ranges for athletes based upon direct data from experts within the field and has anecdotally (reported by peers) formed a basis for practitioners when setting targets with their athletes.

Kasper, A. M., Langan-Evans, C., Hudson, J. F., Brownlee, T. E., Harper, L. D., Naughton, R. J., Morton, J. P., & Close, G. L. (2021). Come Back Skinfolds, All Is Forgiven: A Narrative Review of the Efficacy of Common Body Composition Methods in Applied Sports Practice. *Nutrients*, *13*(4), 1075. https://doi.org/10.3390/nu13041075

REFLECTION FROM PRACTICE:

Although our aims for the paper involved reviewing the available literature, comparing DXA and skinfold thickness, and providing a framework for selection of body composition methods in applied practice, personally, I wanted to develop a resource that could be shared with other nutritionists and those athletes that are interested in tools for measuring body composition, in order to inform conversation on selection of appropriate methodology for practice. I often hear, in my own daily practice and when networking with other nutritionists, that 'DXA is the gold standard of body composition measure' and 'should we start using this?'. My answer is always the same: 'why do you think DXA is the gold-standard for us? It is not about being 'for' or 'against' a method it is about the importance of choosing the right assessment method for the situation as this may not necessarily be practical, accurate or reliable for how we want to use it.' Indeed, we saw discrepancies with the values reported by DXA within a case study of a weight making athlete (Section 2.4). This is the reason we decided to write the paper and develop the resource, in order to provide understanding to facilitate scrutiny of the methods of body composition and the relative pros and cons, as well as create novel data for some of the considerations required when selecting methods. It was also to provide a resource for us to share with peers to answer some of the questions they may have regarding body composition measures and therefore to facilitate informed choice. When reflecting on working with a number of international football players specifically, it seems from my experience that the most widely used form of body composition with private nutritionists originating outside of the UK is bioelectrical impedance, as this may be monitored remotely. However, when reviewing the equipment used, it is often poor quality / not particularly reliable. It is important to

try to improve the available literature for individuals working with private clients so more informed decisions can be made. Our review, which I often share with players and external nutritionists, improves understanding and decisions surrounding tracking of body composition.

CHAPTER 3

SUPPLEMENTATION PRACTICES IN ELITE SPORT: ATHLETES LOOKING FOR 'THE EDGE'

Publications resulted from this chapter:

Close, G.L., Kasper, A.M., Walsh, N.P., & Maughan, R.J. (2022). 'Food First' But Not Always 'Food Only': An Evidenced-Based Approach to Using Dietary Supplements in Sport. *International Journal of Sport Nutrition and Exercise Metabolism.* Online Ahead of Print. https://doi.org/10.1123/ijsnem.2021-0335

Impact Factor: 3.884

Quartile: Q1

Altimetric: 60

Citations: Recently published: 4

Kasper, A. M., Cocking, S., Cockayne, M., Barnard, M., Tench, J., Parker, L., McAndrew, J., Langan-Evans, C., Close, G. L., & Morton, J. P. (2016). Carbohydrate Mouth Rinse and Caffeine Improves High-Intensity Interval Running Capacity When Carbohydrate Restricted. *European Journal of Sport Science*, *16*(5), 560–568. https://doi.org/10.1080/17461391.2015.1041063

Impact Factor: 4.050

Quartile: Q1

Altimetric: 69

Citations: 37

Kasper, A. M., & Close, G. L. (2021). Practitioner Observations of Oral Nicotine Use in Elite Sport: You Snus You Lose. *European Journal of Sport Science*, *21*(12), 1693-1698. https://doi.org/10.1080/17461391.2020.1859621

Impact Factor: 4.050

Quartile: Q1

Altimetric: 12

Citations: 2

Kasper, A. M., Sparks, S. A., Hooks, M., Skeer, M., Webb, B., Nia, H., Morton, J. P., & Close, G. L. (2020). High Prevalence of Cannabidiol Use Within Male Professional Rugby Union and League Players: A Quest for Pain Relief and Enhanced Recovery. *International Journal of Sport Nutrition and Exercise Metabolism*, *30*(5), 315–322. https://doi.org/10.1123/ijsnem.2020-0151

Impact Factor: 3.884

Quartile: Q1

Altimetric: 94

Citations: 14

Burr, J.F., Cheung, C.P., Kasper, A.M., Gillham, S.H., & Close, G.L. (2021). Cannabis and Athletic Performance. *Sports Medicine, 51*(Supplement 1), 75–87.

https://doi.org/10.1007/s40279-021-01505-x

Impact Factor: 11.136

Quartile: Q1

Altimetric: 80

Citations: 2

3.1 PROLOGUE TO CHAPTER 3

When investigating the 'real-world' limitations of accepted measurement methods in nutrition (such as energy intake, expenditure, and body composition), it is important for practitioners to fully consider other areas that are still under debate within the literature. One such area is supplementation, an area still under contention in sport nutrition. Yet practitioners are required to offer daily advice on this area. From my own experience, I have found that athletes often consider a wide array of tested and untested supplements in an attempt to gain either a health or competitive advantage. Due to issues surrounding inadvertent doping, a stigma has been placed on supplementation in sport, and as such I have observed an emphasis on '*food-only*' approaches. We have written a commentary on '*food-first but not food only'* (Close et al., 2022) to raise awareness of some of the situations where athletes may benefit from supplementation. Following on from this, the chapter focuses on some of the emerging supplementation practices observed within sport, such as: 1) ways in which to negate detriments to intensity of training during periods of 'train-low' (often implemented by weight making athletes); 2) the negative impact of oral nicotine use on both sporting performance and health; 3) the prevalence of cannabidiol (CBD) within contact sport where pain relief is the target; and 4) the use of cannabis and its derivatives on sporting performance.

3.2 RATIONALE FOR ‘‘FOOD FIRST’ BUT NOT ALWAYS ‘FOOD ONLY’: AN EVIDENCED-BASED APPROACH TO USING DIETARY SUPPLEMENTS IN SPORT’

Close et al., (2020) provided a commentary on some of the authors observations surrounding supplementation practices within elite sport (Close et al., 2022). We suggested a working definition for the role of a Sport Nutritionist, where the role entails both the protection of athlete’s health and wellbeing, including from ‘rogue’ practices they may find from unsuitably qualified practitioners, as well as sourcing information from the internet. One of the daily activities that nutritionists may find themselves regularly advising on is supplementation. However, there seems to be a growing number of nutritionists and other members of the multidisciplinary team opting for ‘food-only’ approaches whereby supplementation is avoided (Burke et al., 2019), which may be contrary to the health of an athlete. Close et al., (2020) provided a ‘food first’, but not ‘food only’ framework to guide practitioner’s and organisation’s supplementation strategies in a safe and evidence-based manner, without missing out on the potential performance and health benefits of supplementation. The aim of this article was therefore to explore what is meant by a ‘food first’ approach to sport nutrition, providing guidance and clarity on delivering a ‘food first, but not always food only’ strategy where supplementation is selected in an evidence-based manner to enhance performance and promote athlete health and wellbeing. A secondary aim of this article was to assess an approach to sport nutrition which sometimes leaves Sport Nutritionist feeling ‘demonised’ when using supplements.

Close, G.L., Kasper, A.M., Walsh, N.P., & Maughan, R.J. (2022). ‘Food First’ But Not Always ‘Food Only’: An Evidenced-Based Approach to Using Dietary Supplements in Sport. *International Journal of Sport Nutrition and Exercise Metabolism.* Online Ahead of Print.

https://doi.org/10.1123/ijsnem.2021-0335

REFLECTION FROM PRACTICE:

Within my own practice, and when discussing with other members of the team, we determined that a lot of governing bodies/organisations choose to follow a ‘food-first’ philosophy when it comes to supplementation. However, without a definition for ‘food-first’, a number of these organisations and multidisciplinary teams were implementing a ‘food-only’ strategy, whereby almost no supplementation was being advised. Barriers were being put in place for practitioners blocking effective practice. Indeed, a number of these newly qualified practitioners had been adopting this philosophy without question and potentially missing out on strategies to benefit athletes’ health and/or performance. This article introduced an accepted definition of a Sport Nutritionist, an accepted definition of ‘food first’ and a framework for the use of supplements in practice. This journal article was highly cited (including keynote addresses) at a recent conference for the American College of Sports Medicine (2022), who subsequently chose to adopt and promote this approach, and is also being used by SENr practitioners across sport.

3.3 RATIONALE FOR 'CARBOHYDRATE MOUTH RINSE AND CAFFEINE IMPROVES HIGH-INTENSITY INTERVAL RUNNING CAPACITY WHEN CARBOHYDRATE RESTRICTED'

One aim of applied research is to test hypotheses relevant to current practices that occur within sport. We investigated an approach anecdotally reported to be utilised by athletes to avoid bloating through excess fluid intake (Dodgson, 2018) and or carbohydrate consumption, the latter involving 'training low' and restricting dietary carbohydrate as a way to enhance substrate oxidation, reduce energy intake and promote cellular adaptation (Hawley and Morton, 2014). Alongside mimicking real-world practices used by athletes, where training occurs in the evening and fasted running in the morning, we tested whether carbohydrate mouth rinse combined with caffeine had a benefit on decrements to physical performance that athletes may experience when restricting carbohydrate during exercise. We used doses of caffeine and carbohydrate mouth rinse that mimicked some of the most widely available supplement products on the market to ensure ecological validity. This article provides a strong example of research which has the potential to directly impact applied work (as assessed by the Paper-2-Podium Matrix in Section 1.3).

Kasper, A. M., Cocking, S., Cockayne, M., Barnard, M., Tench, J., Parker, L., McAndrew, J., Langan-Evans, C., Close, G. L., & Morton, J. P. (2016). Carbohydrate Mouth Rinse and Caffeine Improves High-Intensity Interval Running Capacity When Carbohydrate Restricted. *European Journal of Sport Science*, *16*(5), 560–568. https://doi.org/10.1080/17461391.2015.1041063

REFLECTION FROM PRACTICE:

The sport I train and compete in is Muay Thai kickboxing. I have a keen interest in weight making sport. One of the strategies I have seen used in practice is restricting energy via carbohydrate control and fasting due to the potential benefits on using fat as an alternative fuel source for metabolism (Coyle et al., 1997). The belief is often that with less carbohydrate available, fat is utilised as an alternative fuel, and thus adipose tissue reduces. Following discussion with one of the other authors on the 'train-low' paradigm, we determined a need to investigate further the potential detriments to performance, of carbohydrate restriction, and what nutritional strategies could be employed to remedy this, in weight making sport (such as mouth rinsing carbohydrate and/or the use of caffeine).

However, when reflecting on the research, with regards to the use caffeine specifically, athletes had been anecdotally using caffeine for a number of years when morning training and cutting weight, even without extensive research confirming the benefits to exercise intensity/capacity when fasted. Athletes would often train with a morning coffee/pre-workout supplement to help with the intensity of fasted morning runs. This was my first experience in my career of research catching up with practices that were already happening within the applied world. This highlights the need for 'fast' research to help drive applied practice whilst maintaining safe practices. We did however determine that carbohydrate mouth rinsing, in weight making athletes, could reduce detriments to repeated sprint performance whilst fasted. In addition to its use in weight making sport, carbohydrate mouth rinse has also been used in professional football (Dodgson, 2018). It is reported that players used the strategy of carbohydrate mouth

rinsing to reduce the quantity of fluid they consume, and reduce the consequent perceptions of bloating, whilst simultaneously improving physical performance. This was covered within the media in the run up to the FIFA World Cup 2018 and reported that some players may want to avoid feeling bloated while obtaining a feeling of refreshment in the heat (Longman, 2018). This research area (e.g. carbohydrate mouth rinse) has contributed to changing the advice that practitioners may give to athletes when choosing how to fuel sessions (e.g. when to fuel and when to restrict) (Collins et al., 2020).

3.4 RATIONALE FOR 'PRACTITIONER OBSERVATIONS OF ORAL NICOTINE USE IN ELITE SPORT: YOU SNUS YOU LOSE'

Nicotine use within adult soccer is well documented in the media, however, its emergence in rugby, particularly within youth cohorts (18-20 years old), is of concern (directly observed by myself and peers). Snus has been discussed as a performance enhancer, with its side effects/health issues largely ignored, such as increased risk of periodontal disease, cancer and type 2 diabetes, and reductions in muscle force, reaction time, and readiness to train. Also concerning within all ages was an apparent acceptance of its use, by wider staff, possibly through a lack of understanding as to the health implications vs. smoking. As such, we felt the need to produce a short review with the aim of educating players, staff, and other academics as to the current landscape of oral tobacco use. To ensure the uptake of the recommendations, we created a short report and accompanying infographic for use within practice. Indeed, many organisations use information from practitioners to set organisational standards regarding the use of products such as this. In this practitioner commentary, we concluded from the current available evidence that there were not only detriments to health and wellness but also to performance whilst habitually using and addicted to nicotine. In addition, we highlighted the need for more research into this area as currently the body of evidence on snus use within sport is limited.

Kasper, A. M., & Close, G. L. (2021). Practitioner Observations of Oral Nicotine Use in Elite Sport: You Snus You Lose. *European Journal of Sport Science*, *21*(12), 1693-1698. https://doi.org/10.1080/17461391.2020.1859621

REFLECTION FROM PRACTICE:

The use by professional athletes of snus pouches was something I first became aware of in football. I will never forget seeing a senior international player do this at the start of my career and when I asked him what this was, I was surprised with his explanation, that this was an oral tobacco/nicotine product. As the prevalence at the club increased, I was asked to review snus and its effects on performance and health. I did this, but it remained unpublished for several years. When I witnessed snus beginning to enter an 18-20 pathway programme in rugby union, I spoke with my co-author, and we decided to translate my report into a research style paper for publication. This was 1) to provide some education to fellow practitioners, who undoubtably see this practice, but do not necessarily question its use; and 2) to provide a resource for writing position stands within amateur and professional team sports. Since its publication, several sports teams have used the infographic (see appendices 10 and 11), to highlight some of the concerns around snus use. Concerningly, when going through peer-review, we were asked by reviewers to add that snus may be a better alternative to smoking (which was added post-review). Although this may be the case, still it is not a rationale for its use by athletes. In addition, reviewers also questioned its prevalence and were reluctant to accept that its use was widespread, despite the authors extensive experience within the practical team sport environment. Although prevalence must be assessed, the key message must remain that snus use risks health and performance, and should not be promoted in the sporting world.

3.5 RATIONALE FOR 'HIGH PREVALENCE OF CANNABIDIOL USE WITHIN MALE PROFESSIONAL RUGBY UNION AND LEAGUE PLAYERS: A QUEST FOR PAIN RELIEF AND ENHANCED RECOVERY'

Although, there is no real rationale for using snus to enhance performance / recovery (as reviewed in Section 3.4), there are some suggested benefits of using cannabidiol (CBD) (detailed further within the manuscript). Following my 'reflections from practice' in Section 3.4, it was important that we first assessed the prevalence of CBD use within sport. Rugby was chosen, as this is where we had witnessed its use, although the reasons for use were unknown. With the lack of clarity regarding the World Anti-Doping Agencies (WADA) position on cannabinoid use (namely the confusion in wording), it is perhaps not surprising, given the proposed therapeutic benefits associated with CBD, especially in relation to pain management that it is used in sport, despite the associated risks of inadvertent doping (Dahlgren et al., 2021; Gurley et al., 2020; Martínez-Sanz et al., 2017). Furthermore, given the relatively recent legislative changes in sport (e.g., removal of CBD from the banned list), it is important that athletes and practitioners have an appreciation for the current claims, evidence, prevalence, and safety concerns surrounding this herbal/pharmaceutical intervention. As such, we designed a study to assess whether rugby players were aware of the risks of doping that CBD may have as well as to understand why they are taking CBD products.

Kasper, A. M., Sparks, S. A., Hooks, M., Skeer, M., Webb, B., Nia, H., Morton, J. P., & Close, G. L. (2020). High Prevalence of Cannabidiol Use Within Male Professional Rugby Union and League Players: A Quest for Pain Relief and Enhanced Recovery. *International Journal of Sport Nutrition and Exercise Metabolism*, *30*(5), 315–322. https://doi.org/10.1123/ijsnem.2020-0151

REFLECTION FROM PRACTICE:

The use of CBD was a topic area that I and one of my fellow authors were getting questioned on by both development (age: 18-20) and senior athletes. Some of the information the athletes were questioning related to ‘batch testing’, whether they ‘could fail a drugs test by taking it’ and when asked about what they were taking, they were failing to remember the brand used or dosage taken. Indeed, one of the players claimed that 50-60% of all players, at their club, used CBD. As a result, we saw a need to assess the use of CBD within the sport. Many players did not understand the risk of taking such a product, nor did they appreciate the need for WADA to help practitioners with translating risks to athletes. It was apparent from the data that Sport Nutritionists are not necessarily consulted by players about CBD use, albeit the reasons for this are unclear. What is clear is that practitioners must proactively educate and protect players from the pitfalls of CBD use, despite its reported benefits for pain management. They see peers and CBD companies reporting the potential benefits of their oils, capsules and edibles but do not appreciate the potential risks of contamination of these products. Interestingly, from my own experience in combat sport and having discussions with fellow competitors, I do not believe this extensive use is limited to the sport of rugby union and believe the prevalence of use and the ‘quest for pain relief’ is perhaps more common in weight making sports (Fitzgerald, 2015; Raimondi, 2020) than rugby union and league. Indeed, cannabis use seems more prevalent within mixed martial arts since its removal from the USADA UFC anti-doping test procedure (McCarthy, 2021). It is therefore understandable that CBD use in mixed martial arts may also be wide-spread, however further research is required to ascertain the prevalence. The research conducted in the rugby arena has led to

further funding being secured for 3 doctorates in philosophy (PhD) at Liverpool John Moores University. The findings are also being used by national governing bodies to educate players on the risks of CBD use and to shape position stands on the safe use, if relevant, of CBD within their sports.

3.6 RATIONALE FOR 'CANNABIS AND ATHLETIC PERFORMANCE'

Despite WADA's stance being that there is an inadvertent risk of doping when using CBD, we have seen a high prevalence of its use in sport. Due to the high prevalence of CBD use in rugby, and the fact WADA bans all cannabinoids other than CBD, it is important to also understand the relationship of other cannabinoids to health and performance. For WADA to ban a substance from use by athletes, 2 of 3 criteria must be satisfied:

1) It has the potential to enhance or enhances performance.
2) It represents an actual of potential health risk to the athlete.
3) It violates the spirit of sport.

Given the prevalence of CBD use within rugby and potentially other sporting arenas, it was important to understand the effects of the whole plant on athletic performance (e.g., criteria 1). This is especially pertinent as some sporting governing bodies (National Basketball association, Ultimate Fighting Championship) have dropped testing athletes for the use of cannabis (and all cannabinoids) out of their banned substance testing procedure both in and out of competition. Together with world-leaders in the field, we reviewed the existing evidence for the physiological effects of cannabis (full cannabinoid profile), THC and CBD on sporting performance.

Burr, J.F., Cheung, C.P., Kasper, A.M., Gillham, S.H., & Close, G.L. (2021). Cannabis and Athletic Performance. *Sports Medicine, 51*(Supplement 1), 75–87. https://doi.org/10.1007/s40279-021-01505-x

REFLECTION FROM PRACTICE:

Following the research detailed in Section 3.5, we collaborated with a research team based in Canada, where cannabis is now legalised, to determine the effects of cannabis on sporting performance. This was especially interesting, as organisations are beginning to remove cannabis / its constituents from their testing battery. This omission by organisations is relevant to my own practice as the questions surrounding cannabinoid use and their effects on sporting performance will continue to grow. Currently the stance in sport is to avoid cannabis completely. Hopefully, this review can be used by WADA to help re-consider and clarify its current and future stance on the use of cannabinoids. If this is made clearer, practitioners (including myself), may be in a better position to help athletes with pain and sleep management as the research evolves. Whilst the Paper-2-Podium pathway for this is complex due to the wide array of methodologies used, this review paper may help sculpt the landscape of cannabinoid use in sport moving forward.

CHAPTER 4

SYNTHESIS

4.1 REALISATION OF AIMS

The focus of this thesis was to inform and challenge current practices within the sport-nutrition space. The research included, achieved the target of impacting working practice of elite sporting organisations, in a variety of situations, such as menu/meal planning of the DP World Tour Golf (Section 2.3), body composition measurement methods of England Rugby Union (Section 2.5), and supplementation policies of The English Institute of Sport (Section 3.2). The PhD via publication approach allowed the realisation of the overarching objective of conducting research that has the potential to immediately impact the 'real-world' of elite sport. It also enabled the achievement of the aims of the PhD programme of work:

1. The initial aim of my PhD (Chapter 1) via publication was to provide a framework for researchers and practitioners when translating lab-based research to practice. This was realised via the creation and publication of the 'Paper 2 Podium Matrix'. This framework provides a tool for practitioners and students to critically evaluate and appraise the available literature and to assess the translational potential of many methods developed in sport science laboratories into sports performance. To this end, the framework has been utilised in both performance and academic environments (cited 25 times at the time of writing). This has not only influenced the translation of research to practice in sport settings, but also been used in design of applied research.

2. The second aim (Chapter 2) of evaluating the field-based tools available to sport-nutrition practitioners, was realised via research into tools used for: energy intake, energy expenditure and body composition assessment. Research was conducted on:

1) the validity of a widely used method for assessing energy intake; 2) how to assess activity-induced energy expenditure practically and accurately within a sport where research was inadequate; and 3) the efficacy of common body composition methods in applied practice. These articles (Stables et al., 2021; Kasper et al., 2022; Kasper et al., 2019; Kasper et al., 2021) have been utilised in a wide array of settings to inform and change practice. Section 2.2 has been presented to the English Institute of Sport to highlight the considerations of applied research tools for measuring energy intake across Olympic sports. Section 2.3 has been directly used with PGA golfers to influence design of their nutritional programmes and interventions. Section 2.4 flagged some of the detrimental effects of acute weight making strategies on chronic athlete health and wellbeing and has influenced advice provided to athletes, from professionals within the area. This work also directly impacted the participant of the case study presented, who moved up a weight class as a result of the analysis. Section 2.5 was conducted as a result of Section 2.4, namely the changes in anthropometry observed via DXA, e.g. the non-physiologically possible changes to muscle mass and body fat within a 3 week period (-1W to +2W). As a result of derived data, this study influenced several organisation's body composition assessment practices and provided standards that organisations have begun to use as their targets and guidelines.

3. The final aim (Chapter 3) of the thesis was to draw on another regular role of the Sport Nutritionist: 'to provide guidance on supplementation practices and procedures'. Research, conducted utilising the Paper to Podium framework, provided an evidence-based approach to using dietary supplements in sport, discussed the growing phenomenon of 'food only' in the applied environment, and provided a working

definition of a Sport Nutritionist's role. Given the growing use of the phrase 'food first', we felt this needed defining and exploring, hence the publication of the 'food first' but not 'food only' approach.

Research was subsequently provided, utilising the 'Food First' but not Food Only framework for optimising training with food restriction (e.g., train low) whilst supplementing a common stimulant (e.g., caffeine) and using mouth rising practices (e.g., carbohydrate mouth rinse) to improve training intensity. This also provided a good example of where food may not be an option to achieve the target of 'training low', but supplementation may help with training intensity. The research theme then transitioned to some of the emerging supplements used within sport, where poor practices may cause issues to health and may actually negatively impact performance as well as increase the potential for inadvertent doping. This included oral nicotine (snus), cannabidiol and cannabis. Research also showed for the first time the prevalence of cannabidiol in an athletic population and drew upon some of the reasons athletes may use this supplement, despite the associated risks.

4.2 REFLECTIONS ON THE IMPACT OF THE THESIS

General reflections

Having set the goal to answer some of the key questions that arise daily in practice, I can now reflect that this novel approach to conducting a PhD has allowed me to focus on answering these key sport-nutrition questions, whilst also guiding other practitioner's, researcher's and student's practice. In this technological age, often

when summarising and translating research to athletes, or when sharing the results with the 'wider world', we use social media and graphics as a conduit. As such, I have appended some of the graphical abstracts that have been designed around the applied research within the thesis, many of which have received high levels of traction on social media (as detailed by the Altmetric scores listed throughout the thesis).

In addition to the traditional methods for reviewing the quality of journal articles (e.g., impact citations), there are now alternative metric scores (Altmetric) for the 'reach' of publications (Reider, 2017), including via social media. These metrics are based upon three main factors: 1) the number of people mentioning the article; 2) the source; and 3) the mentioning of the authors. The dissemination of research findings from the current thesis has been impactful both on both traditional and alternative metric scales (as evidenced at the start of each chapter). Furthermore, the peer reviewed journals in which these articles have been published fall into the upper quartile (top 25%) and have high impact factors (5.968 average impact factor at the time of writing) for this area of science (e.g., Nutrition / Sports Science).

The use of infographics to explain key findings

Social media is a platform where research is often translated to information for the general population and for many applied practitioners (Burke et al., 2017). Due to word-limits imposed e.g., by Twitter, it can be difficult for users to deliver complex arguments and communicate research findings accurately/effectively. A growing form of communication, targeted at conveying complex information in a more readily accessible format, is the use of infographics / graphical abstracts. Indeed, many peer-

reviewed journals now have the option for graphical abstracts to be submitted (appended) and these are used for promotion of articles on platforms such as Twitter. However, the question remains whether graphical abstracts and infographics are of perceived use by athletes and practitioners. Future research / PhD study may wish to investigate whether these graphics are the best way to translate the Paper to Podium message within the applied setting.

4.3 FUTURE RESEARCH AND DIRECTION

Direction of individual research

A number of obvious future studies are apparent from the research included within this thesis. A summary of these future directions highlighted in each publication is listed below:

- Energy intake: 1) Analysis of meals with higher 'hidden' fat content using the remote food photography method; 2) Assessment of additional days with a wider range of energy intakes using the remote food photography method.
- Energy expenditure: 1) Assessment of energy expenditure of golf within a range of populations; 2) Assessment of energy expenditure of golf whilst using buggy transport; 3) Assessment of energy expenditure of different aspects of golf (e.g., structured range and chipping sessions).
- Body composition: 1) Standardisation procedures for using dual-energy X-Ray absorptiometry on taller athletes; 2) Reliability and validity study of ultrasound as a technique to measure body composition.

- Supplementation: 1) Documentation of the prevalence of certain supplements within athletes (including the reasons why); 2) Understanding of athletes knowledge of supplementation and the risks involved; 3) Investigation into the performance implications of nicotine containing products (such as snus); 4) The efficacy of specific supplements currently un-investigated (such as cannabidiol); 5) Further investigation of the psycho-physiological effects of cannabis in performance settings; 6) Side effect profiles of compounds such as cannabis, cannabidiol and tetrahydrocannabinol.

My own personal research direction

My areas of interest include practical research that is designed to answer the end-user's questions and target the unknown questions within elite sport populations. I believe practitioners should focus on and be critical of the research that is pertinent to their own athletes' needs. There is a requirement for more applied research, whereby studies satisfy the main points highlighted in the 'Paper 2 Podium Matrix' and can be translated into practice. Current projects I am working on, which I believe will have a direct impact on practice, include:

- Energy intake: 1) Assessing intake practices of athletes in real-world situations, manuscript entitled '*Nutritional habits of professional team sport athletes: An insight into the carbohydrate, caffeine and fluid habits of Premier League football players during match play*'.

- Energy expenditure: Review of the current consensus-based recommendations for football, manuscript entitled *'Assessing the situation: Is experimental research on carbohydrates for team sport lacking?'*
- Body composition: 1) The use A-Mode ultrasound for measurement of body composition, manuscript entitled *'Body composition methods: Validity and reliability of A-Mode ultrasound for body composition assessment of Premier League football team sport athletes.'*
- Supplementation: 1) Micronutrient recommendations in athletic vs. general populations, manuscript entitled '*Micronutrients and the athlete: A narrative review of the requirements, deficiencies, and consequences*. 2) Review and extrapolation of the dosages of CBD currently found to have an effect within research situations, manuscript entitled '*Systematic review of CBD supplementation dosage: Proposed by research vs. real-world'*. 3) Prevalence and rationale for vitamin D testing within sport, manuscript entitled '*Perceptions and practices in vitamin D testing and supplementation in elite sport'*.
- Other: 1) Guidance on assessing gut issues in team sports, including introducing a new tool for doing so, manuscript entitled *'Gut distress in team sports: A guide for practitioners*.

4.4 CONCLUDING REMARKS

I am excited to see the impact of the research within this thesis. How will the 'Paper to Podium' framework be utilised? Initial data suggest that it is already being adopted within applied research and helping practitioners to evaluate interventions. Will the

‘Food First, Not Food Only’ framework help practitioners assess and implement supplementation safely and effectively? Will the data presented in ‘Come Back Skinfolds, All Is Forgiven’ continue to drive standards in applied practice, and will this drive the development of an elite sport version of the ISAK protocol based on the realities of elite sport? Have we helped athletes reconsider their use of snus? Hopefully ‘Snus You Lose’, ‘CBD - A Quest for Pain Relief and Enhanced Recovery’, and ‘Cannabis and Athletic Performance’ have provided important education and created the opportunity for more open conversations between nutritionists and their athletes. All this can only help produce better practitioners and informed athletes within the growing area of sport nutrition. Our challenge now is to maintain academic standards, rigor, and evidence-based practice without developing into idle practitioners.

Although it is difficult to predict the direction of the sport nutrition discipline and applied research, I am excited to see what the future holds. It is interesting to note that in 2022, a number of sports teams have advertised roles that have a research aspect within the job description and although in its relative infancy, I believe there will be an emergence of impactful Research-Practitioners working in the applied field of sport nutrition. However, our goal as Academic Researchers and/or Researcher-Practitioners remains the same, we should be encouraging other academics, practitioners, and athletes to take responsibility for athlete health and performance as a result of more accessible information and better understanding of the field of practice. It is certainly an exciting time for our discipline.

REFERENCES:

Burke, L.M. (2017). Communicating sports science in the age of the twittersphere. *International Journal of Sport Nutrition and Exercise Metabolism, 27*(1), 1-5. https://doi.org/10.1123/ijsnem.2017-0057

Burke, L.M., Castell, L.M., Casa, D.J., Close, G.L., Costa, R.J.S., Desbrow, B., Halson, S.L., Lis, D.M., Melin, A.K., Peeling, P., Saunders, P.U., Slater, G.J., Sygo, J., Witard, O.C., Bermon, S., & Stellingwerff, T. (2019). International Association of Athletics Federations Consensus Statement 2019: Nutrition for Athletics. *International Journal of Sport Nutrition and Exercise Metabolism, 29*(2), 73–84. https://doi.org/10.1123/ijsnem.2019-0065

Burr, J.F., Cheung, C.P., Kasper, A.M., Gillham, S.H., & Close, G.L. (2021). Cannabis and Athletic Performance. *Sports Medicine,* Online Ahead of Print. https://doi.org/10.1007/s40279-021-01505-x

Close, G.L., Kasper, A.M., Walsh, N.P., & Maughan, R.J. (2022). 'Food First' But Not Always 'Food Only': An Evidenced-Based Approach to Using Dietary Supplements in Sport. *International Journal of Sport Nutrition and Exercise Metabolism, In-Press.*

Close, G. L., Kasper, A. M., & Morton, J. P. (2019). From Paper to Podium: Quantifying the Translational Potential of Performance Nutrition Research. *Sports Medicine*, *49* (Supplement 1), 25–37. https://doi.org/10.1007/s40279-018-1005-2

Collins, J., Maughan, R. J., Gleeson, M., Bilsborough, J., Jeukendrup, A., Morton, J. P., Phillips, S. M., Armstrong, L., Burke, L. M., Close, G. L., Duffield, R., Larson-Meyer, E., Louis, J., Medina, D., Meyer, F., Rollo, I., Sundgot-Borgen, J., Wall, B. T., Boullosa, B., Dupont, G., Lizarraga, A., Res, P., Bizzini, M., Castagna, C., Cowie, C.M., D'Hooghe, M., Geyer, H., Meyer, T., Papadimitriou, N., Vouillamoz, M., & McCall, A. (2020). UEFA expert group statement on nutrition in elite football. Current evidence to inform practical recommendations and guide future research. *British Journal ofSsports Medicine*, *55*(8), 416. https://doi.org/10.1136/bjsports-2019-101961

Costello, N., Deighton, K., Dalton-Barron, N., Whitehead, S., Preston, T., Jones, B. (2019). Can a contemporary dietary assessment tool or wearable technology accurately assess the energy intake of professional young rugby league players? A doubly labelled water validation study. *European Journal of Sport Science, 20*(9), 1151–1159. https://doi.org/10.1080/17461391.2019.1697373

Costello, N., Deighton, K., Dyson, J., McKenna, J., Jones, B. (2017). Snap-n-Send: A valid and reliable method for assessing the energy intake of elite adolescent athletes. *European Journal of Sport Science, 17*(8), 1044–1055. https://doi.org/10.1080/17461391.2017.1337815

Coutts, A.J. (2016). Working fast and working slow: The benefits of embedding research in high performance sport. *International Journal of Sports Physiology & Performance, 11*(1), 1-2. https://doi.org/10.1123/ijspp.2015-0781

Coyle, E.F., Jeukendrup, A.E., Wagenmakers, A.J., Saris, W.H. (1997). Fatty acid oxidation is directly regulated by carbohydrate metabolism during exercise. *American Journal of Physiology. 273*(2 Part 1), E268- E275. https://doi: 10.1152/ajpendo.1997.273.2.E268. PMID: 9277379.

Dahlgren, M. K., Sagar, K. A., Lambros, A. M., Smith, R. T., & Gruber, S. A. (2021). Urinary Tetrahydrocannabinol After 4 Weeks of a Full-Spectrum, High-Cannabidiol Treatment in an Open-label Clinical Trial. *JAMA psychiatry*, *78*(3), 335–337. https://doi.org/10.1001/jamapsychiatry.2020.3567

Dodgson, L. (2018). All that spitting during the World Cup could be something called 'carb rinsing' – here's the science behind it. Retrieved from https://www.businessinsider.com/what-is-carb-rinsing-2018-7?r=US&IR=T

Fitzgerald, M. (2015). Nick Diaz suspended 5 years for failed drug tests: Latest details and reaction. Retrieved from https://bleacherreport.com/articles/2566645-nick-diaz-suspended-5-years-for-failed-drug-tests-latest-details-and-reaction

Garthe, I., Maughan, R.J. (2018). Athletes and Supplements: Prevalence and Perspectives. *International Journal of Sport Nutrition and Exercise Metabolism, 28,* 126–138. https://doi.org/10.1123/ijsnem.2017-0429

Gurley, B. J., Murphy, T. P., Gul, W., Walker, L. A., & ElSohly, M. (2020). Content versus Label Claims in Cannabidiol (CBD)-Containing Products Obtained from

Commercial Outlets in the State of Mississippi. *Journal of dietary supplements*, *17*(5), 599–607. https://doi.org/10.1080/19390211.2020.1766634

Hawley, J. A. & Morton, J. P. (2014). Ramping up the signal: Promoting endurance training adaptation in skeletal muscle by nutritional manipulation. Clinical and Experimental Pharmacology and Physiology, 41, 608–613. https://doi.org/10.1111/1440-1681.12246

Kasper, A. M., Cocking, S., Cockayne, M., Barnard, M., Tench, J., Parker, L., McAndrew, J., Langan-Evans, C., Close, G. L., & Morton, J. P. (2016). Carbohydrate Mouth Rinse and Caffeine Improves High-Intensity Interval Running Capacity When Carbohydrate Restricted. *European Journal of Sport Science*, *16*(5), 560–568. https://doi.org/10.1080/17461391.2015.1041063

Kasper, A. M., & Close, G. L. (2021). Practitioner Observations of Oral Nicotine Use in Elite Sport: You Snus You Lose. *European Journal of Sport Science*, 1–6. Advance online publication. https://doi.org/10.1080/17461391.2020.1859621

Kasper, A. M., Crighton, B., Langan-Evans, C., Riley, P., Sharma, A., Close, G. L., & Morton, J. P. (2019). Case Study: Extreme Weight Making Causes Relative Energy Deficiency, Dehydration, and Acute Kidney Injury in a Male Mixed Martial Arts Athlete. *International Journal of Sport Nutrition and Exercise Metabolism*, *29*(3), 331–338. https://doi.org/10.1123/ijsnem.2018-0029

Kasper, A. M., Langan-Evans, C., Hudson, J. F., Brownlee, T. E., Harper, L. D., Naughton, R. J., Morton, J. P., & Close, G. L. (2021). Come Back Skinfolds, All Is Forgiven: A Narrative Review of the Efficacy of Common Body Composition Methods in Applied Sports Practice. *Nutrients*, *13*(4), 1075. https://doi.org/10.3390/nu13041075

Kasper, A.M., O'Donnell, A., Langan-Evans, C., Jones, A., Lindsay, A., Murray, A., & Close, G.L. (2022). Assessment of Energy Expenditure During Tournament Golf: The Effects of Bag Carrying, Electric or Manual Trolleys. *European Journal of Sports Sciences, In-Press.*

Kasper, A. M., Sparks, S. A., Hooks, M., Skeer, M., Webb, B., Nia, H., Morton, J. P., & Close, G. L. (2020). High Prevalence of Cannabidiol Use Within Male Professional Rugby Union and League Players: A Quest for Pain Relief and Enhanced Recovery. *International Journal of Sport Nutrition and Exercise Metabolism*, *30*(5), 315–322. https://doi.org/10.1123/ijsnem.2020-0151

Longman, J. (2018). That spitting thing at the World Cup? It's probably carb rinsing'. Retrieved from https://www.nytimes.com/2018/07/11/sports/world-cup/harry-kane-england.html

Martin, C.K., Kaya, S., & Gunturk, B.K. (2009). Quantification of food intake using food image analysis. *Proceedings of the Annual International Conference of the IEEE Engineering in Medicine and Biology Society, 1*, 6869-6872. https://doi.org/10.1109/IEMBS.2009.5333123

Martínez-Sanz, J. M., Sospedra, I., Ortiz, C. M., Baladía, E., Gil-Izquierdo, A., & Ortiz-Moncada, R. (2017). Intended or Unintended Doping? A Review of the Presence of Doping Substances in Dietary Supplements Used in Sports. *Nutrients*, *9*(10), 1093. https://doi.org/10.3390/nu9101093

Maughan, R.J., Burke, L.M., Dvorak, J., Larson-Meyer, D.E., Peeling, P., Phillips, S.M., Rawson, E.S., Walsh, N.P., Garthe, I., Geyer, H., Meeusen, R., van Loon, L.J.C., Shirreffs, S.M., Spriet, L.L., Stuart, M., Vernec, A., Currell, K., Ali, V.M., Budgett, R.G., Ljungqvist, A., Mountjoy, M., Pitsiladis, Y.P., Soligard, T., Erdener, U., Engebretsen, L. (2018). IOC consensus statement: dietary supplements and the high-performance athlete. *British Journal of Sports Medicine, 52,* 439–455. https://doi.org/10.1136/bjsports-2018-099027

McCarthy, A. (2021). Nate Diaz openly smokes cannabis during UFC 263 press conference before Leon Edwards fight and Israel Adesanya can't believe it. Retrieved from https://talksport.com/sport/mma/893400/nate-diaz-smokes-cannabis-ufc-263-press-conference-israel-adesanya/

Mujika, I. (2017). Winning the BIG medals. *International Journal of Sports Physiology & Performance, 12*(3), 273-274. https://doi.org/10.1123/ijspp.2017-0016

Murray, A.D., Daines, L., Archibald, D., Hawkes, R.A., Schiphorst, C., Kelly, P., Grant, L., Mutrie, N. (2017). The relationships between golf and health: A scoping review.

British Journal of Sports Medicine, 51, 12-19. https://doi.org/10.1136/bjsports-2016-096625

Raimondi, M. (2020). Kelvin Gastelum tests positive for marijuana for second time. Retrieved from https://www.espn.co.uk/mma/story/_/id/29161991/kelvin-gastelum-tests-positive-marijuana-second

Reider, B. (2017). Consider the alternative. *The American Journal of Sports Medicine, 45*(11), 2457-2459. https://doi.org/10.1177/0363546517727715

Sport and Exercise Nutrition register (SENr). (2022). Scope of practice. Retrieved from https://www.bda.uk.com/senr-sport-and-exercise-nutrition-register/about-senr.html

Stables, R. G., Kasper, A. M., Sparks, S. A., Morton, J. P., & Close, G. L. (2021). An Assessment of the Validity of the Remote Food Photography Method (Termed Snap-N-Send) in Experienced and Inexperienced Sport Nutritionists. *International Journal of Sport Nutrition and Exercise Metabolism*, *31*(2), 125–134. https://doi.org/10.1123/ijsnem.2020-0216

APPENDIX:

Appendix 1. A proposed checklist to aid with the design of research with direct application to practice (based on Close et al., 2019). Tick box if the answer is yes. If the answer is no, consider amending the research design to incorporate point. The higher the number of tick marks, the greater the applicability to practical sport environments.

Research context:

- □ Have you used human participants?
- □ Does your study assess exercise outcomes?
- □ Does your study combine exercise and mechanistic outcomes?

Research participants:

- □ Have you used participants who are the same age as the population to which you are trying to apply findings?
- □ Have you used participants who are the same training status as the population to which you are trying to apply findings?
- □ Have you used participants who are the same level of competitor as the population to which you are trying to apply findings?

Research design:

- □ Is this a randomised cross-over trial?
- □ Is this a repeated measures or matched group design?
- □ Is this study double blind, placebo controlled?
- □ Have you got a rationale for and calculated sample size?

Dietary and exercise control:

- Has diet been controlled?
- Has diet been provided by the research team?
- Has exercise been controlled?
- Have you collected relevant objective data to support controls?
- Is the dietary control representative of real-world context?
- Is the exercise control representative of real-world context?

Validity and reliability:

- Have participants been familiarised to diet?
- Have participants been familiarised to exercise intervention?
- Do you know the reliability and measurement error of the tools used for assessment?
- If reliability and measurement error of the tools used for assessment is unknown, have you conducted your own reliability and error testing?
- Do the exercise protocols used replicate the situation you are trying to apply findings to e.g. based on 'real-world' context?
- Is the data collected in a laboratory-based setting?
- Is the data collected in a field-based setting?

Data analytics:

- Have you reported the analytics used?
- Have you used appropriate significance or magnitude-based inference testing?
- Have you included effect sizes?

- Have you included individual responses?

Feasibility of application:

- Is the intervention cost-effective / cheap to implement?
- Is the intervention simple to implement?
- Is there minimal risk of non-compliance to the intervention?

Risk/reward:

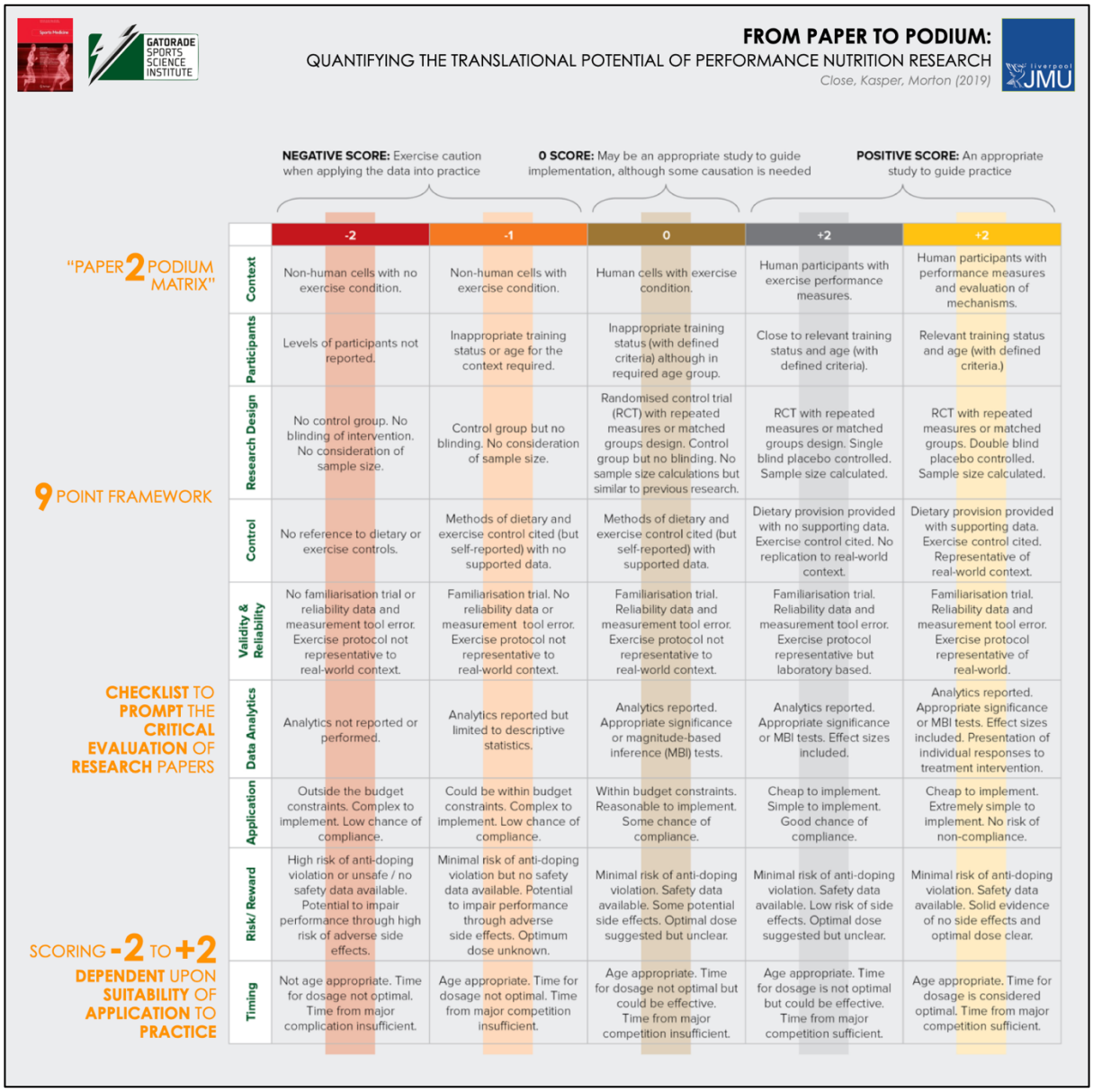
- Is there minimal risk of inadvertently doping?
- Is the safety data of the intervention available?
- Is the adverse / side effect profile known?
- Is there an optimal dose for the intervention?

Timing of intervention:

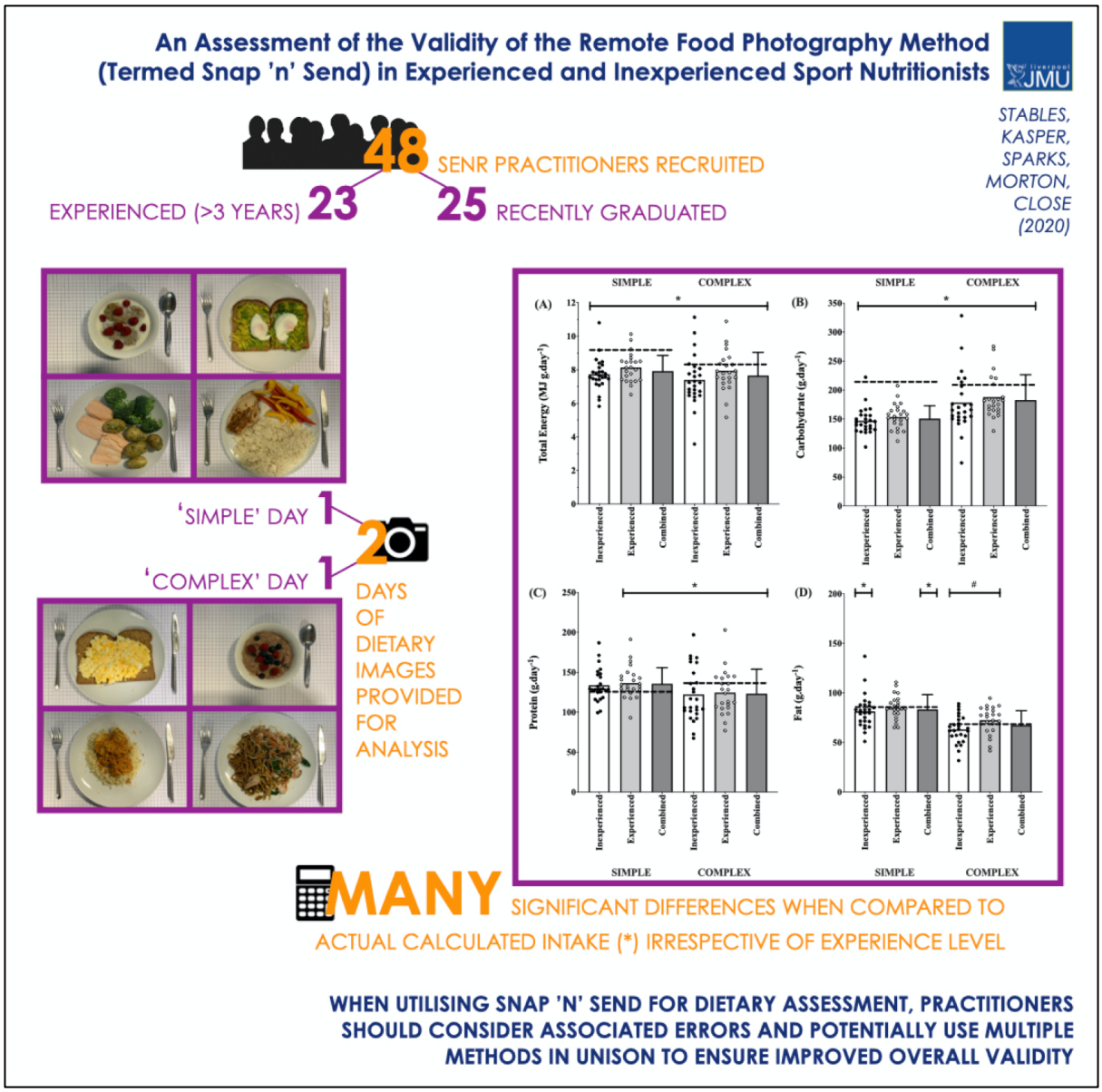
- Is the timing of the intervention considered optimal to be effective?
- Is the timing from the event / exercise test sufficient to warrant testing the new strategy?

For further information surrounding each of these points, please consult Close, G. L., Kasper, A. M., & Morton, J. P. (2019). From Paper to Podium: Quantifying the Translational Potential of Performance Nutrition Research. Sports Medicine, 49 (Supplement 1), 25–37. https://doi.org/10.1007/s40279-018-1005-2

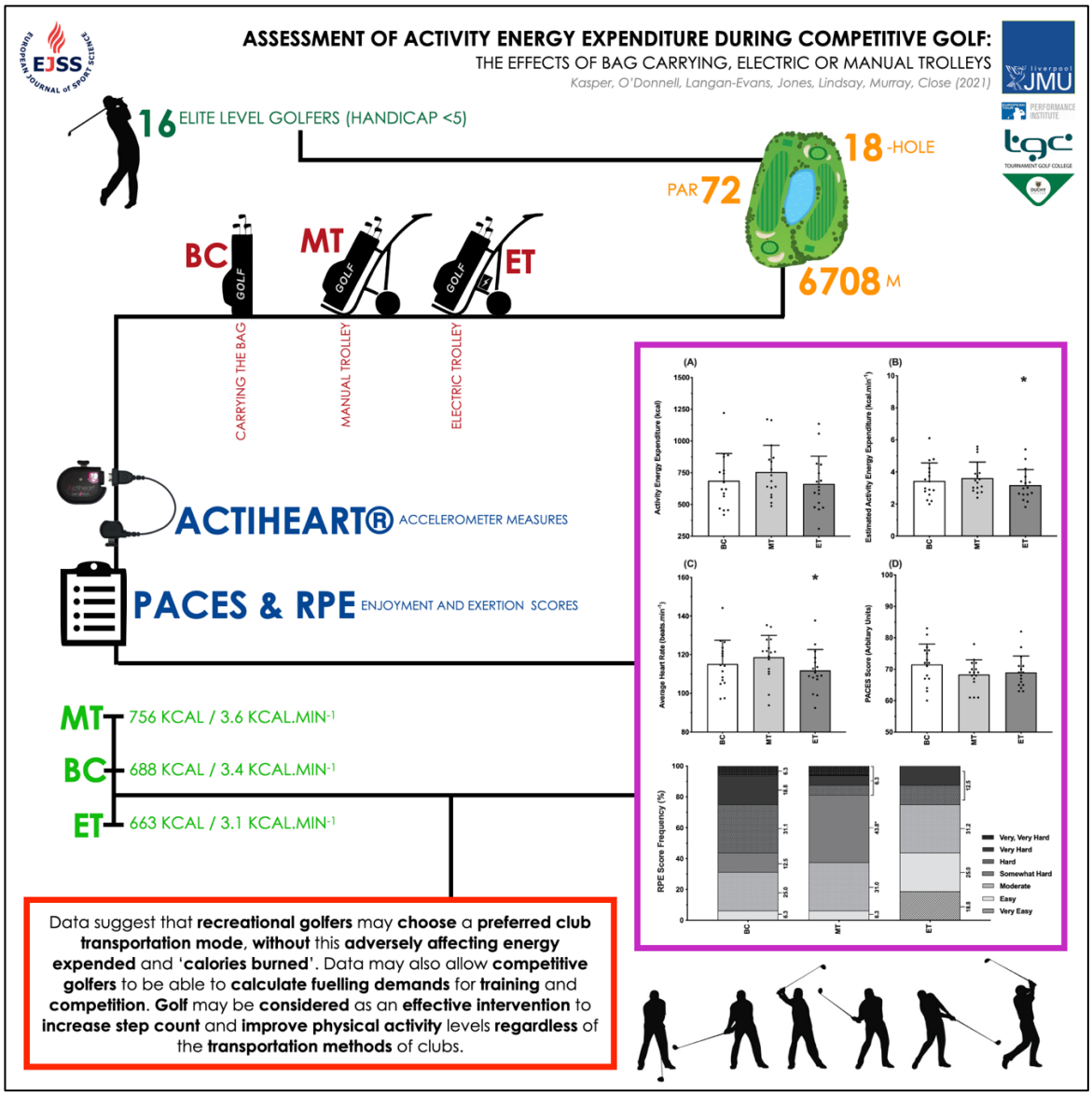
Appendix 2. Infographic / graphical abstract for the paper entitled ‘From Paper to Podium: Quantifying the Translational Potential of Performance Nutrition Research’.



Appendix 3. Infographic / graphical abstract for the paper entitled 'An Assessment of the Validity of the Remote Food Photography Method (Termed Snap-N-Send) in Experienced and Inexperienced Sport Nutritionists'.

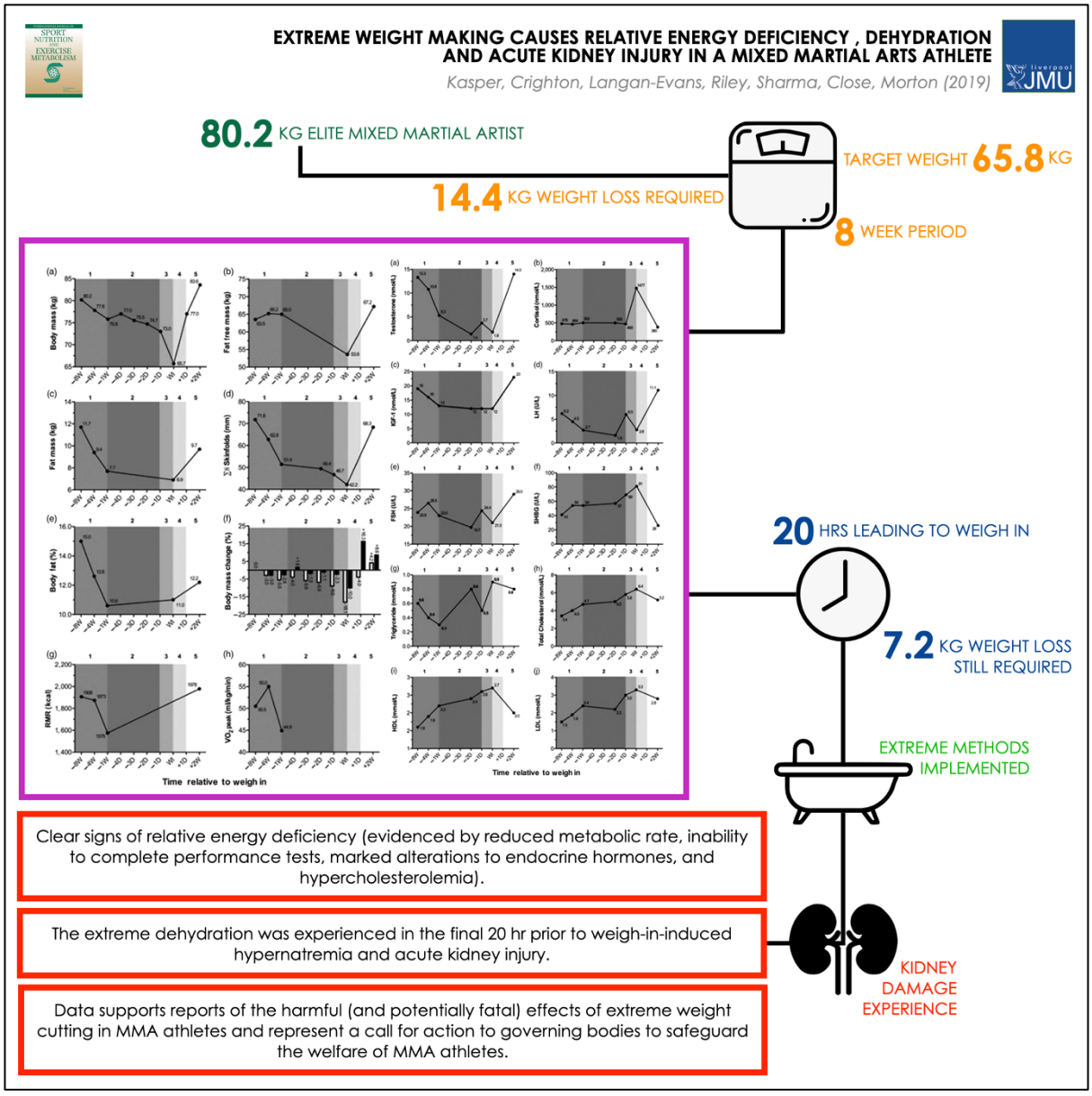


Appendix 4. Infographic / graphical abstract for the paper entitled 'Assessment of Energy Expenditure During Tournament Golf: The Effects of Bag Carrying, Electric or Manual Trolleys'.

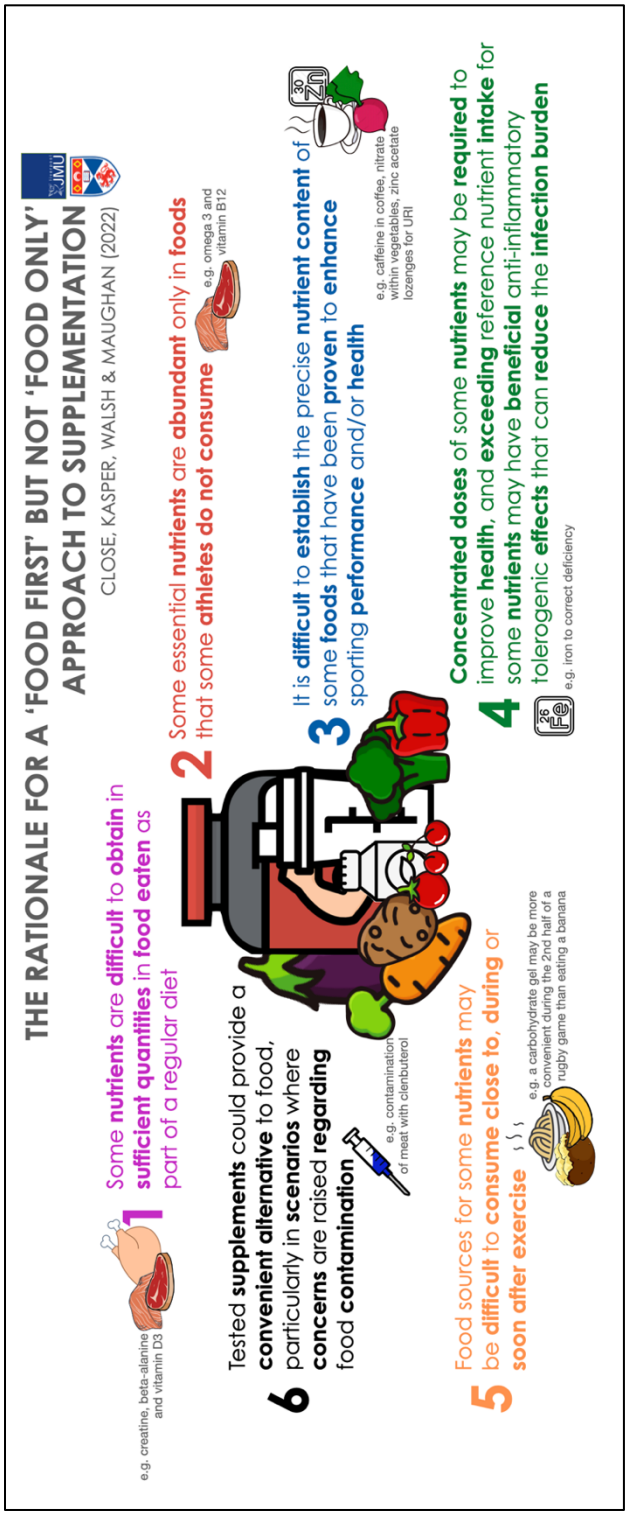


Appendix 5. Infographic / graphical abstract for the paper entitled 'Come Back Skinfolds, All Is Forgiven: A Narrative Review of the Efficacy of Common Body Composition Methods in Applied Sports Practice'.

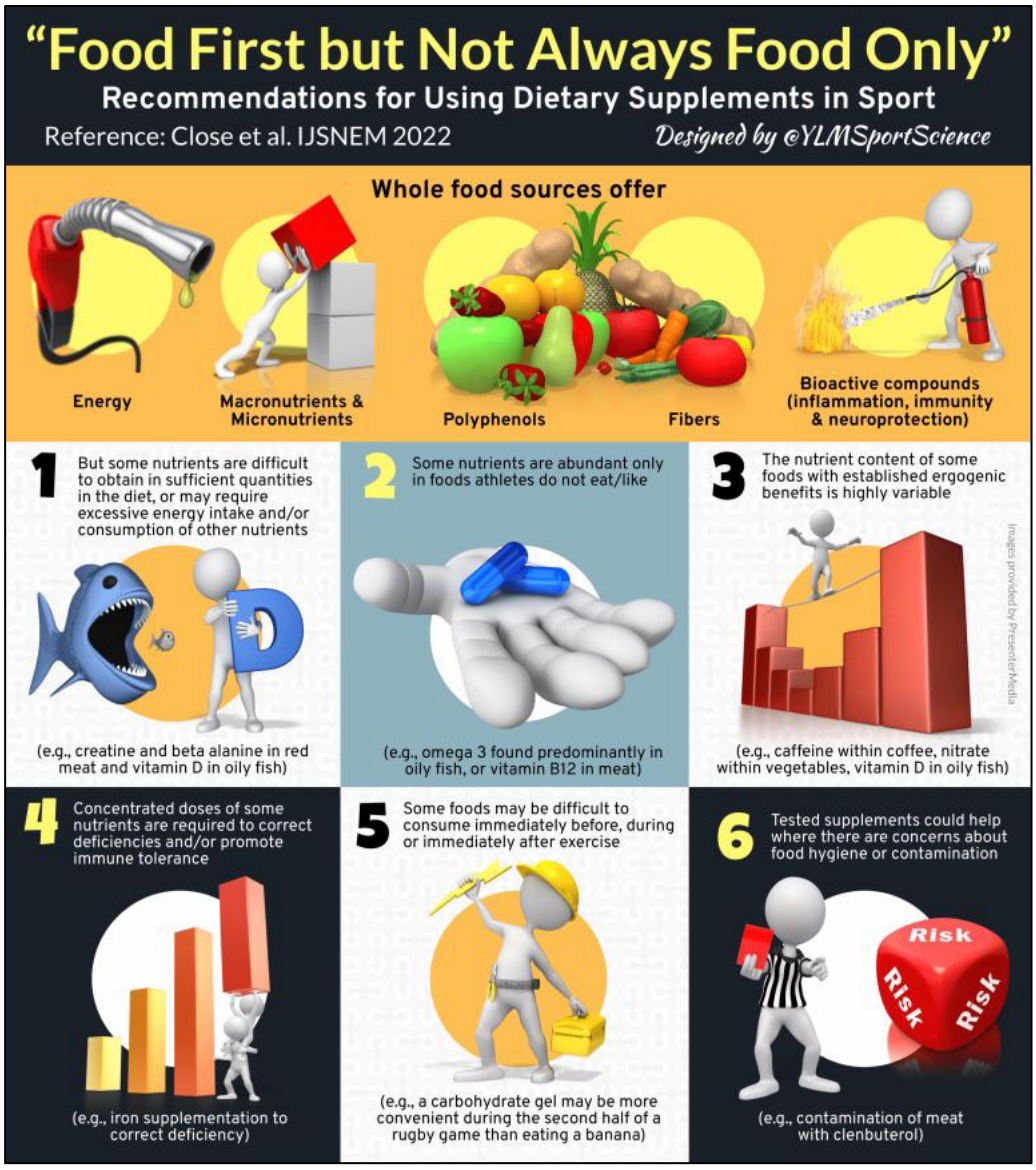
Appendix 6. Infographic / graphical abstract for the paper entitled 'Case Study: Extreme Weight Making Causes Relative Energy Deficiency, Dehydration, and Acute Kidney Injury in a Male Mixed Martial Arts Athlete'.



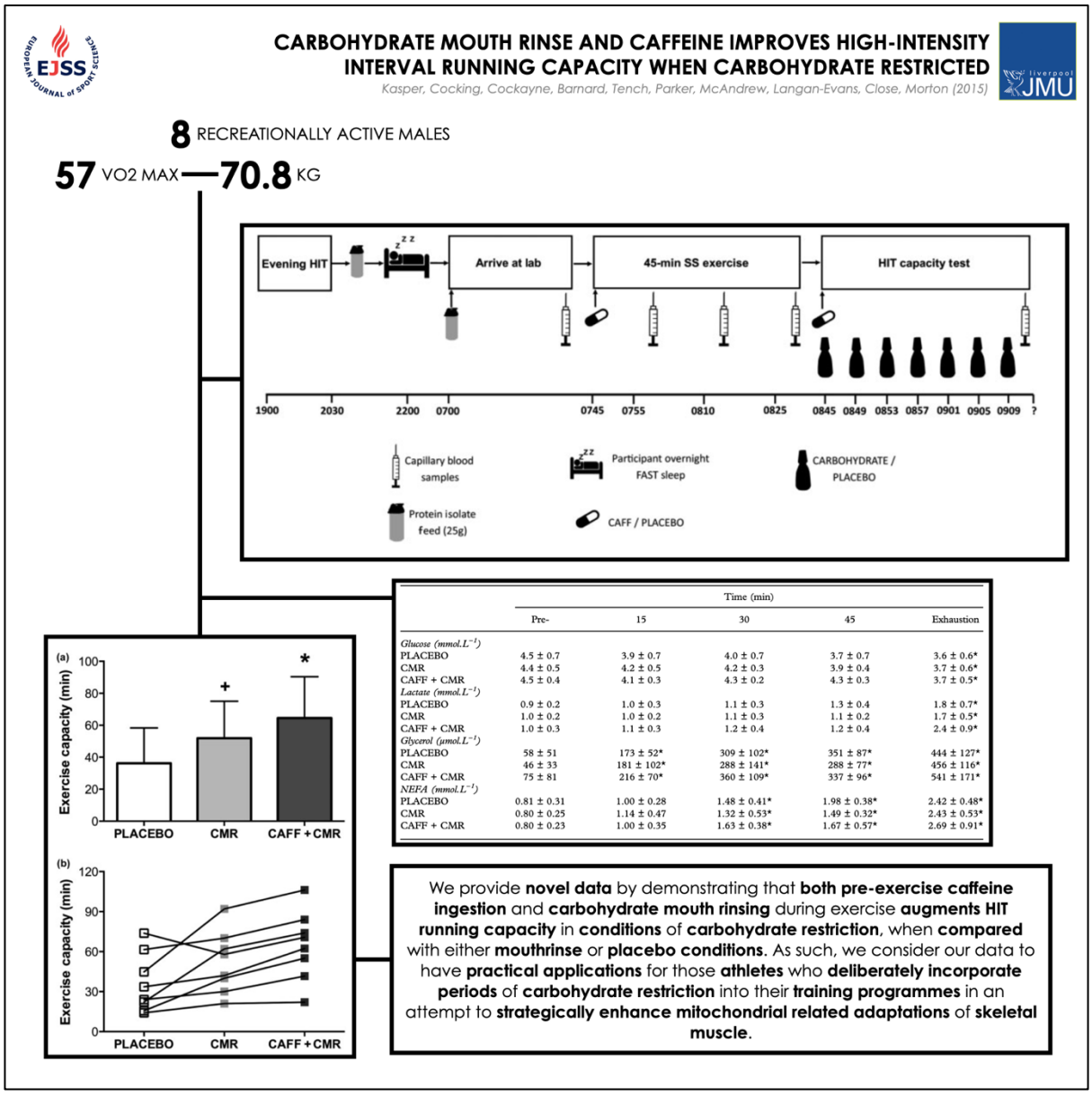
Appendix 7. Infographic / graphical abstract for the paper entitled ‘‘Food First’ But Not Always ‘Food Only’: An Evidenced-Based Approach to Using Dietary Supplements in Sport’.



Appendix 8. Infographic / graphical abstract for the paper entitled ‘‘Food First’ But Not Always ‘Food Only’: An Evidenced-Based Approach to Using Dietary Supplements in Sport’ designed and shared by @YLMSportScience, with a reach of 84.3K Followers and 198K Followers on the social media platforms Twitter and Instagram respectively.

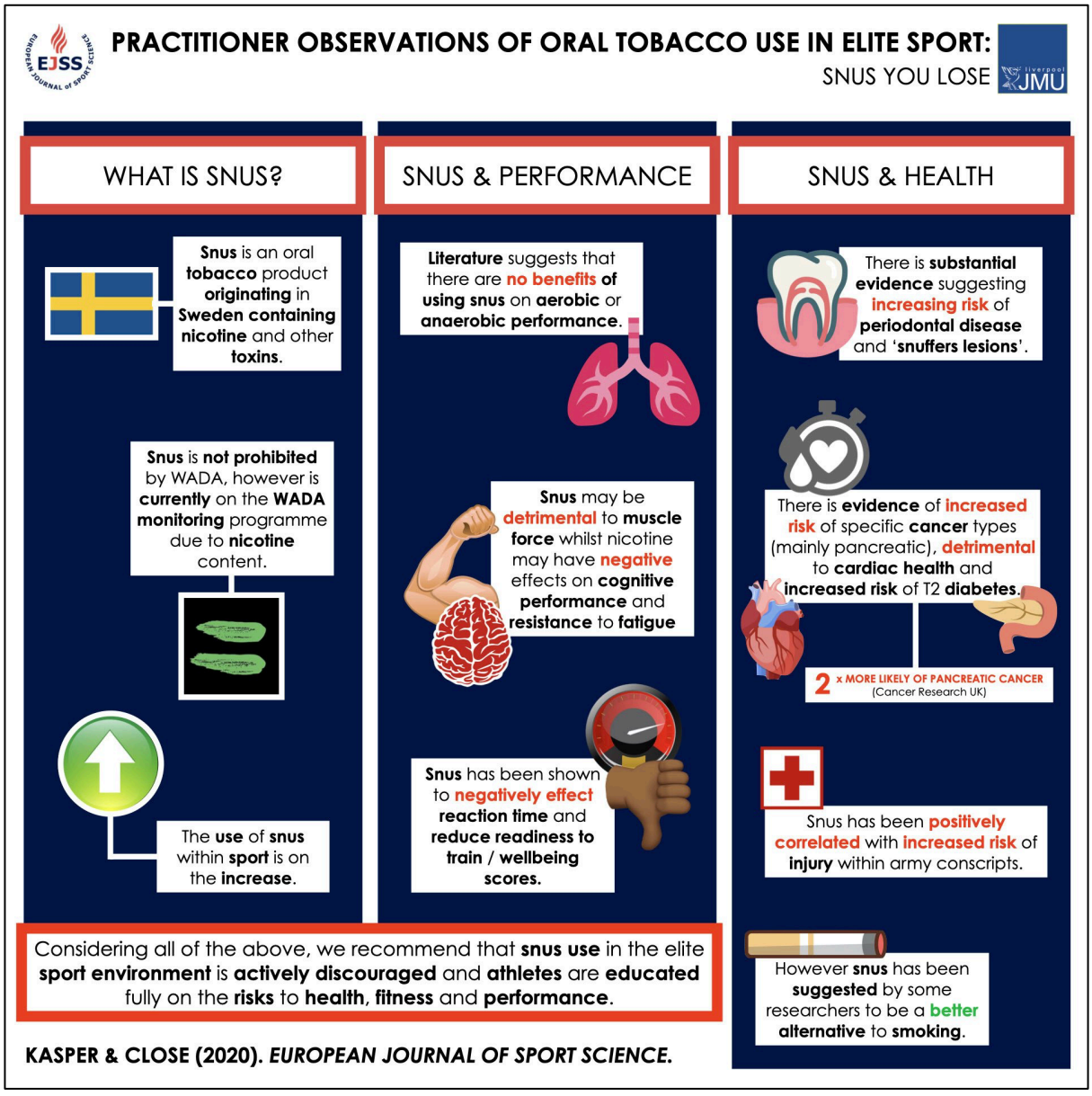


Appendix 9. Infographic / graphical abstract for the paper entitled 'Carbohydrate Mouth Rinse and Caffeine Improves High-Intensity Interval Running Capacity When Carbohydrate Restricted'.

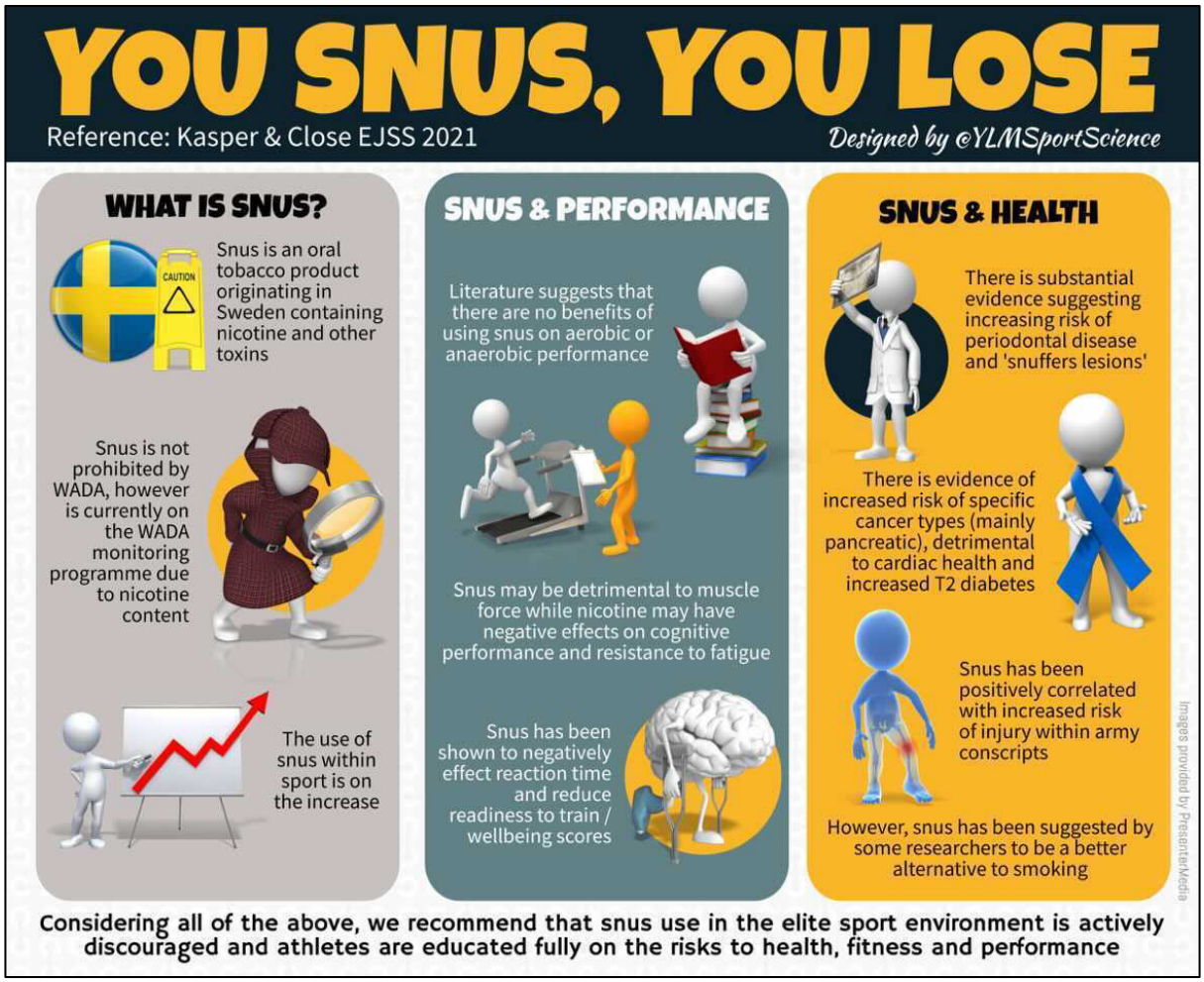


	Time (min)				
	Pre-	15	30	45	Exhaustion
Glucose (mmol.L^{-1})					
PLACEBO	4.5 ± 0.7	3.9 ± 0.7	4.0 ± 0.7	3.7 ± 0.7	3.6 ± 0.6*
CMR	4.4 ± 0.5	4.2 ± 0.5	4.2 ± 0.3	3.9 ± 0.4	3.7 ± 0.6*
CAFF + CMR	4.5 ± 0.4	4.1 ± 0.3	4.3 ± 0.2	4.3 ± 0.3	3.7 ± 0.5*
Lactate (mmol.L^{-1})					
PLACEBO	0.9 ± 0.2	1.0 ± 0.3	1.1 ± 0.3	1.3 ± 0.4	1.8 ± 0.7*
CMR	1.0 ± 0.2	1.0 ± 0.2	1.1 ± 0.3	1.1 ± 0.2	1.7 ± 0.5*
CAFF + CMR	1.0 ± 0.3	1.1 ± 0.3	1.2 ± 0.4	1.2 ± 0.4	2.4 ± 0.9*
Glycerol (μmol.L^{-1})					
PLACEBO	58 ± 51	173 ± 52*	309 ± 102*	351 ± 87*	444 ± 127*
CMR	46 ± 33	181 ± 102*	288 ± 141*	288 ± 77*	456 ± 116*
CAFF + CMR	75 ± 81	216 ± 70*	360 ± 109*	337 ± 96*	541 ± 171*
NEFA (mmol.L^{-1})					
PLACEBO	0.81 ± 0.31	1.00 ± 0.28	1.48 ± 0.41*	1.98 ± 0.38*	2.42 ± 0.48*
CMR	0.80 ± 0.25	1.14 ± 0.47	1.32 ± 0.53*	1.49 ± 0.32*	2.43 ± 0.53*
CAFF + CMR	0.80 ± 0.23	1.00 ± 0.35	1.63 ± 0.38*	1.67 ± 0.57*	2.69 ± 0.91*

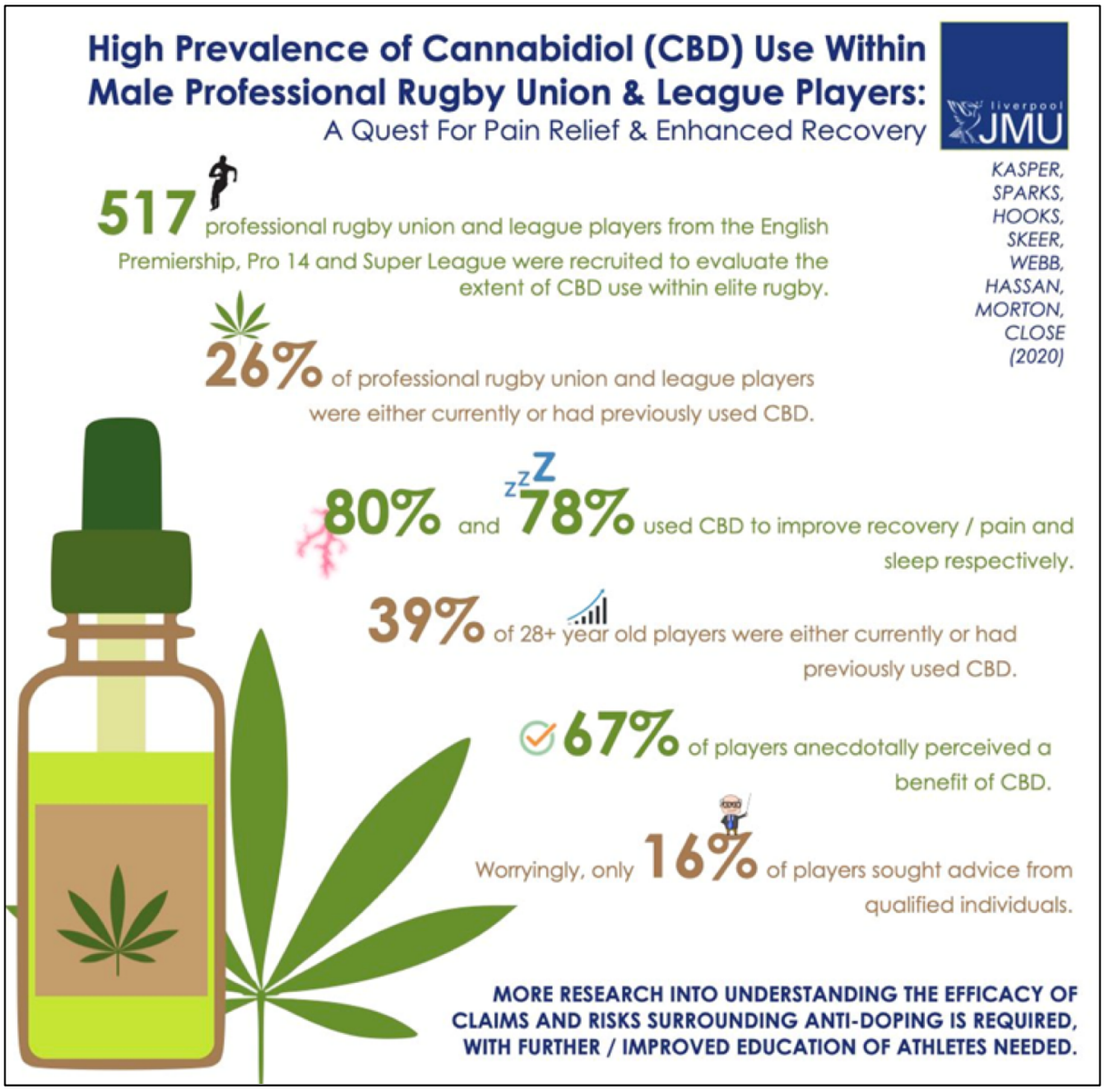
Appendix 10. Infographic / graphical abstract for the paper entitled 'Practitioner Observations of Oral Nicotine Use in Elite Sport: You Snus You Lose'.



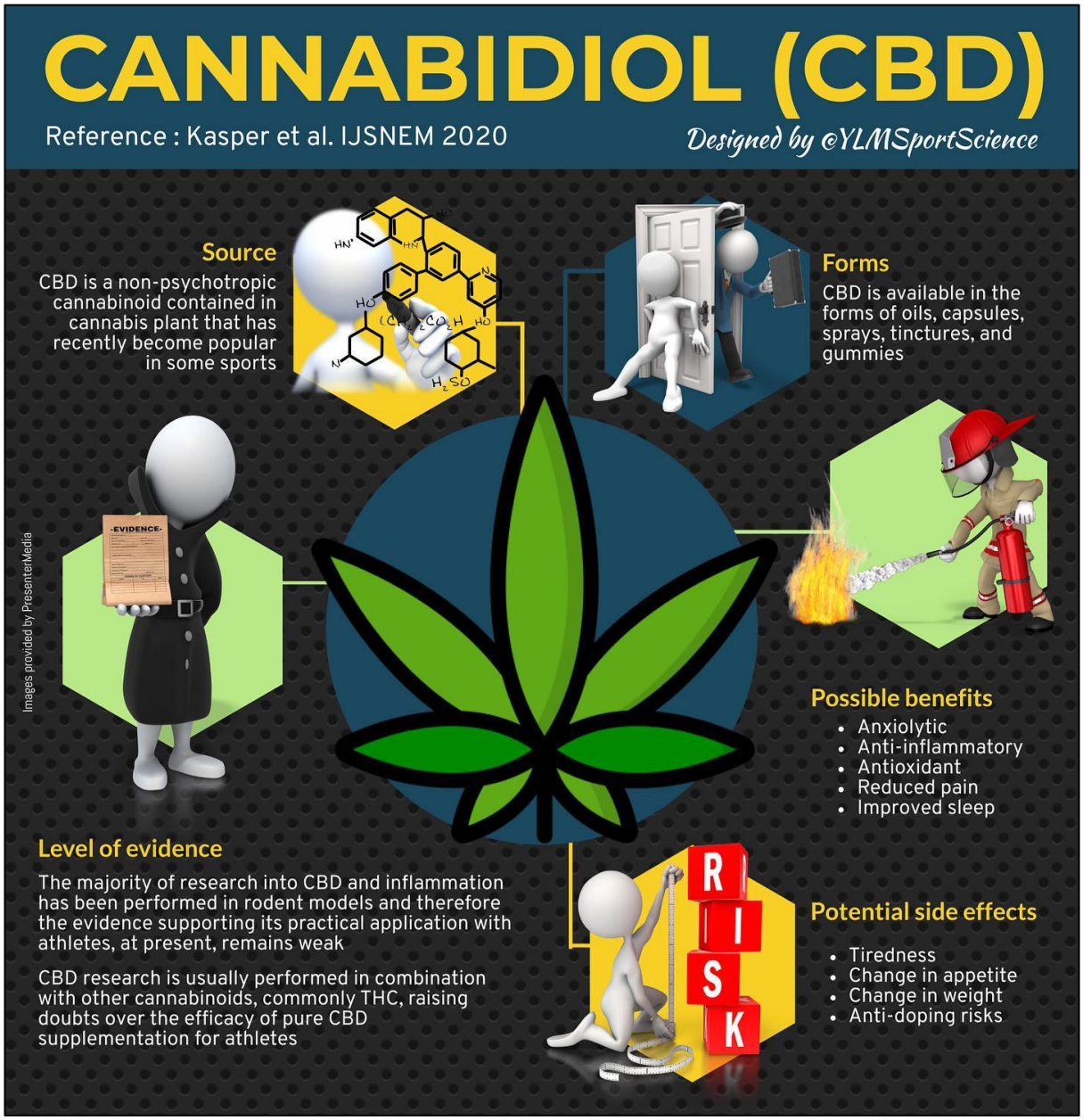
Appendix 11. Infographic / graphical abstract for the paper entitled 'Practitioner Observations of Oral Nicotine Use in Elite Sport: You Snus You Lose' designed and shared by @YLMSportScience, with a reach of 84.3K Followers and 198K Followers on the social media platforms Twitter and Instagram respectively.



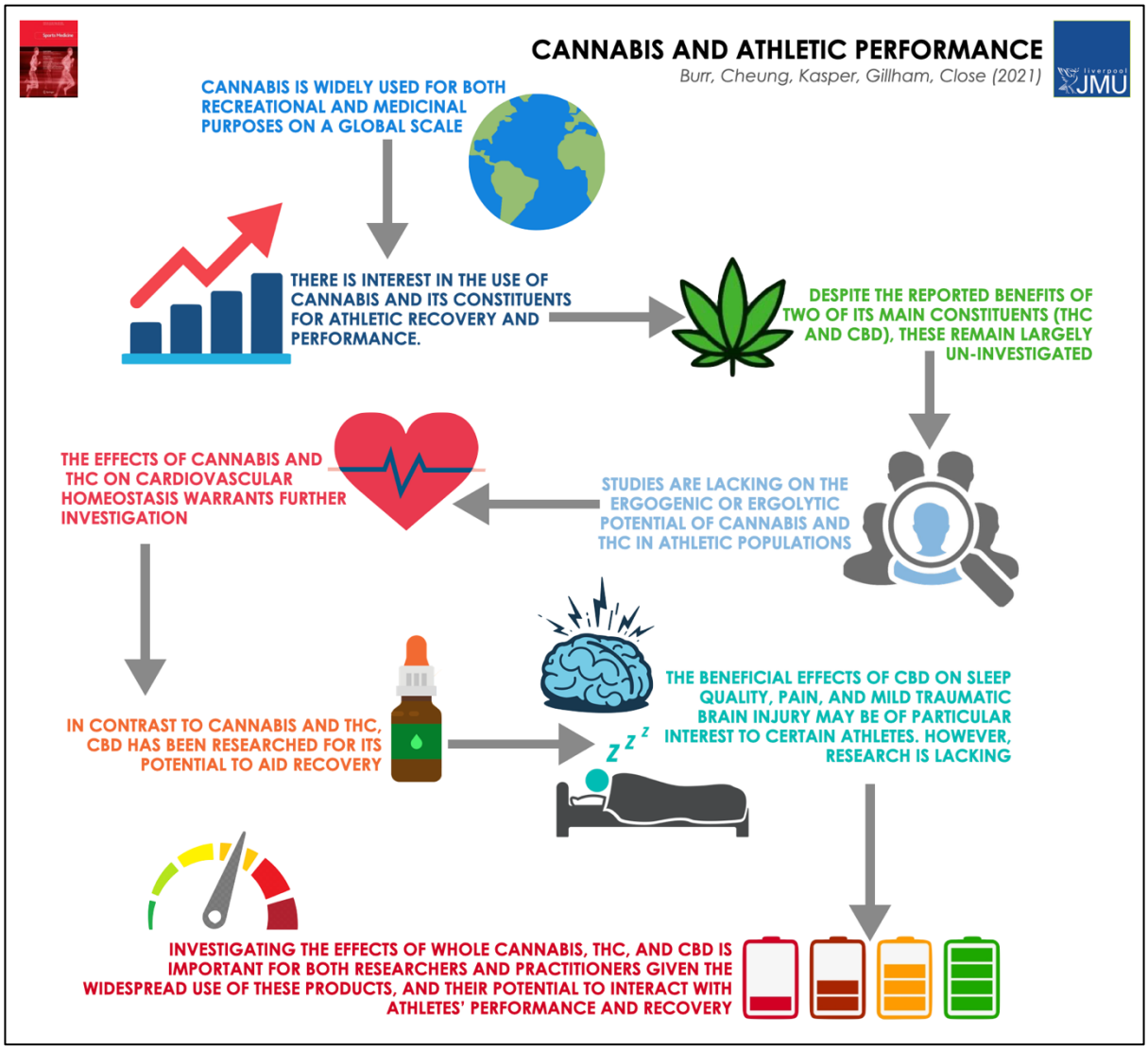
Appendix 12. Infographic / graphical abstract for the paper entitled ‘High Prevalence of Cannabidiol Use Within Male Professional Rugby Union and League Players: A Quest for Pain Relief and Enhanced Recovery’.



Appendix 13. Infographic / graphical abstract for the paper entitled 'High Prevalence of Cannabidiol Use Within Male Professional Rugby Union and League Players: A Quest for Pain Relief and Enhanced Recovery' designed and shared by @YLMSportScience, with a reach of 84.3K Followers and 198K Followers on the social media platforms Twitter and Instagram respectively.



Appendix 14. Infographic / graphical abstract for the paper entitled 'Cannabis and Athletic Performance'.



Appendix 15. Infographic / graphical abstract for the paper entitled 'Cannabis and Athletic Performance' designed and shared by @YLMSportScience, with a reach of 84.3K Followers and 198K Followers on the social media platforms Twitter and Instagram respectively.