Nutrition in Soccer

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Abstract

The game of soccer places various physiological demands on players, who are required to respond by carrying out a range of locomotor activities at different intensities. Such activity patterns contribute to a high energy turnover in both training and match-play, which in turn requires the intake of adequate fuel sources to sustain it.

Adequate nutrient intake constitutes an important foundation for physical performance by providing fuel for biological work, both short and long term as required throughout the course of a soccer match. Despite the popularity of the sport worldwide, few studies investigating the effect of nutrition on performance in soccer have been conducted to substantiate the effect of optimal nutrition over the duration of a standard soccer match. This dearth of evidence has contributed in turn to a lack of specific nutrition guidelines for soccer players, coaches, sport scientists, nutritionists and club administrators.

The aim of this thesis is to investigate the physiological, psychological and sociological aspects of nutrition and soccer, and posit a comprehensive nutritional framework to actively engage soccer players in adopting diets supportive of optimal performance in soccer training and match-play. The researcher set out by hypothesising that an optimal diet positively influences physical performance in soccer match-play. To test this hypothesis, a 90 h diet was developed for the participating semi-professional soccer players. Following implementation of the diet, a 90-minute soccer-specific simulation protocol, $BEAST90_{mod}$ was used to test its effects on physical performance in soccer. The remaining three inter-linked studies were longitudinal in nature, and carried out with participants forming part of the Malta U21 National Soccer Team. In the first instance, players' habitual dietary intake, expenditure and energy balance was examined. The researcher then gathered information about the players' knowledge, attitudes, habits, perceptions and barriers towards a diet conducive with optimal soccer performance. The same players finally underwent a 9-month nutritional education and support intervention, the efficacy of which was measured by the researcher throughout the intervention period.

The principle aim of the research is to present findings that provide players and stakeholders in soccer a clear indication of the effects of specialist nutrition in soccer, and empower them with a range of appropriate tools and strategies as employed throughout the support programme. It ultimately seeks to improve physical performance in soccer training and match-play by informing sound individual and team approaches to nutritional decision-making.

Key words: Soccer nutrition, dietary intake, effect of nutrition on physical performance in soccer, soccer-nutrition knowledge, nutritional attitudes, nutritional barriers, energy balance, nutrition intervention, nutrition education and support intervention programme

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ATP	adenosine triphosphate
$BEAST90_{mod}$	ball-sport endurance and sprint test
BM	body mass
BMR	basal/basic metabolic rate
CHO	carbohydrate
cm	centimetres
g	gram or grams
GI	glycaemic Index
$g \cdot kg^{-1}$ BM	grams per kilogram of body mass per day
HR_{max}	maximal heart rate
kg	kilogram or kilograms
km	kilometres
LIST	Loughborough Intermittent Shuttle Test
m	metre or metres
MET	metabolic equivalent of task
$mL \cdot kg^{-1}$ BM	millilitres per kilogram of body mass
mmol	millimole
$mmol \cdot kg^{-1}d.w.^{-1}$	millimole per kilogram of dry weight
$mmol \cdot L^{-1}$	millimole per litre
n	number of subjects in sample
PRO	protein
RDA	recommended daily allowance
RPE	rating of perceived exertion
RMR	restal/resting metabolic rate
SD	standard deviation
TDEE	total daily energy expenditure
TDEI	total daily energy intake
VO_{2max}	maximal rate of oxygen consumptio

Chapter 1

Introduction and Review of Literature

1.1 Introduction

Soccer is arguably the most popular sport in the world in terms of numbers of participants and spectators. It is played at all ages amicably, as well as at amateur, semi-professional and professional levels. It attracts millions of supporters to stadiums (Vallerand et al. 2008) and brings the world together, even though this may sometimes lead to clashes and disputes. According to a study by FIFA (Fédération Internationale de Football Association [www.fifa.com]), in 2007, 265 million people, or 4% of the world's population, play soccer. As a result of this popularity, soccer is a common means of strategic marketing, used by firms to communicate with mass audiences and obtain competitive advantages (Biscaia, Correia and Rosado 2013). The birth of the modern game of soccer can be traced back to 1863 in England, where the laws of the game were originally codified, even though the essence of the sport is centuries older. According to FIFA, the Chinese competitive game "cuju", literally meaning "kick ball", is the earliest known form of soccer. Today, FIFA whose headquarters are in Zurich, Switzerland, is the sport's main governing body.

Soccer is played by eleven players including a goalkeeper, who must collectively keep the spherical ball in play inside a rectangular field measuring between 90 and 120 metres in length and between 45 and 90 metres in width (FIFA 2016). The objective of the game is to score by getting the ball into the opposing goal. A standard soccer match consists of two periods of forty-five minutes each, with a fifteen minutes half-time break in between. Soccer is by nature a strength and power-contact sport involving high-intensity activity, training and competition (Alghannam 2013; Williams 2012; Tumilty 1993). It is a physiologically demanding game of acyclical and intermittent, high-intensity activity (Williams 2012; Mohr, Krustrup and Bangsbo 2005; Reilly 1997; Tumilty 1993), incorporating irregular changes of pace and anaerobic efforts (Reilly and Doran 2000) as well as longer period of low-level, moderate-intensity exercise, challenging a variety of physiological systems (Alghannam 2013). In a top competitive match at elite level, players typically perform between 1000 and 1400 different types of activity, mainly short in nature (Clemente et al. 2013; Mohr, Krustrup and Bangsbo 2003; Rienzi et al. 2000; Reilly and Thomas 1976) at different intensities (Stolen et al. 2005). These activities may be broken down into a range of running and walking speeds including cruises and sprints, jumps, multidirectional movements namely running backwards and sideways as well as stopping, starting, cutting, turning and jumping (Stolen et al. 2005) at a rate of approximately 5 to 6 seconds with a very short recovery time (Reilly and Williams 2003) of approximately three seconds every two minutes (Reilly 2003). In terms of high intensity activity it was found that

throughout the course of a match, players engaged themselves in around 150 to 250 high intensity bouts (Mohr, Krustrup and Bangsbo 2003) ranging approximately from 2.5 (O'Donoghue et al. 2001) to 4 seconds (Mohr, Krustrup and Bangsbo 2003; Mayhew and Wenger 1985; Withers et al. 1982) in duration and occurring every 40 to 70 seconds (Bradley et al. 2009; Reilly 1994b; Reilly and Thomas 1976). In this regard, O' Donoghue (2002) similarly provided evidence that 98% of such high intensity bursts are under ten seconds in duration. The most common form of high intensity bouts are in the form of 2 to 5 second sprints which the researchers estimate that occur between 90 to 110 times or once every 90 seconds during the length of a match (Williams 2012; Di Salvo et al. 2010; Rienzi et al. 2000; Reilly 1994a; Reilly and Thomas 1976).

1.2 Total distance covered in soccer

Match analysis provides a means of evaluating both the outcome and process of the team's and players' individual performance (Carling et al. 2008; Reilly 2007) through quantification of the many characteristics of team play and the demands specific to individual playing positions (Carling, Williams and Reilly 2005). The physical demands and compilation of discrete actions or movements (Reilly 1996) at different modes, intensities, duration and frequencies (Stolen et al. 2005) can be determined from match analysis and physiological measurements during match-play such as video-recordings, film analysis, synchronised trigonometric techniques, computer-aided video analysis (Bangsbo 2014) and more recently time-motion analysis (Di Salvo et al. 2007; Rienzi et al. 2000), global positioning systems (Aughey and Falloon 2010; Henning and Briehle 2000), heart telemetry (Coutts et al. 2009; Barbero-Alvarez et al. 2008; Eniseler 2005; Esposito et al. 2004; Ali and Farrally 1991) and maximal rate of oxygen consumption readings (Drust, Reilly and Cable 2000) amongst others. Despite such an array of methods however, which are also considered to be technologically advanced (Carling et al. 2008), work-rate profiles expressed as distance covered are still considered to be the most appropriate performance measurement in soccer (Reilly 2003). It has been suggested that this is due to it being the only means of true representation of a soccer match, since the other nominated methods are restricted to use only during training sessions.

Early studies reported a generally lower overall total distance covered, with Brookes and Knowles (1974), Winterbottom (1959) and Smaros (1980) reporting an overall distance of 3.4, 4.9 and 7.1 kilometres, respectively. In one of the more

advanced studies at that time, Reilly and Thomas (1976) reported a distance of 8.7 kilometres among players in the English First Division. During the same year Ohashi (1988) reported a distance of 9.8 kilometres among Japanese international and league players using cameras for analysis, while Van Gool, Van Gervan and Boutmans (1988) estimated a distance of 10.2 kilometres among Belgian University players. Recent studies have generally shown a higher total distance covered, ranging from 10 to 13 kilometres (Mascio and Bradley 2013; Bangsbo, Mohr and Krustrup 2006; Mohr, Krustrup and Bangsbo 2003) as highlighted in Table 1 below. Such a discrepancy could be attributed to the fact that unlike the most recent studies where players at the top of their national league (Bangsbo 1994) were observed, earlier studies only examined the activity patterns of lower standard and amateur players (Ohashi 1988; Van Gool, Van Gervan and Boutmans 1988; Saltin 1973).

Table 1: Total distance covered in a soccer match

Author (year)	Population	Method of analysis	TDC in a match (metres)
Ohashi et al. (1991)	Japanese International and National League players	Trigonometry	11, 529
Di Salvo et al. (2007)	Spanish Premier League and Champions League players (*n = 300)*	Multiple-camera	11, 393
Miyagi, Ohashi and Kitagawa 1999)	Yugoslavian International players	Trigonometry	10, 460
Rienzi et al. (2000)	South American International players (*n= 17)* English Premier League players (*n*= 6)	Video camera	8, 638 10, 104
Strudwick and Reilly (2001)	English Premier League	Video camera	11, 264
Mohr, Krustrup and Bangsbo (2003)	Professional top-class soccer players playing for an elite European team of which 14 of them also play for their respective national teams (*n*= 18) Professional players from a top Danish league, five of who play for their respective national team (*n*= 24)	Video filming	Top-class players: 10, 860 Moderate players: 10, 330
Thatcher and Batterham (2004)	Professional youth players (*n*= 12)		10, 274
Rampinini et al. (2007)	Professional players (*n*= 18)		10, 864
Di Salvo et al. *(*2007)	Elite European in Spanish and Champions League matches	Automatic computer	11, 393

	(*n*= 300)		
Barros et al. (2007)	Brazilian First Division Players (*n*= 55)	Automatic tracking method	10, 012
Bradley et al. (2009)	English Premier League	Automatic computer	10, 714
Osgnach et al. (2009)	Italian Serie A players (*n*= 399)	Video match analysis	10, 950
Dellal et al. (2010b)	Professional French First Division players	Semi-automatic video system	10, 426 to 12, 030

1.2.1 Total distance covered at different intensities

When analysing total distance covered in a match, it is important to note that total energy expended during soccer participation is greater than covering the equivalent distance by means of running alone (Reilly 2007), due to additional imposed physical demands (Andrzejewski et al. 2012) including environmental influences, level of competition (Mohr, Krustrup and Bangsbo 2003; Bangsbo 1993; 1994b), and sport-specific movements (Armstrong 2006) such as slide tackling, powerful heading, ball possession and long passing which pose significant physiological stress on the player (Bradley et al. 2013; Carling 2010; Bangsbo 1994c). Other contributing factors increasing physiological demands include the individual player's tactical pattern (Rampinini et al. 2007), level of fitness (Krustrup et al. 2005), playing style (Mohr, Krustrup and Bangsbo 2003; Guerra, Soares and Burini 2001) and most importantly, their positional role within the team (Rienzi et al. 2000; Salvo and Pigozzi 1998; Reilly 1997; Reilly and Thomas 1976).

The typical range of activities performed by soccer players may be classified to include walking, low-, moderate-, and high-intensity (or cruising) and maximum effort (sprinting) movements. Other match-related activities include backwards and sideways running, accelerations and decelerations, jumping, shuffling, swerving and turning movements (Bloomfield, Polman and O'Donoghue 2007). There appears to be a consensus in the literature, as a majority of studies show that that the greatest portion of soccer performance (approximately 80 – 90%) is spent engaged in low to moderate intensity activity, while the remaining 8 to 20% represent high-intensity activities (Bangsbo 2014; Bradley et al. 2009; Bloomfield, Polman and O'Donoghue 2007; Spencer et al. 2005; Rienzi et al. 2000). In terms of distance, this equates to approximately 8 to 9 kilometres of low intensity running, and 1.5 to 2.5 kilometres of running at a very quick paces and sprints (Di Salvo et al. 2010; Bradley et al. 2009; Barros et al. 2007). Other studies reporting the distance covered while engaged in varying intensities and movement patterns are presented in Table 2 below.

Table 2: Total distance covered or % of total distance covered at different intensities in a soccer match

Author (year)	Population	TDC	Activity: Standing/ Walking/ Jogging (metres)	Activity: Low speed running (metres)	Activity: Moderate speed running (metres)	Activity: High speed running (metres)	Activity: Sprinting (metres)
Rienzi et al. (2000)	South American International players (*n*= 17)	8, 638			Cruising: 950		345
	English Premier League players (*n*= 6)	10, 104			Cruising: 909		303
Mohr, Krustrup and Bangsbo (2003)	Professional soccer players playing for an elite European team of which 14 of them also play for their respective national teams (*n* = 18)	10, 860	Standing: 2, 117 Walking: 4,539		High speed running: 243 Moderate speed running: 1, 824		650 1, 520
	Professional players from a top Danish league, five of who play for their respective national team (*n* = 14)	10, 330			High speed running: 190		410
Barros et al. (2007)	Brazilian 1st Division Players (*n*= 55)		Standing, walking and jogging: 5, 537	1, 615	1, 731	691	437
Dellal et al. (2011)	Players in the FIFA World Cup 2010 (*n*= 443)					3.9% of TDC	5.3% of TDC

While constituting a minority percentage of the overall total distance covered in a match, the high-intensity efforts are a crucial element in elite soccer performance (Bangsbo 2014; Di Salvo et al. 2009) since the most decisive actions in a match are often performed in this category (Stolen et al. 2005; Mohr, Krustrup and Bangsbo 2003). This also tends to distinguish top-class from sub-elite or lower standard players. Mohr, Krustrup and Bangsbo (2003), showed using computerised time-motion analysis that international top-class players perform 28% more high-intensity running (2.42 vs 1.90 kilometres) and 58% more sprinting (650 vs 410 metres) than professional players at a lower level. Ingebrigtsen et

al. (2012) similarly found that top teams in the Danish league covered 30 to 40% more high-speed running distance when compared with the middle and bottom teams, while Di Salvo et al. (2013) observed that Championship players in England engaged in more high-speed running and sprinting than players in the Premier league, although the differences in this study were small.

1.2.2 Total distance covered at different positions

Each playing position in top-level soccer is characterised by a typical activity profile (Bangsbo 2014; Di Salvo et al. 2007; Mohr, Krustrup and Bangsbo 2003; Rienzi et al. 2000). Time-motion analyses have also indicated significant individual differences in the physical demands of the players, and a degree of positional specificity according to the demands of a particular match (Rienzi et al. 2000; O' Donoghue 1998; Bangsbo 1993; Reilly and Thomas 1976).

Research suggests that the greatest overall distance is covered by midfield players in their role as a link between the defence and offense/attack (Clemente et al. 2011; Dellal et al. 2011; Bloomfield, Polman and O'Donoghue 2007; Bangsbo 1994c; Ekblom 1986; Reilly and Thomas 1979) while central defenders and attackers covered the least overall distance (Dellal et al. 2010b; Rampinini et al. 2007; Di Salvo et al. 2007; Mohr, Krustrup and Bangsbo 2003; Salvo and Pigozzi 1998; Bangsbo 1994c). This shows a difference in both tactical requirements and the physical capacity of the two contrasting playing positions (Mohr, Krustrup and Bangsbo 2003; Bangsbo 1994c). Unsurprisingly, goalkeepers cover the least distance, approximated at about four kilometres during the course of a match (Clemente et al. 2011). It is important to note however that there is a large inter-player variability in the total distance covered by different players, depending predominantly on the individual player's capacity, including their biological potential and level of fitness, as well as other team related considerations such as the level of the match and the tactics employed (Andrzejewski et al. 2012; Mohr, Krustrup and Bangsbo 2003; Shephard 1999). Summarised below in Table 3 are a selection of studies comparing playing positions against total distance covered.

Table 3: Total distance covered by position in a soccer match

Author (year)	Population	Position: Full Backs/ External Defenders	Position: Centre Backs/ Central Defenders (metres)	Position: Midfielders/Central Midfielders (metres)	Position: External Midfielders/ Wingers (metres)	Position: Strikers/ Forwards (metres)

		(metres)				
Reilly and Thomas (1976)	English First Division players	8, 245	7, 759	9, 805	Not studied	8, 397
Mohr, Krustrup and Bangsbo (2003)		10, 980	974	11, 000		10, 480
Di Salvo et al. (2007)	Spanish Premier League and Champions League players	11, 410	10, 627	12, 027	11, 990	11, 254
Barros et al. (2007)	Brazilian 1st Division Players	10, 642	9, 029	10, 476	10, 598	9, 612
Rampinini et al. (2007)	Professional soccer players	11, 233	995	11, 748	Not studied	10, 233
Dellal et al. (2010b)	Professional French First League Players	10, 656	10, 426	Central defensive midfielders: 11, 501 Central attacking midfielders: 11, 726	12, 030	10, 943
Clemente et al. (2011)	FIFA World cup 2010 players	9, 905	9, 169	10, 631	Not studied	9, 875

1.2.3 Total distance covered at different positions at different intensities

A number of studies have suggested significant discrepancies in the intensities experienced by the different positional roles within a team. In an early study, Reilly and Thomas (1976) reported that defenders and forwards covered more distance engaged in walking and sprinting and less in jogging and cruising, while midfield players were found to spend a significantly greater percentage of time performing high intensity activity than defenders and forwards, supporting prior research that showed midfielders cover a greater distance during soccer competition than defenders (Bangsbo 1994c; Withers et al. 1982; Reilly and Thomas 1976).

In Mohr, Krustrup and Bangsbo (2003) the midfielders, full-backs and attackers covered a greater distance engaged in high-intensity running than did the defenders (2.23, 2.46, 2.28 vs 1.69 kilometres, respectively), with the attackers and full-backs covering a greater distance by sprinting than the midfield players and defenders (0.69 and 0.64 vs 0.44 and

0.44 kilometres, respectively). This supports earlier findings by Withers et al. (1982) who reported more than twice as much sprinting by full-backs than central defenders (2.5 times longer), while midfielders and attackers sprinted significantly more than central defenders (1.6 to 1.7 times longer). In a study by Bloomfield, Polman and O'Donoghue (2007), midfielders spent significantly less time standing still than centre-backs and forwards (20 and 23% less, respectively). Also, midfielders were found to spend less time walking (4 to 13%) than the other three playing positions. The highest values recorded for time spent in the high-speed running zone were performed by fullbacks and midfielders, who spent more time in this zone than the forwards (19%) and centre-backs (38%), respectively. Fullbacks spent more time sprinting than centre-backs and midfielders (23 to 42% respectively), while forwards sprinted more than centre-backs (33%). Rampinini et al. (2007) also showed that strikers perform the most maximal sprints and for longer durations, followed by midfielders and defenders (O' Donoghue 1998). In a later study, Clemente et al. (2011) showed that central defenders spend the least time engaged in medium and high-intensity activity. Similar findings were reported by (Bangsbo 1994c), who found that defenders were observed to cover a smaller total distance engaged in high-intensity running than other players. Carling et al. (2008) showed that external midfield players cover the most high-intensity running distance specifically when their team was in possession of the ball, an incidence also observed by Bradley et al. (2013) in the English Premier league.

1.3 Substrate utilisation in soccer

Soccer has been described as a stochastic, acyclical and intermittent aerobic event interspersed with periods of high-intensity activities (Bangsbo 2014; Krustrup et al. 2005; Stolen et al. 2005; Wragg, Maxwell and Drust 2000). The total contribution of active play is typically 90 minutes (Reilly 2007), suggesting that the primary energy source during the match (around 90%), is predominantly supplied via aerobic glycolysis (Stolen et al. 2005; Reilly, Bangsbo and Franks 2000). High-intensity intermittent periods of the match however require use of the anaerobic systems (Bangsbo, Mohr and Krustrup 2006; Al-Hazzaa et al. 2001; Aziz, Chia and Teh 2000). The ratio of low-to-high intensity exercise in terms of distance covered is estimated at about 5:2, or about 7:1 when based on time (Reilly 2007). Players must therefore possess sufficient aerobic and anaerobic capacity to sustain performance in, and quickly recovery from, such intermittent and repeated bouts of high-intensity effort.

The fuel sources that sustain exercise are generally dependant on the intensity and duration of effort, as well as the nutritional and training status of the athlete. The ability of a muscle to perform long duration exercise depends on, among other things, the supply of sufficient blood, oxygen and nutrients. The chemical energy provided by the dietary nutrients is stored by the body in the form of an energy-rich compound known as Adenosine Triphosphate (ATP), which provides the immediate energy for muscular contraction via the conversion of Adenosine Diphosphate (ADP) to ATP. The energy released by this process meets the contractile energy demand of protein filaments, causing the muscle to develop force (Williams 2012). There is however, only a small amount of ATP stored within each muscle cell, lasting only a few seconds. ATP is constantly reconstituted as it is used. The rate at which ATP is used by the muscle cell depends on how many muscle fibres are recruited. In order to prevent ATP stores from running low, there exist three distinct processes designed to replace ATP at a rate that meets demand, and because soccer is a hybrid sport, during a match the muscles are required to utilise all three known energy sources to produce ATP (Williams 2012; Bangsbo, Mohr and Krustrup 2006; Shephard 1999).

The aerobic system is highly taxed according to studies which show average and peak heart rates to be in the region of 85 and 98% of maximal values, respectively (Bangsbo, Mohr and Krustrup 2006; Krustrup et al. 2005; Bangsbo 1994a; Ali and Farrally 1991; Ekblom 1986; Reilly and Thomas 1979), corresponding to an average oxygen uptake of around 70% of maximum (Bangsbo 2014; Andrzejewski et al. 2012). Activities fuelled by such metabolic processes include low to average speed running. On the other hand, the anaerobic system fuels the high intensity actions during a match, such as tackling, jumping, high-intensity and sprinting (Rhea et al. 2009; Aziz, Chia and Teh 2000), as well as other sport-specific manoeuvres such as position contention and ball possession (Reilly 2007; Aziz, Chia and Teh 2000). Blood lactate concentrations of 2 to 10 mmol $\cdot$ L^{-1} observed during soccer matches, with individual values as high as 12 mmol $\cdot$ L^{-1} and above (Krustrup et al. 2006; Bangsbo 1994b; Ekblom 1986), indicate that the rate of muscle lactate production is also high during match-play (Bradley et al. 2009; Krustrup et al. 2006; Mohr, Krustrup and Bangsbo 2003).

1.4 Energy expenditure for a soccer player

The fact that soccer is a hybrid activity comprising training and match-play that varies in terms of intensity and duration (Eniseler 2015), it is challenging to precisely determine its exact energy cost (Williams 2012). Research has shown that

energy expenditure per time unit is directly proportional to the intensity level of the exercise task. Hence, the energetic and metabolic demands of soccer training and match-play also vary across the season as a result of environmental influences, standard of competition, patterns of play and their playing position (Burke, Loucks and Broad 2006; Shephard 1999; Di Salvo and Pigozzi, 1998; Reilly 1997; Reilly and Thomas 1976). Such energetic requirements are also unique for each soccer player, arising from the contribution of basal metabolic rate, thermic effect of food and thermic effect of activity (Manore and Thompson 2006).

Bangsbo (2014) estimated the energy expenditure in a match to be in the region of sixteen kilocalories (kcal) per minute, tallied to 1400 kcal for the entire duration of a 90-minute match. At elite level, up to 2000 kcal could be expended throughout the total duration of a match (Bangsbo et al 2006; Bangsbo 2014). In their study, Coelho et al. (2010) specifically reported an energy expenditure of 1540 ± 130 kcal per player during a single match among U20 soccer players in the first division Brazilian league. In an early review, Shephard (1992) had reported an energy expenditure estimate of 1565 kcal, while Stolen et al. (2005) more recently estimated that an average player with a maximal rate of oxygen consumption of 70 $mL \cdot kg^{-1} \cdot min^{-1}$ expended the equivalent of 1772 kcal during a competitive match. Table 4 below presents further studies estimating total energy expenditure in a soccer match. As regards to the energy expenditure in soccer training, variance is again seen according to the composition of the particular exercise session (Eniseler 2015). In one of the few studies estimating energy expenditure in soccer training Reilly and Thomas (1979) reports an expenditure of between 1080 and 1350 kcal among English professional players, although the general tempo of training has since significantly changed. New research in the field is likely to feature augmented figures.

Table 4: Energy expenditure in a soccer match

Author	Population	Energy expended in a match (kcal)
Reilly and Thomas (1979)	Professional English players	1566
Bangsbo (1994c)	Danish players	1360 for players weighing 75kg player
Garcia et al. (2005)	Brazilian professional players	1021
Osgnach et al. (2010)	Italian Serie A players	1314

The most common method of estimating energy expenditure is through the use of total distance covered, providing a useful scale of work rate averaged over the entire duration of the match (Alghannam 2013). This method however, tends to under-reflect true energy expenditure, as the thesis is based on the assumption that exertion occurs only when the player significantly changes location on the playing surface, and excludes whole body movements that are a characteristic, integral, and defining part of any soccer game (Di Salvo et al. 2007). These are namely translated and expressed via repeated random bouts of high intensity anaerobic and aerobic activity, frequent alterations of activities including the numerous accelerations and decelerations, changes of direction, unorthodox movement patterns and the execution of various technical skills (Williams 2012; Dellal et al. 2010a; Armstrong 2006; Burke, Loucks and Broad 2006; Bangsbo 1997; Reilly 1997; Reilly 1996; Shephard 1992) that either individually or in conjunction significantly accentuate metabolic loading, which in return may ultimately drive players to the threshold of exhaustion (Do Prado et al. 2006; Reilly and Ekblom 2005). Global tracking positioning systems have also been used to estimate energy expenditure, but their prohibited use during official games makes such data difficult to collect and access. Advanced new technology has been used in an attempt to address this gap, as seen in study by Walker et al. (2015) who used inertial sensors in the form of tri-axial accelerometers to estimate energy expenditure in team sport training.

Estimating the total daily energy requirement for each player is fundamental in understanding the individual's overall Total Daily Energy Expenditure (TDEE). Other individual daily energy costs from physical activity and lifestyle factors must be added to the calculated energy cost from soccer training or match-play after first calculating the individual's players Basal Metabolic Rate (BMR). An accessible and practical way of estimating this is to use predication equations of BMR using age, gender, height and body mass [BM] as suggested by Harris and Benedict (1919). Estimated BMR results are then multiplied by various activity factors to determine the player's TDEE. A more complex, yet more precise way of estimating energy expenditure may be achieved through the use of Metabolic Equivalent of Task (MET) that every player expresses throughout the day, information recorded using a detailed activity diary. The energy cost of activity undertaken throughout the day is then summed up to predict the TDEE. Research has shown the estimated TDEE of elite soccer players to be in the region of 3550 kcal per day, ranging from 3100 to 4050 kcal for the lightest and heaviest soccer players, respectively (Rico-Sanz et al. 1998; Reilly and Thomas 1979). In a popularly cited study, Reilly and Thomas (1976) reported a daily expenditure of 3439 kcal among the English league professional players using

heart rate monitoring and activity records for assessment, while Rico-Sanz (1998) estimated an overall daily expenditure of 3821 kcal using activity records as a means of assessing TDEE among Puerto Rican Olympic players. Similarly, Ebine et al. (2002) reported a value of 3532 kcal per day among Japanese professional players using the "doubly labelled water method". The latter, combined with indirect calorimetry provide a more accurate measurement of energy expenditure; however its complex, time-consuming and costly use renders its application in the field of soccer research difficult.

1.5 Fatigue in soccer

Fatigue in soccer is defined as a decline in capacity to sustain muscular work, manifested as a reduction in work rate usually occurring towards the end of the match (Reilly, Drust and Clark 2008; Mohr, Krustrup and Bangsbo 2003). As the exercise intensity increases or the duration is prolonged, difficulty in supplying energy at the required rate may arise, and fatigue develops (Hargreaves 2000). At high standards of training and competitive play, players are known to experience observable fatigue (Bangsbo, Mohr and Krustrup 2006; Reilly 1997), which is indeed one of the major limiting factors in soccer performance, especially during the anaerobic phases of the match (Bangsbo, Mohr and Krustrup 2006).

1.5.1 Causes of fatigue

A more comprehensive understanding of the underlying mechanisms affecting the onset of fatigue towards the end of a match is arguably of vital importance, given that the majority of soccer players succumb to it (Mohr, Krustrup and Bangsbo 2003). The causes are multifactorial (Williams 2012; Bangsbo, Iaia and Krustrup 2007; Nybo and Secher 2004), and may involve various mechanisms acting centrally and peripherally (Alghannam 2012) with one of the main mechanisms to fatigue during a soccer match being the depletion of liver and muscle glycogen (Krustrup et al. 2006; Rico-Sanz et al. 1999). Indeed, an exercise-induced elevation of lactate in active muscle was orginally postulated to contribute to a temporary decline in performance during intense periods during the match (Krustrup et al. 2006). Other physiological factors contributing to fatigue include an increase in metabolic acidosis (Bangsbo, Iaia and Krustrup 2007), reduction in plasma glucose (Costill and Saltin 1974), dehydration (Nedelec et al. 2013), phosphocreatine depletion and a reduction of intramuscular ATP availability (Bangsbo, Iaia and Krustrup 2007). The most straight-forward contributing

factor to fatigue that has been observed consistently over the years however has been muscle glycogen depletion (Foskett et al. 2008). Low levels of pre-exercise glycogen were first investigated by Saltin (1973) and Shephard and Leatt (1987), who found that less glycogen available at the start of exercise resulted in, players reaching exhaustion sooner.

In an early study, using information gathered from muscle biopsy samples, Agnevik (1970) showed that players' glycogen stores were nearly emptied after a match. Saltin (1973) observed that muscle glycogen stores were almost fully depleted at half-time when pre-match values were low (~ 200 mmol · kg^{-1} d.w. $^{-1}$), with the values still somewhat high at half-time, but below 200 mmol.kg^{-1}dry $weight^{-1}$ at the end of the match. A 31% and a 49% reduction in glycogen concentration in the vastus lateralis was reported by Currie et al. (1981) and Smaros (1980), respectively. Krustrup et al. (2006) also observed a depletion of muscle glycogen stores during soccer match-play following a number of repeated sprint bouts. In that study, the authors investigated muscle glycogen levels pre- and post-match, and observed a decrease (449 ± 23 – 255 ± 22 mmol · kg^{-1}d.w. $^{-1}$) in overall muscle glycogen levels. The difference in muscle glycogen content represents the net utilisation of muscle glycogen, however not all studies have reported such depletion (Krustrup et al. 2006). Jacobs et al. (1982) reported concentrations of ~ 200 mmol · kg^{-1}d.w.$^{-1}$ at the end of a match, indicating that muscle glycogen stores are not always, so significantly depleted. Analysis of single muscle fibres after a match in this same study did however reveal that a significant number of fibres are indeed depleted or at least partially depleted at the end of a match (Krustrup et al. 2006). In a more recent study Bangsbo, Iaia and Krustrup (2007) reported a 40% to 90% muscle glycogen concentration reduction throughout the course of a match.

Hargreaves (1994) argues that the activity profile of soccer places a heavy demand on the body's liver and muscle glycogen stores, and as a match progresses it steadily declines (Williams 2012; Bangsbo et al. 1992) at a rate depending on a range of factors including, but not limited to, the level of competition and fitness level of the player, as well as the duration and intensity of the match (Hargreaves 1994; Bangsbo et al. 1992; Saltin 1973). A significant causal factor leading to muscle depletion may be extensive eccentric muscle contractions (Doyle, Sherman and Strauss 1993), a type of muscle action which in itself has been shown to decrease the rate of glycogen re-synthesis and lead to increased glycogen utilisation during subsequent exercise (Asp et al. 1998). The same can be said of high intensity and alternating fast and slow running bouts during the course of soccer match, since the sustained repetition of such

patterns tends to reduce muscle glycogen concentrations and result in a consequent decline in performance (Alghannam 2011; Bangsbo, Mohr and Krustrup 2006; Burke, Kiens and Ivy 2004; Bangsbo, Norregaard and Thorsoe 1992; Nicholas et al. 1999; Reilly 1997; Bangsbo 1994b; Kirkendall 1993) most commonly towards the end of the match.

1.5.2 Consequences of fatigue

The influence of fatigue on physical performance has been extensively researched in soccer. Fatigue can be defined as a decline in performance despite the necessity to continue performing, which manifests in a deterioration in work-rate towards the end of a match (Reilly 2003). Researchers tend to frequently discuss two types of fatigue in particular: central and muscle fatigue. In the former, there is a loss of motivation and reduced activation of the central nervous system which can be conscious or unconscious usually resulting from hypoglycaemia, while the latter is the actual fatigue occurring in the muscle fibres resulting from ATP depletion and the accumulation of lactic acid (Williams 2012). Whichever the type of fatigue, ultimately it results in the muscle producing less force (Bangsbo 2014), which has been shown to impair physical abilities both during and after brief periods of high-intensity activity (Mohr et al. 2004) following forty-five minutes of soccer-specific exercise (Oliver, Armstrong and Williams 2007; Ali et al. 2007), as well as at the end of competitive and simulated matches (Mohr, Krustrup and Bangsbo 2003; Rahnama et al. 2003; Thompson, Nicholas and Williams 1999). Indeed, fatigue manifests itself in a number of performance-related ways, including the player's inability to sustain physical activity at a given intensity, leading to a progressive reduction in muscle strength which in itself is required to sustain a consistent work-rate throughout the course of a match (Bangsbo, Iaia and Krustrup 2007; Bangsbo 1994; Kirkendall 1993), most commonly towards the end (Mohr, Krustrup and Bangsbo, 2005; 2003; Rahnama, Reilly and Lees 2002; Van Gool, Van Gervan and Boutmans 1988; Reilly and Thomas 1976).

1.5.2.1 Reduction in total distance covered

Motion analyses of professional soccer play has demonstrated intra-match declines (Iaia, Rampinini and Bangsbo 2009) and inter-match variations (Williams, Abt and Kilding 2010) in physical performance. In effect, match profiling shows that players may experience impaired performance transiently (Rampinini et al. 2007; Mohr, Krustrup and Bangsbo 2003), occurring specifically during different phases of a match; after short-term periods of intense activity, at the initial phase of the second half, overall in the second- versus the first- half (Weston et al. 2011) and in the final period towards the

end of the match (Mohr, Krustrup and Bangsbo 2005; Alghannam 2012; Bradley et al. 2009; Mohr, Krustrup and Bangsbo 2003). Researchers have observed a reduction in the total distance covered in the second half when compared with the first, indicating that fatigue is developed in the second half, despite total distance covered not constituting the best indicator of physical performance in a match (Bangsbo 1994). In an early study, Agnevik (1970) adjudged that the same players ran less distance during the second half when compared to the first, presumably as a result of declining energy availability. Saltin (1973), found that a significant reduction in muscle glycogen after 90 minutes of match-play resulted in less total distance covered by players with lower levels of muscle glycogen when compared to those with higher levels. A decline in work-rate during the second half was also found in later studies by Van Gool, Van Gervan and Boutmans (1988), as well as by Reilly and Thomas (1976). According to the latter, Belgian players covered 444 metres less in the second half of the match than in the first. Bangsbo et al. (1991) reported that the distance covered in the first half was 5% greater than in the second. Temporary fatigue has also been evidenced in a study by Krustrup et al. (2006) whereby players performed a repeated sprint test immediately after an intense period during each half, and also at the end of each half. The findings in such studies show that after intense periods in the first half, players' sprint performance is significantly reduced, whereas by the end of the first half, the ability to perform repeated sprints is recovered. Table 5 below shows some of the more recent studies elucidating the effects of fatigue on the total distance covered throughout each half of a soccer match.

Table 5: Distance covered in the 1st and 2nd half in a soccer match

Author (year)	Population	Distance covered in 1st half (metres)	Distance covered in 2nd half (metres)	Difference between distance covered in each of the halves (metres)
Rienzi et al. (2000)	South American professionals (*n*= 18)	4, 605	4, 415	190
Mohr, Krustrup and Bangsbo (2003)	Top class players (*n*= 18)	5, 510	5, 350	160
	Moderate players (*n*= 24)	5, 200	5, 130	70
Barros et al. (2007)	Brazilian First Division Players (*n*= 55)	5, 173	4, 808	905
Di Salvo et al. (2007)	Spanish Premier League and Champions League players (*n*= 300)	5, 709	5, 684	25
Bradley et al. (2009)	English Premier League players	5, 422	5, 292	130

(*n*= 370)

1.5.2.2 Reduction in total distance covered at high intensity

Total distance covered specifically at levels of high intensity has also been shown to be reduced in the second half when compared to the first, in both elite and sub-elite soccer (Carling and Dupont 2011; Coelho et al. 2011; Bradley et al. 2010; Di Salvo et al. 2009; Krustrup et al. 2006; Mohr, Krustrup and Bangsbo 2003; Reilly 1997; Reilly and Thomas 1979). Overall, high-intensity running and sprinting appear to be the most affected in terms of performance after versus performance before a soccer match (Mohr, Krustrup and Bangso 2005; Mohr et al. 2004; Rebelo 1999). This could be due to the reliance of high-intensity bouts of activity on muscle glycogen and blood glucose levels as a substrate for the sustained high rate of ATP re-synthesis (Balsom et al. 1999a; Parolin et al. 1999; Nicholas et al. 1995; Gaitanos et al. 1993; Costill and Hargreaves, 1992; Saltin 1973). When muscle glycogen concentrations fall below the critical threshold of approximately 175 $mmol.kg^{-1}d.w.^{-1}$, the ability to perform high-intensity exercise is significantly affected, particularly in the second half (Mohr, Krustrup and Bangsbo 2005; 2003; Bangsbo 1994; Reilly and Thomas, 1979) and even more so in the last fifteen min of a top-class match (Mohr et al. 2003). This is mainly attributed to the rapid depletion of ATP-PC and the relatively short time available to replenish phosphocreatine stores (Krustrup et al. 2006; Van Someren 2006; Mohr, Krustrup and Bangsbo 2005; Mohr et al. 2004; Rebelo, 1999; Hawley, Dennis and Noakes 1994). According to Mohr, Krustrup and Bangsbo (2003), both elite and sub-elite soccer players covered a greater distance in high-intensity running in the first half of a match than in the second (top class: 1.27 vs 1.15 kilometres; moderate: 1.01 vs 0.9 kilometres, respectively). Additionally, the distance covered sprinting for top-class and moderate players was also greater in the first half of a match than in the second (0.35 vs 0.30 kilometres; and 0.21 versus 0.19 kilometres, respectively). Such a decline in sprint performance in the second half as a consequence of fatigue has been generally consistent, and further shown to be independent of the positions held by players within the team. Other studies have also reported that in the case of various top European leagues, soccer players had a reduced ability to perform repeated sprints after a soccer match when compared to their ability to do so before it (Di Salvo et al. 2009; Bradley et al. 2009; Rebelo et al. 1998).

It is important to note that even though the above data appears to be consistent in demonstrating a decrease in performance in the second half of a match, the debate regarding the validity of relatively simplistic comparisons of total distance covered in each half to the onset of fatigue, is still ongoing (Edwards and Noakes 2009). It has been postulated that teams and players may pace their efforts in order to sustain a given work-rate throughout the duration of the match, suggesting that players may intentionally exert an effort below their physical capacity in the second half as an energy-sparing technique (Carling et al. 2008). It is interesting to note that in a study conducted by Di Salvo et al. (2007) on players in professional Spanish soccer clubs and other teams participating in UEFA Champions League matches reported no statistical difference across halves in high-intensity running performance, highlighting the need for further research in the area.

1.5.2.3 Skill deterioration

Little research has investigated the effects of fatigue on technical performance during soccer match-play (Russell and Kingsley 2014). Skill deterioration is however, inevitably one of the most important aspects of the match, directly affected by fatigue, with signifucant effects on match outcomes. The high-energy cost of soccer can lead to muscle glycogen depletion, thus increasing the muscle's reliance on blood glucose, in turn causing hypoglycaemia, and limiting the amount of fuel available to the brain (Williams 2012). This latter consideration appears relevant since factors affecting the brain and central nervous system will similarly adversely affect a player's physical and mental performance on the field (Williams 2012; Welsh et al. 2002). This may cause a number of adverse outcomes including technical errors, lapses in concentration, reduced fine motor and skill coordination, as well impaired ability to make relevant tactical decisions (Russell, Benton and Kingsley 2011; Rampinini et al. 2009; Ali et al. 2007; McGregor and Williams 1999; MacLaren 1996; Reilly and Williams, 1996) mostly affecting dribbling (Stone and Oliver 2009; McGregor and Williams 1999), passing (Russell and Kingsley 2014; Rampinini et al. 2009) and shooting (Russell and Kingsley 2014; Stone and Oliver 2009). Other studies exploring the effects of fatigue on skill performance however, have shown that technical abilities are not always affected, as posited by Carling and Dupont (2011), who found that elite French players were generally able to maintain their skill-related performance throughout the course of an entire match. Similarly, Abt, Zhou and Weatherby (1998) found no deterioration in the performance of shooting and dribbling tasks undertaken before and after a sixty minutes intermittent treadmill run when recreational players consumed different CHO intakes (8

vs 4 g·kg^{-1} BM) in the forty-eight hours before a simulated match. It is questionable however, whether the treadmill protocol used in this research was really a reliable and valid measure of match skills where sufficient glycogen degradation takes place. Nonetheless, one could then also explore additional factors other than fuel depletion leading to skill deterioration occurring during real match-play. Given the assumed link between skill maintenance throughout match-play and final score-line outcomes, further research on the effects of enhanced fuel status on skill deterioration is warranted.

1.6 Dietary habits in soccer players

Despite salient studies reporting the benefits of optimal nutrition in soccer performance (Ono et al. 2012; Hassapidou 2001; Rico-Sanz et al. 1998; Maughan 1997; Jacobs 1982) existing research on soccer players across multiple age groups reveals many nutrition concerns, in which a significant irregularity of intake for optimal performance appears to exist. Several studies have shown players with a low TDEI to be in a state of energy deficit (Russell and Pennock 2011; Le Blanc, Le Gall and Grandjean 2002). While dietary intake among male soccer players ranges quite widely between studies, the typical daily energy intake reported in a study by Garcia-Roves et al. (2014) was between 2500 and 3100 kcal. Studies investigating TDEI among male soccer players using a variety of daily intake methods are presented in Table 6 below.

Table 6: Dietary intakes of male soccer players (mean daily intake ± SD)

Author (year)	Population	Data Collection measure	TDEI (kcal)
Jacobs et al. (1982)	Swedish professional players (*n*= 15)	7 day food diary (household measures)	4747 ± 1123
Short and Short (1983)	US collegiate players (*n*= 8)	3 day food diary (household measures)	2964
Van Erp-Baart et al. *(*1989)	Dutch international players (*n*= 20)	4 – 7 day food diary (household measures)	3418
Caldarone, Teanquilli and Giampietro (1990)	Italian professional players (*n*= 33)	7 day dietary recall (household measures)	3059 ± 574
Bangsbo, Norregaard and Thorsoe (1992)	Danish professional players (*n*= 7)	10 day food diary (household measures)	3752
Zuliani et al. (1996)	Italian professional players (*n*= 25)	4 day food diary (household measures)	3657 ± 430
Maughan (1997)	2 Scottish Premier league	4 day food diary	Club 1: 2629 ± 620

	clubs (*n*= 51)	(weighted measure)	Club 2: 3059 ± 526
Rico-Sanz et al. (1998)	Puerto Rican Olympic team players (*n*= 8)	12 day food diary (household measures)	3944 ± 1076
Ebine et al. (2002)	Japanese professional players (*n*= 7)	7 day food diary (household measures)	3107 ± 574
Reeves and Collins (2003)	English professional players (*n*= 21)	7 day food diary (household measures)	3059 ± 191
Ruiz et al. 2005)	14 to 21 year-old Basque club players (*n*= 81*)*	3 day food diary (weighted measures)	3035 ± 693
Caccialanza, Cameletti and Cavallaro (2007)	Junior teams of an Italian first division team (*n= 43)*	food diary (weighted measures)	Club 1: 2560 ± 636 Club 2: 2640 ± 614
Garrido, Webster and Chamarro (2007)	Elite adolescent Spanish players (*n*= 62)	5 day food diary (weighted measures for main meals and reported intake for snacks)	Buffet-style: 2740 ± 531 Menu-style: 3148 ± 619
Chryssanthopolous et al. *(*2009)	Greek 4th national division soccer players (*n*= 16)	7 day food diary (household measures)	2818
Russell and Pennock (2011)	Young professional soccer players in the UK (*n*= 10)	7 day food diary (household measures)	2831 ± 164
Iglesias-Guitierrez et al. (2012)	16 – 21 year old Spanish first division players (*n*= 108)	3 day food diary (weighted measures)	2794 ± 526
Renon and Collado (2013)	Semi-professional soccer players (*n*= 21)	Food diary	2221
Briggs et al. (2015a)	Male players from English Premier League club (*n*= 10)	7-day self-reported weighed food diary and 24 h recall	2245

Apart from consuming an overall low TDEI, as seen in the table above, several published reports suggest that soccer players consume diets that are not very different from those consumed by the general public. Such intake typically results in suboptimal distribution of energy with respect to the basic energy-producing nutrients, namely in terms of fat and protein levels that are too high when compared to evidence-based recommendations, combined with a generally low carbohydrate (CHO) intake.

1.6.1 Carbohydrate intake

Carbohydrate intake among soccer players has been reported in a number of studies as seen in Table 7 below. A trend these studies indicates low levels of CHO intake among the different populations investigated. This inadequate intake is likely due to low consumption of the main sources of dietary carbohydrates such breads, cereals, fruits and vegetables (Clark 1994) especially at dinner time (Ruiz et al. 2005).

Table 7: Daily CHO intake in male soccer players

Author	Population	Data Collection measure	CHO intake as a % of TDEI or g·kg^{-1} BM
Jacobs et al. (1982)	Swedish professional players (*n*= 15)	7-day food diary (household measures)	47 ± 3% of TDEI or 8.1 g·kg^{-1} BM
Short and Short (1983)	US collegiate players (*n*= 8)	3-day food diary (household measures)	43% of TDEI
Van Erp-Baart et al. *(*1989)	Dutch international players (*n*= 20)	4–7 day food diary (household measures)	47% of TDEI or 5.6 g·kg^{-1} BM
Caldarone, Teanquilli and Giampietro (1990)	Italian professional players (*n*= 33)	7-day dietary recall (household measures)	56% of TDEI
Bangsbo, Norregaard and Thorsoe (1992)	Danish professional players (*n*= 7)	10-day food diary (household measures)	46% of TDEI or 5.5 g·kg^{-1} BM
Zuliani et al. (1996)	Italian professional players (*n*= 25)	4-day food diary (household measures)	56% of TDEI or 7.4 g·kg^{-1} BM
Maughan (1997)	2 Scottish Premier league clubs (*n*= 51)	4-day food diary (weighted measure)	Club 1: 51 ± 8% of TDEI or 4.4 g·kg^{-1} BM Club 2: 48 ± 4% of TDEI or 5.3 g·kg^{-1} BM
Rico-Sanz et al. (1998)	Puerto Rican Olympic team players (*n*= 8)	12-day food diary (household measures)	53 ± 6% of TDEI or 8.3 g·kg^{-1} BM
Reeves and Collins (2003)	English professional players (*n*= 21)	7-day food diary (household measures)	57 ± 4% of TDEI or 5.9 g·kg^{-1} BM
Korkmaz (2004)	All players of the Turkish National soccer Team		55% of TDEI
Ruiz et al. (2005)	14 to 21 year-old Basque club players (*n= 81)*	3-day food diary (weighted measures)	45% of TDEI or 4.7 ± 1.0 g·kg^{-1} BM
Murphy and Jeanes (2006)	English Premier League players (*n*= 22)	7-day food diary (household measures)	51% of TDEI or 4.3 g·kg^{-1} BM
Garrido, Webster and Chamarro (2007)	Elite adolescent Spanish players (*n*= 62)	5 day food diary (weighted measures for main meals and	Buffet-style: 4.4 ± 1.1 g·kg^{-1} BM Menu-style:

		reported intake for snacks)	5.6 ± 1.4 g·kg^{-1} BM
Caccialanza, Cameletti and Cavallaro (2007)	Junior teams of an Italian first division team (*n= 43)*	Food diary (weighted measures)	Club 1: 53 ± 4% of TDEI or 4.9 ± 1.5 g·kg^{-1} BM Club 2: 53 ± 6% of TDEI or 5.0 ± 1.3 g·kg^{-1} BM
Chryssanthopolous et al. (2009)	Greek 4th national division players (*n*= 16)	7-day food record using household measures	43% of TDEI or 4. 2 g·kg^{-1} BM
Russell and Pennock (2011)	Young professional soccer players in the UK (*n*= 10)	7-day food diary (household measures)	56 ± 1% of TDEI or 5.9 ± 0.4 g·kg^{-1} BM
Iglesias-Guitierrez et al. (2012)	16 – 21 year old Spanish first division players (*n* = 108)	3-day food diary (weighted measures)	45 ± 5% of TDEI or 4.7 ± 1.1 g·kg^{-1} BM
Briggs et al. (2015a)	Male players from English Premier League club (*n* = 10)	7-day self-reported weighed food diary and 24 hour recall	5.6 g·kg^{-1} BM

1.6.2 Protein intake

Unlike CHO intake, nutritional assessment of soccer players generally reveals sufficient protein consumption to accommodate even the highest estimates of protein requirements (Alghannam 2013). Reported intakes (Table 8) tend to vary from 1.6 g·kg^{-1} BM (Reeves and Collins 2003) to 1.8 ± 0.1 g·kg^{-1} BM (Ruiz et al. 2005). These findings suggest that emphasis should not only be placed solely on the amounts of proteins ingested, as the recommended intake is easily and sometimes even inadvertently achieved by most soccer players from a variety of food sources with various amino acid profiles, but also on the timing and quality of protein intake (Alghannam 2013). Some of the studies evaluating protein intake among male soccer players are outlined in Table 8 below.

Table 8: Daily protein intake in male soccer players

Author (year)	Population	Data Collection measure	PRO intake as a % of TDEI or g·kg^{-1} BM
Jacobs et al. (1982)	Swedish professional players (*n*= 15)	7 day food diary (household measures)	13.5 ± 1.5% of TDEI or 2.3 g·kg^{-1} BM
Short and Short (1983)	US collegiate players (*n*= 8)	3 day food diary (household measures)	16% of TDEI
Van Erp-Baart et al. *(*1989)	Dutch international players	4 – 7 day food diary	13% of TDEI or

	(*n*= 20)	(household measures)	1.5 g·kg^{-1} BM
Bangsbo, Norregaard and Thorsoe (1992)	Danish professional players (*n*= 7)	10 day food diary (household measures)	16% of TDEI or 1.9 g·kg^{-1} BM
Maughan (1997)	2 Scottish Premier league clubs (*n*= 51)	4 day food diary (weighted measure)	Club 1: 16 ± 2% of TDEI or 1.3 g·kg^{-1} BM Club 2: 14 ± 2% of TDEI or 1.4 g·kg^{-1} BM
Rico-Sanz et al. (1998)	Puerto Rican Olympic team players (*n*= 8)	12 day food diary (household measures)	14 ± 2% of TDEI
Reeves and Collins (2003)	English professional players (*n*= 21)	7 day food diary (household measures)	15 ± 2% of TDEI or 1.6 g·kg^{-1} BM
Korkmaz (2004)	Turkish National Soccer Team (*n*= 24)	7-day food Diary	14% of TDEI
Ruiz et al. (2005)	14 to 21 year-old Basque club players (*n*= 81)	3 day food diary (weighted measures)	18% of TDEI or 1.8 ± 0.5 g·kg^{-1} BM
Garrido, Webster and Chamarro (2007)	Elite adolescent Spanish players (*n*= 62)	5 day food diary (weighted measures for main meals and reported intake for snacks)	Buffet-style: 1.5 ± 0.3 g·kg^{-1} BM Menu-style: 1.6 ± 0.3 g·kg^{-1} BM
Caccialanza, Cameletti and Cavallaro (2007)	Junior teams of an Italian first division team (*n*= 43)	Food diary (weighted measures)	Club 1: 17 ± 2% or 1.5 ± 0.4 g·kg^{-1} BM Club 2: 17 ± 2% or 1.5 ± 0.4 g·kg^{-1} BM
Chryssanthopolous et al. (2009)	Greek 4th national division players (*n*= 16)	7-day food record using household measures	17% of TDEI or 1.6 g·kg^{-1} BM
Russell and Pennock (2011)	Young professional soccer players in the UK (*n*= 10)	7 day food diary (household measures)	16 ± 1% of TDEI or 1.7 ± 0.1 g·kg^{-1} BM
Iglesias-Guitierrez et al. (2012)	16 – 21 year old Spanish first division players (*n*= 108)	3 day food diary (weighted measures)	17 ± 2% of TDEI or 1.6 ± 0.4 g·kg^{-1} BM
Briggs et al. (2015a)	Male players from English Premier League club (*n*= 10)	7-day self-reported weighed food diary and 24 hour recall	1.5 g·kg^{-1} BM

1.6.3 Fat intake

Similar to observations made related to protein intake, but unlike findings related to CHO intake, fat is the most over-consumed macronutrient (Garcia-Roves et al. 2014; Iglesias-Guitierrez et al. 2012; Ruiz et al. 2005). A notable

difference is that in the case of fat, exceeding the recommended amounts is normally involuntary. Foods that are high in fat are more easily converted to storage fat than CHO-rich and protein-rich foods posing problems to the body composition of the player. Furthermore, excessive fat intake frequently constitutes a partial replacement of the total amount of CHO required. In such a scenario, an excessive fat intake is not only contributing to an excessive storage of fat in the soccer player's body tissues, but is also restricting muscle and liver CHO storage capacity (Williams 2012). Table 9 below provides insights about the common percentage values of fat ingested by soccer players as documented in the literature.

Table 9: Daily fat intake in male soccer players

Author (year)	Population	Data Collection measure	FAT intake as a % of TDEI per day
Jacobs et al. (1982)	Swedish professional players (*n*= 15)	7 day food diary (household measures)	29 ± 8% of TDEI
Short and Short (1983)	US collegiate players (*n*= 8)	3 day food diary (household measures)	41% of TDEI
Van Erp-Baart et al. *(*1989)	Dutch international players (*n*= 20)	4 – 7 day food diary (household measures)	35% of TDEI
Bangsbo, Norregaard and Thorsoe (1992)	Danish professional players (*n*= 7)	10 day food diary (household measures)	38% of TDEI
Maughan (1997)	2 Scottish Premier league clubs (*n*= 51)	4 day food diary (weighted measure)	Club 1: 31 ± 5% of TDEI Club 2: 35 ± 4% of TDEI
Rico-Sanz et al. (1998)	Puerto Rican Olympic team players (*n*= 8)	12 day food diary (household measures)	32 ± 4% of TDEI
LeBlanc et al. *(*2002)	French elite soccer players (*n*= 180)	5-day food record	29.1 to 34.1% of TDEI
Reeves and Collins (2003)	English professional players (*n*= 21)	7 day food diary (household measures)	27 ± 3% of TDEI
Korkmaz (2004)	Turkish National Soccer Team (*n*= 24)	7-day food Diary	31% of TDEI
Ruiz et al. (2005)	14 to 21 year-old Basque club players (*n*= 81)	3 day food diary (weighted measures)	38% of TDEI
Caccialanza et al. (2007)	Junior teams of an Italian first division team (*n*= 43)	food diary (weighted measures)	Club 1: 31 ± 6% of TDEI Club 2: 30 ± 4% of TDEI
Chryssanthopolous et al. (2009)	Greek 4th national division players (*n*= 16)	7-day food record using household measures	39% of TDEI
Russell and Pennock (2011)	Young professional soccer players in the UK (*n*= 10)	7 day food diary (household measures)	31 ± 1% of TDEI
Iglesias-Guitierrez et al. (2012)	16 – 21 year old Spanish first division players (*n*= 108)	3 day food diary (weighted measures)	37 ± 5% of TDEI
Briggs et al. (2015a)	Male players from English	7-day self-reported	29% of TDEI

	Premier League club (*n*= 10)	weighed food diary and 24 h recall

1.7 Carbohydrate and performance in soccer

In order to optimise muscle glycogen levels, the provision of diets with high CHO content is advocated (Williams and Rollo 2015). A relatively large body of scientific research shows that diets high in CHO optimise and improve soccer performance. This has been observed in both field and laboratory-based investigations pre-, inter- and post- training, as well as in match simulations. The benefits of adequate CHO supplementation seen in a number of studies vary from an increase in muscle glycogen concentration, reduction in net glycogen depletion, delay in the onset of fatigue and general improvement in performance overall, among others (Table 10). When CHO stores are inadequate to meet the energy needs of the players' training requirements however, a number of mental, physical, and technical parameters are at stake, jeopardising training/playing capacity and the ability to continue a progressive training programme (Burke, Loucks and Broad 2006). This is mainly due to the fact that if a low CHO diet is consumed, CHO stores quickly become depleted and the muscles become unable to meet ATP requirements in support of the high-demands of soccer training and match-play (Bangsbo, Mohr and Krustrup 2006). An excessive CHO intake on the other hand, may alter body composition over the long term (Clark 1994). Sherman et al. (1981) have also posited the existence of an upper limit for CHO intake (around 600 grams per day) beyond which additional CHO does not contribute significantly to muscle glycogen storage and player performance.

Table 10: CHO and performance in soccer

Author	Population	CHO manipulation	Protocol	Result
			Increase in total distance covered	
Sougilis et al. (2013)	Male professional soccer players (*n*= 22)	Two teams on an 84 hours prior diet manipulation consisting of a high (8 g·kg^{-1} BM) or a low (3 g·kg^{-1} BM) CHO diet.	11-a-side soccer match between the two teams on different CHO diets. Dietary manipulation for the teams reversed for the second match	An increase of a total distance of 1.3 km for each player when followed a high-CHO (9.4 km versus 8.1 km) compared to the low CHO diet
			Increase in high intensity and intermittent running	
Bangsbo, Norregaard	Professional soccer	Two teams on a 48 h prior diet manipulation consisting	Intermittent high-intensity field and	An increase of 5.5% or 0.9 km in the distance covered

and Thorsoe (1992)	players	of a high (8 g·kg^{-1} BM or 65 % of TDEI) or a moderate (4.5 g·kg^{-1} BM) or 39% of TDEI) CHO diet	treadmill running for approximately 90 minutes	during intermittent running to fatigue by the high CHO group (17.1 km versus 16.2 km) at the end of the protocol when compared to a normal diet
Foskett et al. (2008)		Subjects consumed either a 6.4% CHO-electrolyte solution or a placebo in a double-blind fashion immediately before each trial (8 mL · kg · BM) and at 15 minute intervals (3 mL · kg · BM) during intermittent high-intensity running to fatigue performance after CHO loading for two days	Intermittent high-intensity running to fatigue protocol	Subjects ran longer in the CHO-electrolyte group (158 minutes) compared with the placebo group (131 minutes)
Balsom et al. (1999a)	Soccer players (*n*= 7)	Two teams on a 48 h prior diet manipulation consisting of a high (67% TDEI) or a moderate (40% of TDEI) CHO diet.	6 s high intensity bouts performed during short-term (<10 min) and prolonged (>30 min) duration at 30 s intervals on a cycle ergometer	Reduction in high intensity work in both protocol durations by the low CHO group when compared to high CHO participants. Low CHO diet resulted in 44% less high intensity running than high CHO diet
Balsom et al. (1999b)	Soccer players (*n*= 6)	Players on diet manipulation consisting of a high (65% TDEI) or a low (30% of TDEI) CHO diet.	Completed a 90 minutes four-a-side match on two occasions	Players performed more (33%) high intensity exercise in the match following the high CHO diet
		Improvement in technical performance		
Abt, Zhou and Weatherby (1998)	Male midfield soccer players (*n*= 6)	One group on a mixed diet, one group on a high- CHO diet both for 48 h	60 minutes intermittent treadmill exercise	Skill performance was not impaired by either of the dietary implementations
Ali et al. (2007)	Male university soccer players (*n*= 16)	Players ingested either a 6.4% CHO -electrolyte drink or placebo solution every 15 minutes of exercise	90 minutes LIST	Sprinting and shooting performance increased in CHO-electrolyte trial Shooting performance was similar for both trials

In a review of some of the fundamental nutritional demands of soccer, the authors stressed the need for a high CHO intake, especially in the two or three days before competition (Hawley, Dennis and Noakes 1994). Several studies have

argued that pre-exercise performance meals high in CHO (carbohydrate loading), are known to boost muscle and liver glycogen reserves (Chryssanthopoulos et al. 2004; Bangsbo et al. 1992) in a way that favourably impacts on prolonged intermittent exercise performance. In a specialised protocol, Balsom et al. (1999b) analysed the movement of four players during a 90-minute four-a-side indoor match following a two-day high (65%) or a low (30%) CHO diet. Assuming an average BM of 70 kilograms (since the authors did not report the BM of the participants), the high CHO diet provided approximately 7.2 $g \cdot kg^{-1}$ BM of CHO, while the low CHO diet provided approximately 3.3 $g \cdot kg^{-1}$ BM of CHO. Results show that in the case of a high CHO diet, players were able to sustain higher intensity exercise during the match. In a study by Chryssanthopoulos et al. (2004), a high carbohdyrate meal breakfast alone, increased the players' muscle glycogen by 10%. In a more recent study, Little et al. (2010) affirmed an improved repeated sprint performance by players who ingested both high and low CHO pre-exercise meals when compared to a fasting state.

Fuelling during exercise is also regarded as an important aspect of performance, especially in the prevention of cramping due to dehydration and electrolyte loss most commonly resulting in turn from a lack of potassium, magnesium, sodium and calcium which all have very specific roles in the provision of energy in soccer (Clark 2014). This usually takes the form of a fluid-based supplement since quick absorption is imperative. Nicholas et al. (1999) reported that CHO ingestion as an inter-exercise nutritional strategy, normally in the form of fluid, has been found to improve exercise capacity during soccer performance at any level of competition by delaying the onset of fatigue, possibly due to the sparing of muscle glycogen. Many studies, which have examined the effect of CHO ingestion during simulated or real life soccer matches, have been comprehensively reviewed by Phillips, Sproule and Turner (2011). These studies have mostly employed the Loughborough Intermittent Shuttle Test (LIST), designed to elicit similar demands to soccer match (Nicholas, Nuttall and Williams 2000; Currell and Jeukendrup 2008). Welsh et al. (2002) report that participants who drank a higher amount of CHO than their placebo counterparts during the test managed to record a 50% improvement in endurance capacity. Nonetheless, in a recent study by Goedecke et al. (2013) group data showed that the ingestion of 700 millilitres of a 7% CHO solution (49 grams) did not significantly improve performance during a simulated soccer match in league soccer players who had normal pre-match nutrition. Yet, when adjusting for BM, increasing CHO intake was associated with improved time to fatigue during the simulated soccer match, emphasizing the fact the personal nutritional strategies based on body size should be used to ensure improved performance during the latter stages of a

match. In studies investigating players' technical performance aspects, researchers have shown that following CHO ingestion during a soccer simulation protocol, players are able to maintain (Williams 2012; Rampinini et al. 2007), and at times improve (Ali et al. 2007), skill and technical abilities, despite the onset of fatigue. Conversely, Zeederberg et al. (1996) found no benefits arising from the ingestion a 6.9% CHO solution during actual match-play, when video analysis was used to analyse skill proficiency such as tackling, heading, dribbling and shooting. Passing and dribbling technical abilities specifically were also found to be unaffected following the ingestion of a CHO-electrolyte solution (Russell and Kingsley 2014). In Goedecke et al. (2013), players did not improve their agility following CHO ingestion via a 700 millilitres of a 7% CHO solution sports drink during a soccer-simulated protocol. Russell, Benton and Kinglsey (2012) also found an attenuated decrement in shooting performance during the simulated soccer match-play when players received a 6% CHO-electrolyte solution at different intervals, as compared to when the soccer players had just taken an electrolyte solution. Debate persists therefore surrounding the effects of inter-exercise CHO supplementation.

A number of studies have also investigated the effects of ingesting a CHO solution both before and during a soccer-simulated protocol. It has been suggested that by doing so, players are able to spare glycogen (Williams 2012; Nicholas et al. 1999; Leatt and Jacobs 1989), reduce the risk of hypoglycaemia (Bean 2006), maintain plasma glucose levels (Ali et al. 2007), and improve running time to fatigue (Welsh et al. 2002; Davis; Nicholas et al. 1995b) in the latter stages of exercise trials (Ali et al. 2007; Welsh et al. 2002). According to Leatt and Jacobs (1989) soccer players who consumed 500 millilitres of a 7% glucose solution ten minutes before a practice match, and the same volume again at half-time, used 39% less muscle glycogen than the players who drank a sweetened placebo, demonstrating that glucose ingestion reduces net muscle glycogen utilisation in soccer match-play. In terms of soccer-related benefits, the most influential factor on performance is the prolonged running capacity experienced by the players following ingestion of a CHO-electrolyte solution before and during a match (Foskett et al. 2008; Balsom et al. 1999b; Nicholas et al. 1995; Kirkendall 1993). Nicholas et al. (1995a) achieved similar results, indicating that players who drank a CHO-electrolyte solution (6.9%) immediately before and during the three-minute breaks between each fifteen minute block of exercise in the intermittent free-running protocol were able to run 2.2 minutes longer during the second part of the test. Sprint performance has also been found to improve during the latter stages of exercise following pre- and inter- exercise CHO ingestion (Welsh et al. 2002). In a review by Phillips, Sproule and Turner (2011) it was concluded that studies are

almost unanimous in supporting the consumption of CHO-electrolyte solutions during prolonged intermittent exercise for maintaining and/or improving exercise performance and capacity. A number of studies in this review however posed methodological concerns, limiting their applicability to actual team matches.

With regards to the post-match role of CHO, it has been shown that adequate intake after exercise maximises recovery speed of muscle glycogen stores, allowing for more frequent and higher-quality training sessions (Maughan and Shirreffs 2007b), and an enhanced ability to facilitate recovery between matches, promoting better adaptations to training (Ono et al. 2012; Austin and Seebohar 2011; Hawley, Tipton and Millard-Stafford 2006; Williams and Serratosa 2006). This strategy elicits an increased rate of muscle glycogen re-synthesis (Ivy et al. 1988) compared to that associated with a normal mixed diet (Coyle 1991). On the contrary, failure to consume CHO in the immediate phase of post-exercise recovery leads to very low rates of glycogen restoration until feeding occurs in a way that peak performance is impaired (Williams 2012). Appropriately-timed ingestion is paramount because it provides an immediate source of substrate to the muscle cells, initiating effective recovery (Ivy et al. 1988). Similar weight is given to the specific type of CHO provided, as research has showed that CHO-rich foods with a moderate or high Glycaemic Index (GI) appear to have some advantages over low-GI choices in promoting glycogen synthesis (Burke et al. 1993), while the form of the CHO fluids or CHO solids does not appear as influential (Keizer et al. 1986). The pattern of food intake also does not appear to affect glycogen storage in overall daily recovery, as long as total CHO needs are met (Burke et al. 2011; Costill et al. 1981).

1.8 Protein and performance in soccer

Amino acids from proteins form building blocks of hormones and enzymes that regulate metabolism and other body functions (FIFA 2010; Wolfe 2006). Protein also plays a key role in the adaptations that take place in response to training, including the repair and maintenance of body tissues (FIFA 2010; Lemon 1994) to counter the increased rates of protein breakdown that normally occur during exercise, repair, and adaptation following the exercise stimulus. Furthermore, even though a minor contributor, the metabolism of amino acids also serves as an auxiliary fuel source (FIFA 2010) during the intense prolonged phases of a soccer match (Hawley, Tipton and Millard-Stafford 2006; Burke et al. 2004; Lemon 1994) occurring typically under extreme conditions such as starvation, when fats and glycogen stores are severely depleted (Williams 2012). Some studies have found that the intake of small amounts (about 20 to 25

grams) of high quality protein such as leucine during and after exercise, enhances protein synthesis and promotes the remodelling of muscle tissue that is an integral part of the process of adaptation to training (FIFA 2010; Maughan and Shirreffs 2007; Korkmaz 2004).

Compared to research on CHO, there are only a few studies investigating the effects of protein ingestion in soccer (Maughan and Shirreffs 2007b; Hawley, Tipton and Millard-Stafford 2006; Tipton and Wolfe 2004). Research on protein nevertheless agrees that protein ingestion near the time of exercise may promote a positive nitrogen balance across the active muscles, and facilitate a more effective adaptation to training. It is more common however, for players to consume an excessive amount of protein in their daily diet (FIFA 2010), perpetuating the popular belief that additional protein increases strength and enhances performance; there is however, no evidence to date of any dietary practices that support this hypothesis (Maughan and Shirreffs 2007). Other studies have conversely suggested that exceeding the recommended intake of protein may actually be detrimental to health. This is likely due to kidney overloading, since all nitrogen surplus resulting from protein degradation must be excreted (Maughan 1997). Korkmaz (2004) however adjudges that the excess protein ingested may simply be used as a substrate for oxidative metabolism, either directly or as a precursor of glucose. In the unlikely scenario that the soccer player fails to meet the recommended daily protein needs, probably due to a restricted energy intake over an extended period of time or a lack of dietary variety, a negative nitrogen balance would be experienced, resulting in increased protein catabolism, which in turn causes a loss of muscle tissue and slower recovery (Kreider et al. 2010). More importantly, evidence suggests that the inclusion of protein with CHO may be beneficial to performance in soccer (Highton et al. 2013). It has recently been shown that adding protein to a CHO supplement increases endurance running capacity towards the end of a simulated soccer match by 43% when compared to a CHO solution with equal energy content alone (Alghannam 2011). Similarly, co-ingestion of protein and CHO may also attenuate decrements of performance towards the end of a match to a greater magnitude than with CHO ingestion alone (Highton et al. 2013). Where a lower amount of CHO is consumed, the co-ingestion of protein (0.4 $g \cdot kg^{-1}h^{-1}$) could be useful for increasing post-exercise muscle glycogen synthesis rates, as it may stimulate insulin secretion, glucose uptake and muscle glycogen synthase (Jentjens and Jeukendrup 2003). This topic is still nevertheless strongly debated, and further research investigating the precise type and amount of each nutrient required to optimise training and competition in soccer is warranted. Indeed in a recent study, Gunnarsson et al. (2013) failed to identify an increase

in glycogen re-synthesis 48 h after a soccer match following the ingestion of a whey protein and CHO enriched diet compared with a normal diet.

1.9 Fat and performance in soccer

Fat is a necessary nutrient that assists in a number of bodily functions including the preservation of body heat (via insulation), cushioning of vital organs, transportation and storage of fat-soluble vitamins, structural integrity of cell membranes and nerve fibres, and perhaps most importantly the provision of valuable energy storage and supply (Kreider et al. 2010; Zello 2006; Clark 1994). While fat is not the primary source of energy in soccer, it is indeed necessary during the low-intensity periods of soccer training and match-play when the aerobic energy pathway comes into play (Bangsbo et al. 2006), especially during periods of rest after high intensity activities during match-play or training (Bangsbo, Iaia and Krustrup 2007; Bangsbo, Mohr and Krustrup 2006; Krustrup et al. 2006). This energy is derived from intramuscular triglycerides or via the blood as free fatty acids, with an estimated 40% of total energy being met from the oxidation of FFA (Krustrup et al. 2006; Bangsbo 1994). Because it is difficult to estimate the contribution of lipid metabolism in intermittent sports such as soccer, lipid intake recommendations are usually calculated with a view of facilitating adequate CHO intake, and not to contribute directly to energy metabolism during soccer play (Rodriguez et al. 2009).

1.10 Hydration and performance in soccer

The high metabolic rates associated with soccer training and match-play have been shown to cause sweat production in both warm and temperate environments (Shirreffs, Sawka and Stone 2006). The literature consistently reports that soccer players lose between three to four litres of sweat throughout the course of a match (Maughan and Shirreffs 2007a; Shephard 1999). In their study, Shirreffs et al. (2005) reported an average sweat rate of 1460 millilitres per hour, which approximates the previously reported values when expressed over an entire 90 minute match. Such a quantity of sweat loss represents a BM loss of between 1 and 2.5 kilograms during matches played in temperate climates, and up to four kilograms when performing in high temperature and humidity levels (Rico-Sanz et al. 1998; Zeederberg et al. 1996; Kirkendall 1993; Ekblom 1986; Smaros 1980). It is worth noting that such losses of fluids, salts and minerals are

highly variable between individuals, even when performing the same exercise at the same intensity, time, climatic conditions and duration (Williams 2012; Shirreffs, Sawka and Stone 2006; Casa et al. 2000).

Such a high amount of sweat lost could lead to a substantial rise in core body temperature (Murray 2007; Edwards and Clark 2006; Casa et al. 2000; Rico-Sanz et al. 1996), especially when the match is played in warm environmental conditions (Monteiro, Guerra and Barros 2003; Sanz-Rico et al. 1996; Shephard 1990) as well as during the intermittent phases of the match when intensity increases (Burke 2001). In such cases, the body tends to dissipate heat and regulate body temperature through sweat, thus losing valuable fluids as well as sodium, chloride, potassium, magnesium and calcium (Casa et al. 2000; Maughan, Leiper and Shirreffs 2000). This may be a precipitating factor leading to muscle cramping (Maughan and Shirreffs 2007). When fluid deficit reaches 3 to 5% of BM, players are likely to start experiencing fatigue (Murray 2007; Nybo and Secher 2004), at which point a decrease in performance is also likely (Casa et al. 2000; Maughan, Leiper and Shirreffs 2000). Such a decrement is manifested in various ways, principally in the impairment of thermoregulatory function (Maughan and Shirreffs 2007; Berning 2002), and possibly some aspects of cognitive function (Maughan and Shirreffs 2007), which may put players at a higher risk of injury (Berning and Steen 1998) while impairing the performance of soccer-specific skills at levels of hypo-hydration equivalent to 2.4% of BM (McGregor and Williams 1999). Specific physical decrements have also been shown, including the deterioration of continuous and intermittent running (Maxwell et al. 1999) as well as sprint performance (Krustrup et al. 2006), accompanied by a reduction in aerobic power, muscular endurance and strength (Fogelholm 1994). Severe dehydration can ultimately lead to life-threatening conditions including heat exhaustion, and in extreme cases, heat stroke (Nichols et al. 2005). Effective hydration strategies are therefore vital for the maintenance of optimum performance throughout training and match-play (Maughan et al. 2004; Casa et al. 2000; Burke 1997; Maughan 1997).

1.11 Nutritional planning in soccer

The International Society of Sports Nutrition (www.sportsnutritionsociety.org) posits the fundamental nutritional priority that athletes consume enough calories to offset the amount of energy expended on a daily basis (Kreider et al. 2010). Soccer training and competition result in increased energy requirements that must be met by increased energy intake for the maintenance of performance capacity, and prevention of excessive fatigue development (Williams 2012; FIFA

2010; Bangsbo 1994; Clark 1994; Lemon 1994). Studies have shown that when energy is less than thirty grams per kilogram of lean muscle mass per day, problems such as tiredness, fatigue, reduced performance and a compromised immune system may follow (Burke, Loucks and Broad 2006).

In the case of semi-professional players with work or educational commitments during the day and training sessions in the evening, various nutritional challenges emerge. With such a hectic schedule, some players may lose their appetites after training, eat poorly, regularly miss meals, and lose weight easily, while others become ravenous and resort to take-away or fast foods. Typically, the energy demands of training and competition require that the soccer player ingest a well-balanced diet in terms of macro and micro nutrient intake, meeting total energy expenditure, with special emphasis on CHO (MacLaren 2003; Reilly 1994a; Korkmaz 1994). The diet plan should also be low in fat, with controlled intake of protein, and adequate intake of fluid to meet hydration requirements (Williams 2012).

Since soccer players generally train at moderate to high intensity, the estimated mean daily energy demand for senior male players has been estimated in the region of between 3500 kcal (Williams 1994) and 4000 kcal on training days (Rico-Sanz et al. 1998; Reilly and Thomas 1979). Factors including training volume and intensity, body size, phase of the season and players' physical status must be taken into consideration in estimating total energy requirements and planning a successful nutritional strategy (Garcia-Roves et al. 2014). Regarding total Calorie consumption, the recommendations suggest a macronutrient intake of 65%, 15% and 20% for CHO, protein and fat, respectively (MacLaren 1996). Similar guidelines of 55 to 65% CHO, 12 to 15% protein, and less than 30% fat were provided by Clark (1994) and FIFA (2010). Expressing daily requirements as percentage (%) of TDEI however, may lead to a misinterpretation of results in terms of absolute macronutrient intake. Nowadays, the use of % of TDEI to calculate energy requirements is wholly discouraged for CHO and protein. Researchers instead prefer to express recommended intake in terms of $g \cdot kg^{-1}$ BM (Garcia-Roves et al. 2014), to more accurately distinguish individual caloric needs. Although these forms of expressing macronutrient intake are not equivalent, they are complimentary, so researchers tend to make use of both options simultaneously in order to provide a more complete overview of macronutrient intake recommendations for soccer players (Garcia-Roves et al. 2014).

1.11.1 Carbohydrate requirements

The CHO recommendations for soccer players have been widely established at between 60 to 70% of TDEI (FIFA 2010; Reilly, Bangsbo and Franks 2000; Maughan 1997; Clark 1994; Hargreaves 1994). More comprehensive recommendations suggest that soccer players engaged in moderate to vigorous training should aim to consume a high CHO diet from nutrient-rich complex CHO food sources ranging from a minimum of 7 $g \cdot kg^{-1}$ BM (Burke et al. 2006; Hawley, Tipton and Millard-Stafford 2006) to 10 $g \cdot kg^{-1}$ BM (Hawley, Tipton and Millard-Stafford 2006; Hawley, Dennis and Noakes 1994; Costill 1988), and up to a maximum of 12 $g \cdot kg^{-1}$ BM for intensive training or maximum glycogen refuelling (Burke et al. 2004). Apart from absolute daily intake, players must also be aware of which foods to choose in order to meet their CHO needs. The quality of the CHO selected also depends on the time of intake (FIFA 2010). The majority of CHO intake should come from nutrient-dense CHO-rich foods, also known as complex CHO, rather than simple CHO characteristic of foods containing refined sugars that are not particularly nutrient-rich (Deakin 1994). CHO are often classified according to their postprandial glycaemic response (Jenkins et al. 1981), which is essentially a ranking of how quickly CHO raises blood glucose levels in the body following ingestion (Foster-Powell, Holt and Brand-Miller 2002; Costill and Hargreaves 1992; Coyle 1991). High GI foods are rapidly digested and absorbed by the body, a process characterised by a rapid increase in blood glucose and an accompanied rise in insulin supply of glucose as substrate, thus acutely increasing liver and muscle glycogen (Jenkins et al. 1981). Foods in this category are those with a GI index of 70 or more, such as bagels, white bread, most breakfast cereals, white rice, sports drinks, soft drinks, sugar, jam, honey and candies among others (Williams 2012; FIFA 2010). Low-GI foods on the other hand are CHO that are digested and absorbed slowly, resulting in a lower rise in circulating glucose (Williams 2012) and insulin (Jenkins et al. 1981). Foods in this category are those with a GI index of less than 55, such as beans, milk, brown pasta and nuts.

1.11.2 Protein requirements

Few studies have specifically evaluated the protein requirements of soccer players (Garcia-Roves et al. 2014). Researchers suggest that soccer players could benefit from a protein intake of 15% of TDEI, provided that adequate energy in the form of CHO is consumed to maintain the energy demands of exercise (FIFA 2010; Clark 1994; Lemon 1994). In terms of $g \cdot kg^{-1}$ BM, researchers maintain that soccer players should aim for a daily protein intake of between

1.2 (Tipton and Wolfe 2004) and 1.4 to 1.7 g·kg^{-1} BM (Boisseau et al. 2007; Boisseau et al. 2002; Tarnopolsky et al. 1992; Lemon 1994), even though the extent of protein metabolism during a soccer match remains unclear considering the varying intensity and duration of physical activity throughout the course of a typical match (Shephard 1999). During periods of intense training, it is suggested that protein requirements be increased up to approximately 2.0 g·kg^{-1} BM (Burke et al. 2016; Lemon 2000). This should come from high protein-rich foods including those animal sources like eggs, cow's milk, cheese, yoghurt, chicken, and fish, despite the considerable amounts of saturated fats associated with some of such choices. Since some protein-rich foods are also high in fat, players need to choose lean meat, and low-fat milk and dairy products, while ensuring that meals are prepared with minimal added fat. In this regard, fish is considered the best choice of protein from the animal sources. Other choices for protein intake are vegetable sources including breakfast cereal, soy milk, nuts, seeds, tofu, legumes and lentils among others (Deakin 1994).

1.11.3 Fat requirements

There are as yet no clear recommendations for fat intake in soccer players, other than not exceeding 30% of TDEI, which should mainly come from unsaturated sources (FIFA 2010; Clark 1994; Hargreaves 1994). As a general guideline however, Kreider et al. (2010) has defined the recommended distribution of fat to be 7% from saturated fat, 10% from polyunsaturated fats, and 13% from mono-unsaturated fat sources.

1.11.4 Micronutrient requirements

Vitamins are vital for the repair of muscle tissue during recovery (FIFA 2010). They also promote growth, maintain health, and are important for the regulation of metabolic processes, synthesis of energy, effective function of neurological processes, and the prevention of cell degradation and destruction in the body (Kreider et al. 2010). Minerals represent a fundamental structural component of tissue and an important constituent of enzymes and hormones (FIFA 2010). They also regulate metabolic and neural processes (Kreider et al. 2010). Recommended guidelines are easily met when players follow a well-balanced diet. Only those players who restrict their total energy intake to meet weight-loss goals or lack dietary variety are at risk of inadequate intake of these micronutrients (Maughan and Shirreffs 2007; MacLaren 2003). Over-consuming them, on the other hand, was not shown to enhance performance, except in cases of pre-existing deficiencies (Kreider et al. 2010).

1.11.5 Hydration requirements

Fluid intake is essential to performance in soccer, since it lubricates joints, regulates body temperature, maintains blood volume, reduces the risk of dehydration, optimises performance and regulates metabolic processes, among other functions (Shirreffs 2010; Dunford and Doyle 2008; Reilly 1997). Players should therefore properly hydrate before, during, and after training and match-play in order to sufficiently keep up with the demands of the game (Kreider et al. 2010; Casa et al. 2000). Maughan et al. (2010) make a general recommendation of 500 millilitres for up to two hours before kick-off. Shirreffs, Sawka and Stone (2006) further develop this recommendation to an equivalent of between 6 to 8 $mL \cdot kg^{-1}$ BM in the same period.

In general, players are typically advised to avoid dehydration during training and competition by ingesting fluids in sufficient quantities to replace individual sweat losses (Aragon-Vargas et al. 2009) however this is sometimes not always possible due to high sweat rates (Coyle 2004) which may significantly exceed the individual's maximum capacity for gastric emptying. As a general rule, players should aim to drink enough to limit net fluid loss to no more than about 2% of BM (Maughan and Shirreffs 2007), even though the intermittent nature of the game has been shown to slow gastric emptying and place an even lower limit on fluid intake capacity (Leiper et al. 2001). It is advised that players drink one litre of fluid for every kilogram of BM lost, but this recommendation is quite generic, thus providing little specialised guidance for individual players engaged in real game situations (Deakin 1994). Since fluid intake seldom matches loss, leaving most to finish training and match-play with a fluid deficit (Guttierres et al. 2011), players are encouraged to take advantage of opportunities to hydrate themselves during breaks in play and intervals (Sawka et al. 2007). Fluid sources should be either water or sports drinks depending on the duration of the session (FIFA 2010; Aragon-Vargas 2004). While water is the most important means of hydration for the player, an isotonic sports drink containing 6 to 8% CHO solution along with approximately fifty milligrams of sodium per hundred millilitres, and smaller amounts of the other electrolytes such as potassium and chloride, is a better option in cases where the duration of the activity exceeds sixty minutes (Kreider et al. 2010). Such drinks assist in the maintenance of serum sodium concentrations during periods of high sweat losses (Montain et al. 2006; Shirreffs et al. 2005), instantly replenish CHO levels as storage capacity diminishes throughout the course of the match (Sawka et al. 2007; Maughan 2006; Coyle 2004), and overall limit the onset of effects detrimental to soccer performance, such as dehydration.

1.12 Nutrition on match-day

Unlike the training diet, menu planning on match-day has received much attention by researchers. Indeed, players and coaches have referred to match-day nutrition as the cornerstone of a successful nutritional (Williams and Serratosa 2006). According to Holway and Spriet (2011), many soccer players and technical staff traditionally consider nutrition on match day as a nutritional priority, a claim also supported by Burke et al. (2006), who adjudged that soccer players traditionally attach more importance to pre and post-match meals than to daily diet, suggesting that nutrient intake is closer to optimal on match days due to the application of a specific dietary regimen. FIFA (2010) suggest that preparation for a match includes not only appropriate training, but also the crucial factor of consuming the right quantities of the right foods.

1.12.1 Pre-match nutrition

The main goals of a pre-match meal are to provide energy to the working muscles (Clark 2014), maximise blood sugar and glycogen stores, minimise hunger during play (Rollo 2014), and maximise hydration (Res 2014), among others. It should specifically counteract early losses of glycogen which essentially leads to hypoglycaemia, fatigue, and impaired performance (FIFA 2010; Williams and Serratosa 2006; Helge et al. 1996; Coyle 1991).

Pre-match meal planning typically begins with consideration of the time schedules surrounding the match. If the match begins in the early afternoon, players will typically have a light breakfast followed by a main meal around midday (Clark 2014). If the match is played later in the afternoon or evening, players will have a late breakfast followed by a light lunch and a pre-match meal during the late afternoon (Clark 2014). Players should start a match on an almost empty stomach, so they are generally advised to focus on low-GI index CHO rich foods to provide a total of 1 to 4 $g \cdot kg^{-1}$ BM during the three to four hour period before kick-off (Williams and Serratosa 2006). Rollo (2014) specifically suggests an intake of 2.5 $g \cdot kg^{-1}$ BM of CHO. A CHO intake of less than 1 $g \cdot kg^{-1}$ BM will force the body to rely more heavily on blood glucose, which does not provide enough CHO to adequately sustain the player throughout the subsequent activity (Maughan et al. 2010). A protein intake equivalent to 1 $g \cdot kg^{-1}$ BM should be added to the pre-match meal, although this is not considered to be a nutrient of utmost importance at this particular time (Williams 2012; Williams and Serratosa 2006).

The meal should contain low-GI, easy-to-digest, complex CHO rich foods, since this results in long-term stable blood glucose concentrations and general feelings of satiety (Stevenson, Williams and Nute 2005). This will also maximise and facilitate body energy storage by helping to 'top up' muscle and liver glycogen stores (Little et al. 2010). Players should unequivocally avoid inappropriate foods such as those containing simple sugars or large quantities of fibre, or those representing high protein sources that inadvertently also contain high concentrations of fats, such as ground beef and dairy products (Clark 2014). Such protein-rich sources take longer to digest and absorb, and are therefore inappropriate for consumption immediately prior to match-play as their slow digestion would interfere with energy provision to the working muscles (Williams and Serratosa 2006).

A pre-match snack with a small dose of CHO that is rapidly digested and absorbed, such as dried fruit and CHO energy bars (Deakin 1994) administered within an hour prior to kick-off, may help to spare muscle glycogen and maintain blood glucose (Shephard and Leatt 1987). The closer the ingestion of CHO occurs to kick-off, the greater the reliance should be on liquid-form CHO, such as fruit smoothies, yogurt drinks, fresh or tinned fruit (Deakin 1994), or sports drinks (Coombes and Hamilton 2000).

In terms of oprimal pre-match hydration, players should ensure they drink sufficient fluid with meals before competition, as well as on the day itself (Williams 2012). As a general recommendation Casa et al. (2000) and Shephard (1999) suggest an intake of 500 millitres or the equivalent of 6 to 8 $mL \cdot kg^{-1}$ BM two hours before kick-off (Shirreffs, Sawka and Stone 2006), followed by as much as possible at half-time, allowing sufficient time for urination of excess fluid before the match continues (FIFA 2010; 2006). When players are exposed to hot weather conditions, it is suggested they drink a further 300-600 mL of fluid during the fifteen minute period immediately before the start of the match (FIFA 2010; 2006; Casa et al. 2000). Shirreffs, Sawka and Stone (2006) suggest an intake of 6 – 8 $mL \cdot kg^{-1}$ BM in the two to three hours before kick-off. While such guidelines are considered to be generally sound for most players, a number of other factors come into play, including exercise intensity and the variability of sweat rates between players and from one match to another (Reilly 1997). More individualised approaches to planning and affecting optimal fluid intake that consider such factors are therefore needed, and could lead to better individual performances.

1.12.2 Inter-match nutrition

The primary purpose of inter-match nutrition is to maintain a sufficient concentration of blood glucose and muscle glycogen storage in order to sustain a high rate of energy production and delay fatigue as much as possible (Williams and Serratosa 2006). This is achieved by consuming adequate fluids that can move through the stomach and into the bloodstream without causing any form of distress to the player during the match (Austin and Seebohar 2011). The best opportunity for the player to replenish some of the fluid and CHO lost during the match is during the half-time interval. In this regard, the most effective and convenient way to consume a combination of fluids, CHO and electrolytes is to ingest a well-formulated isotonic sports drink containing 6 to 8% CHO (Williams 2012; Burke 2010; Kreider et al. 2010; Williams and Serratosa 2006). This choice of intake is easily digested and absorbed, helps maintain hydration status, provides substrate to delay fatigue, and maintains skill and cognitive function to minimise diminishing performance levels towards the end of a match. Other sources may include diluted fruit juices, high-CHO energy bars, fruit, water and gels, although they are less recommended due to their association with gastrointestinal discomfort (Williams and Serratosa 2006).

1.12.3 Post-match nutrition

Recovery from exercise is an active process where tissues undergo repair and reproduction, and fluid balance and substrate stores are replaced. Nutrition is known to be a significant factor affecting the quality of such recovery (Nedelec et al. 2013). The restoration of nutrients and energy stores, particularly CHO at this time (Burke et al. 2006; Ivy et al. 2002), is crucial to the efficient return to normal physiological function, lessening of muscle soreness, and the disappearance of the psychological symptoms associated with extreme fatigue, thereby reducing the risk of injury (Nedelec et al. 2013). The main goal for recovery nutrition in soccer is to replenish glycogen stores, ensuring recovery in time for the next match or training session given the highly congested fixtures that typically characterise soccer at any level (Burke et al. 2006; Adamo, Tarnopolsky and Graham 1998; Fallowfield and Williams 1993). Timing of intake is crucial to ensure rapid recovery at this stage (Kreider et al. 2010; Kerksick et al. 2008). While complete recovery in soccer takes place over a period of up to forty-eight hours (Ivy 1991), the first fifteen minutes are considered as a crucial and effective time window for the ingestion of post-exercise nutrition (Williams and Serratosa 2006) in part due to the increased rate of glycogen synthesis characteristic of this period (Ivy et al. 1988; Costill et al. 1981). An immediate

recovery strategy providing 1 to 1.2 g·kg^{-1} BM per hour of CHO (Burke et al. 2006) is therefore helpful in delivering an immediate source of substrate to the muscle cell (Karp et al. 2006), thus initiating effective recovery (Burke, Kiens and Ivy 2004; Jentjens and Jeukendrup 2003). The quality of CHO ingested also plays a role, as studies have shown that high GI CHO can lead to even more rapid glycogen re-synthesis during the first twenty-four hours of recovery than low GI CHO (Parkin et al. 1997; Burke, Collier and Hargreaves 1993). This could take the form of fresh fruit or juice, breakfast cereal, oats, or CHO based sports nutritional supplements in solid or liquid form (Deakin 1994, Williams 1994). Over a four-hour recovery strategy the recommendation should be equal to 4.0 to 4.8 g·kg^{-1} BM (Burke et al. 2004; Jentjens and Jeukendrup 2003). Jentjens and Jeukendrup (2003) supplied in meals and drinks ingested every fifteen to thirty minutes as the best frequency for recovery nutrition. According to Burke, Colliers and Hargreaves (1993) and Costill et al. (1981) however, the pattern of food intake does not appear to affect glycogen storage in overall daily recovery, as long as total CHO needs are met.

To date, post-match nutrition has often been based on CHO, with the aims of enhancing glycogen restoration (Moore et al. 2009; Williams and Serratosa, 2006; Burke et al. 2004; Ivy et al. 2002; Tipton et al. 2001), stimulating insulin secretion, increasing glucose uptake and muscle glycogen synthase (Jentjens and Jeukendrup 2003), and reducing overall muscle soreness (Millard-Stafford et al. 2005). Latest research however shows that adding a dose of protein to the post-exercise ingestion provides added benefits, such as an enhancement in glycogen restoration (Ivy et al. 2002; Reilly 1997), while also helping to re-build the muscle fibres that would have been damaged during extensive exercise (Res 2014). Maughan et al. (2010) suggest the addition of small amounts (20 to 25 grams) of high quality protein, but such a recommendation is quite generic and therefore challenging to apply in practice with any sort of precision. As a fact, the co-ingestion strategy has been the subject of much debate (Burke, Kiens and Ivy 2004). In light of this however, a more recent study (Nedelec et al. 2013) still supports the timely co-ingestion of a CHO to protein ratio of approximately 3:1, such as for instance, flavoured milk combined with a chicken/honey/peanut butter sandwich. A post-match meal consumed within four hours of the final whistle should comprise a low-fat protein source such as chicken, combined with potatoes and vegetables to satisfy recommended co-ingestion ratios (Nedelec et al. 2013; Borsheim et al. 2002; Tipton et al. 2001).

Effective post-match hydration should equally replace fluid loss, itself dependent on a range of environmental factors including match conditions, duration and intensity (Williams 2012). The ideal choice of post-match beverage will consist of a CHO-electrolyte solution (Shirreffs et al. 1996), with sufficient quantities of sodium to facilitate an increase in water retention, and corresponding decrease in urine output and thirst (Nedelec et al. 2013; Burke et al. 2006; Casa et al. 2000). Shirreffs et al. (1996) further recommend such fluids be ingested in quantities equivalent to at least 150% of the exercise-induced loss in BM, or 1.2 to 1.5 litres of fluid per kilogram of BM lost during the course of the match.

1.13 Barriers for optimal nutrition in soccer

Studies on the dietary habits of soccer players have shown that most do not consume diets that may be considered compatible with peak physical performance, and that such dietary habits leave much room for improvement (Ingram and Davies 1996; Rico-Sanz et al. 1998). Research in other sports has highlighted various barriers that have been shown to hinder elite and other ordinary athletes from achieving optimal dietary practices. These include loss of appetite after training or eating poorly, regularly missing meals, and the temptation to consume take-away or fast foods among others (Heaney et al. 2011; 2008). Irrespective of the causal factors, many athletes tend to have difficulty meeting their daily nutrient and energy requirements, despite knowledge of its profound importance as a primary energy source for the working muscles (Ono et al. 2012). Understanding the influence of these factors is essential for the design and implementation of an effective performance-optimising diet and nutrition education programme (Garcia-Roves et al. 2014).

Deficits in nutritional knowledge and lack of nutritional support by professional people have been shown to contribute mostly to athletes' poor dietary behaviours (Shifflett, Timm and Kahanov 2002). In terms of nutritional knowledge, a number of studies have indicated that most athletes are unable to correctly identify either the roles of certain important nutrients, or the recommended percentages of energy contribution from the macronutrients (Dunn, Turner and Denny 2007; Shifflett, Timm and Kahanov 2002). In a study on the nutritional knowledge and food skills in talented adolescent athletes in different sports, the soccer players faired best in basic and generic nutrition knowledge, answering 68% correct answers (Burkhart and Coad 2010). When tested on more sport-specific nutrition knowledge however, they were the least informed, answering only 37.1% of the questions correctly. When asked about the recommended guidelines for

food and fluid intake before, during and after exercise, the soccer players also struggled, with none of the players knowing what to eat pre-competition, and only 7% knowing what to ingest during. With regards to recovery they fared better, answering 64% of the questions about recommended guidelines correctly (Burkhart and Coad 2010). In another study carried out by Nikolaidis and Theodoropoulou (2014), most sample groups of athletes were shown to be predominantly unable to correctly identify the roles of various important nutrients, or the recommended percentages of energy contributions from the basic macronutrients.

Nutrition information is obtained by athletes from diverse sources including coaches, teammates, athletic trainers, fitness trainers, parents, supplement manufacturers, and the media (Spriet 2015). Unfortunately, many of these stakeholders may be considered unsuitable or unqualified to provide nutritional advice, as the information they convey generally tends to be unreliable and not based on fact, adding to the myths surrounding nutrition that may ultimately negatively affect players' diets (Burns et al. 2004). This is particularly common among coaches, many of whom are former players possessing knowledge of nutrition limited to what they learnt throughout their own professional careers (Ono et al. 2012). As a result, appropriate attention to nutrition is often excluded from the ongoing practical routines and habits of clubs and individual players. In fact, in a study by Ono et al. (2012), it was clearly demonstrated that many professional clubs still do not employ the services of sports nutritionists, or at least do so only infrequently. Only a handful fully utilise and maximise the expertise of dietetic professionals to enhance performance (Ono et al. 2012; Rosenbloom, Jonnalagadda and Skinner 2002). Consequently, existing members of the support staff are responsible for nutrition within the club, who are often limited in their knowledge or influenced by their own ingrained beliefs, possibly riddled by myths and misinformation, or based on anecdotal, non-conclusive, biased or simply inaccurate recollections of isolated personal experiences. This is particularly disconcerting, since for many players the coach remains a primary source of nutrition education, whose nutrition knowledge is often regarded to be accurate and complete (Walsh et al. 2011; Juzwiak and Ancona-Lopez 2004; Shifflett, Timm and Kahanov 2002; Corley, Demarest-Litchford and Bazzarre 1990).

Soccer players tend to acquire and internalise such knowledge as soccer habitus, and unconsciously embody it throughout the career span just as their coaches did before them (Bourdieu 2001), resulting in many false beliefs and misconceptions. The internet represents the latest major source of misinformation and dubious nutritional claims, as

players are regularly exposed to erroneous data propagated by pharmaceutical and sports supplement manufacturers for the express purpose of selling their products (Ostry, Young and Hughes 2007). The controversial state the nutrition field currently assumes only serves to highlight the pressing need for sound and consistent nutrition education. Unregulated websites and news articles supplying or advertising commercial nutrition products often present opinion as fact, or worse, purposely present misleading, skewed or plainly incorrect information related to nutritional recommendations, supplements and diets, which are consequently accepted as fact by unsuspecting soccer players seeking to enhance performance under the otherwise sound premise that sound nutrition duly contributes to this effect (Williams 2012). Players should understand that improvements in performance and fitness occur as a result of long-term changes in diet and effective training, and not via quick-fix solutions as marketing efforts by nutritional product manufacturers might suggest (Williams 2012; Rosenbloom, Jonnalagadda and Skinner 2006).

Financial limitations to purchase nutritious food represent another common barrier to good nutritional practice among soccer players (Hansen 2010; Heaney et al. 2008). Such financial constraints force players to purchase cheaper foods which are not normally as nutritious. Time management issues and living arrangements also commonly influence players' nutritional intake (Heaney et al. 2008). Lifestyle issues remain a consistent problem for players in the transitional phase between home and more independent settings, who may no longer rely on meals prepared by parents or guardians. A significant number of players under such conditions remain unskilled in preparing and cooking their own nutritious meals. Effective time-management becomes a priority in this setting as a result of rigorous academic/work and training schedules, leaving players with insufficient time to shop for and prepare healthy meals. Time-management and cooking skills would therefore constitute essential components of any prospective nutrition education programme as would meal-planning (Hansen 2010; Heaney et al. 2008). Another common barrier to effective nutritional practice among players is the tendency toward infrequent meals (Cole et al. 2005; Jonnalagadda, Rosenbloom and Skinner 2001), which may promote muscle catabolism, fat synthesis and overall undesirable changes in body composition (Benardot et al. 2005). Ruiz et al. (2005) noted that as players get older (20 years and above), they also tend to skip meals or substitute the items they eat, especially in the case of breakfast and snacks. In an age-comparative study, the eldest team skipped the most meals, ingested the fewest Calories, and consumed more fat and less CHO during each meal.

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1.14 Limitations of previous research

While nutrition is said to play a vital role in performance in soccer (Alghannam 2013), as documented in this review of literature, studies agree that most players do not in fact follow diets that are supportive of soccer training and match-play. Despite prevalent research revealing poor dietary habits of soccer players, and the associated detriments this has on performance (Burke, Kiens and Ivy 2004), very little research has been conducted in order to investigate the reasons for such lack of appropriate dietary practice.

No studies were encountered to date, involving the objective testing of personalised and tailored nutrition interventions in soccer. This could in part be due to difficulties in accessing soccer populations and manipulating diets in view of highly congested fixtures. The problem of limited access persists despite the established hypothesis that individualised

and tailor-made nutritional plans that suit players' personal requirements may lead to enhanced performance in soccer (Holway and Spriet 2011; Rico-Sanz 1998). Nonetheless, this does not mean that they do not exist. It could well be that professional clubs conducting such research would not want to reveal the "secrets" of their tested dietary strategies.

Irrespective of prospective causes for such a dearth in literature, the lack of clear, specific, and accepted nutrition guidelines for soccer players may be due precisely to this lack of evidence-based research, perpetuating personal incumbent nutritional theories that are essentially flawed and lacking in scientific validity.

1.15 Study aims

Many factors contribute to success in the sport, and nutrition arguably plays only a small part relative to the influence of genetic endowment, training, motivation and others (Maughan and Shirreffs 2007). All things being equal however, a carefully-planned nutritional plan that meets overall energy expenditure demands, optimises energy stores, reduces fatigue, supports training, achieves and maintains optimal body mass and physical condition, promotes rapid recovery, and supplies adequate hydration can offer additional related benefits and provide a competitive edge over the competition (FIFA 2010; Burke, Loucks and Broad 2006; Manore and Thompson 2006; Murphy and Jeanes 2006). Today, every individual player and every team must strive to achieve every advantage necessary to win in a highly competitive modern landscape, encouraging an understanding among players that proper fuelling through optimal nutrition constitutes an important and integral part of any training programme.

In light of the inconsistencies associated with specialist soccer dietary research, this study attempts to address some of the gaps that exist in the literature as shown in the above review. The researcher has incorporated four systematic studies that ultimately provide a pool of data about nutrition and soccer, on which stakeholders within the game can make informed decisions, hopefully implementing effective nutritional strategies for maximising soccer performance.

The two-year longitudinal study explored a number of aspects of nutrition in soccer.

1. Initially, the researcher specifically established whether optimal nutrition does indeed mark a positive effect in physical performance in soccer. To ascertain this, the researcher tested the physical performance of soccer players from a local Maltese Premier league club via the soccer-specific protocol, the BEAST90$_{mod}$ without a dietary intervention, and again a week after with a 90 h dietary intervention. The rest of the studies utilised the

U21 national soccer team as a population available for the two-year period, in preparation for as well as throughout their European U21 Championship (2013 – 2015) campaign.

2. The aim of the second study was to analyse the energy balance of the national U21 team players during a week of intensive training and a match at the weekend. A systematic analysis of the energy balance was imperative for training adaptation and performance in which the primary concern for each of the players was for energy intake to balance energy expenditure. Pre-match and post-match nutritional strategies as well as daily macronutrient shares were evaluated.

3. The aim of the third study was to explore and understand the U21 players' habits, attitudes, perceptions and barriers towards sound nutritional planning via one-to-one semi-structured interviews. A soccer-related nutrition knowledge assessment was conducted to identify the players' existing knowledge about soccer-related nutrition ahead of the interviews. An interview with the team manager and coach provided further insight into current nutritional support at the organisational level, including the provision of recommendations for improvement. A post-match interview was conducted with each player in the starting formation elucidating their experiences in the match at this pre-nutritional support intervention stage.

4. In the final study, the researcher launched a nine-month nutrition education and support intervention programme with the team. A similar study with such an intense intervention has not been encountered by the researcher to date, and it is believed that the information generated from this study may constitute a valid contribution to the field of nutrition science in soccer. The intervention provided the players with a soccer-specific tailored diet, informative nutrition lectures, daily nutrition information through a Facebook group, and individualised team menus ahead of four international home matches. Baseline research tools used in the previous studies (7-day Food and Exercise diary; perception, habits, attitudes and barriers semi-structured interview; nutrition in soccer knowledge test) were all reused under consistent conditions in this study to measure the effectiveness of a nine-month nutrition education and support intervention. Common players who played in the home international match against the same international side were also interviewed after the match in order to gain feedback about their performance following the nutrition intervention.

Chapter 2

General Methodology

This general methodology chapter describes the main materials and instruments that were used in each of the studies. Some data collection measures were used more than once, in order to elicit differences at pre- and post-intervention phases.

2.1 Participants

The four-interlinked studies were conducted on sub-elite and elite soccer players in Malta. The population of the first study were senior players from a leading club in the local Premier League, while the population for the remaining studies were players forming part of the training squad of the U21 Maltese national team.

The Premier League squad consisted of twenty-two players from an established top-division club who, at the time, were challenging for the title in the most prestigious Maltese league. All players were over eighteen years of age. The players are semi-professional, either working or studying in the morning, and training every evening from 18:30 to 20:30 hours. Their schedules included one competitive match at the weekend, and one or two days of rest per week according to the match schedule. This scenario is by no means unique, and is applicable to other such players in small countries where the game is semi-professional, yet the country is nevertheless involved in international tournaments. The players of the U21 national team were the participants of the other three studies, representing their country in international matches for the European U21 Championship. These players were also semi-professional, combining their college or work schedules with training in the evenings. The players trained with the national team on Monday morning, and Tuesday morning and evening. The Tuesday morning session was optional for those players who did not have any work or college commitments. During the rest of the week, the players trained with their respective clubs, playing one competitive match in the weekend. Across the three studies, the researcher used the same individual players, regardless of whether or not they were called-up by the technical staff for all international matches during the study period. Nonetheless, all the players in the team participated in the studies, no matter at what stage they entered or left the team for inclusion rather than research purposes.

2.2 Subject preparation and documentation

Two separate documentation processes, one for the first study and another for the rest of the studies were conducted. Common documents included the Participant Information Sheet (Appendice 1 and 7), Consent form (Appendice 2 and 8), and Health and Lifestyle Questionnaire (Appendix 3). The information gathered by means of these documents assessed the suitability and risk factors concerning the players participating in this study. While extensive medical tests were conducted on all the players at the beginning of the season by the Malta Football Association (MFA), the researcher still opted to use such forms in order to acquire information about specific medical conditions that might be affected by the requirements of the study.

Upon ethics approval, the researcher contacted the respective technical staff of each of the research participants, requesting an appropriate time to meet the players for an introductory meeting. At this meeting, the researcher explained the aims and objectives of the research and associated procedures verbally and in writing via the Participant Information Sheet. The players were then handed the Consent Form and the Health and Lifestyle Questionnaire which they were asked to read in their own time. Such forms gathered information about the players' food likes, dislikes, allergies and other nutrition-related data, as well as information about the player's medical history and typical daily lifestyle habits and schedules. Participating players filled in these forms and returned them to the researcher within a week. This procedure was repeated ahead of all four studies.

2.3 Anthropometry

Age, height, body mass (BM) and percentage Body Fat (%BF) data were collected from all participants to determine the physical characteristics of the players. Age was recorded through the provision of date of births by the MFA. The BM was recorded with the players standing barefooted, bare-chested and in shorts on a digital balance (Tanita HD-384) to the nearest 0.1 kilograms (kgs). Height was measured with the players standing barefoot against a stadiometer (HM200P Portstad) to the nearest centimetre (cm). Body fat measurements were recorded to the nearest 0.1 millimetres as suggested using Harpenden callipers (British Indicators, UK) and taken at eight skinfold sites; biceps, triceps, subscapular, iliac crest, supraspinale, abdominal, front thigh and medial calf (Withers et al. 1987). This method of body composition monitoring to indicate body composition changes over the study period was chosen due to its practicality to

conduct in a field-based setting, as well as simplicity, practicality and cost-effectiveness when compared to other body composition methods such as hydrostatic weighing or air-displacement methods. The %BF was calculated using the equation attributed to the same author (Withers et al. 1987) where %BF is equal to (0.161 x triceps) – (0.033 x subscapular) – (0.005 x biceps) + (0.175 x iliac crest) – (0.123 x supraspinale) + (0.046 x abdominal) + (0.023 x front thigh) + (0.162 x medial calf) + 6.692. Specifically the sum of eight skinfolds has been suggested to be the most appropriate for soccer players (Wallace et al. 2007), whose study compared with the sum of eight skinfold measure to Dual-Energy X-ray Absorptiometry (DEXA) which is considered to be the 'gold standard' for the measurement of body composition and found no difference in %BF measurement between the two methods ($p > 0.05$), which were also highly correlated ($r = 0.700$; $p < 0.001$). All skinfolds were taken by the researcher who practised the protocol on other players before the actual assessment, closely following the step-by-step instructions for measuring skinfolds according to Eston and Reilly (2001). The researcher was supervised by a qualified ISAK kinanthropometric, Mr. Dermot Galea at all instances where body fat measurements needed to be taken to ensure reliability. The data collected was used to estimate body composition and predict energy requirements.

2.4 Food and Exercise Diary

Local Premier league and international U21 players participating in this study were required to fill in the Food Diary for a period of four days in the first and fourth study and the Food and Exercise diary for a period of seven days in the second study.

The Food Diary, which provided information about each of the players' habitual energy intake, was chosen over other energy intake recording methods such as food recalls, diet history and food frequency questionnaires, because primarily it does not require the participants to rely on memory as they fill in the food sources and portions in real time. It is also considered to be the most common measure used in sports nutrition research (Burke 2015). Recording the foods eaten however may influence what is actually being eaten, also referred to as atypical eating, which could be considered a set-back in the use of this method, as well as the requirement for basic literacy on the part of the players in order to be able to complete it. It is also time-consuming, and that fact that it is a self-reported method of data collection, it requires a degree of honesty and food knowledge to be completed accurately.

Each day in the selected Food Diary was staggered on an hourly basis, with the exception of 00:00 to 06:00 hours which was integrated in one box. The energy intake section included entries for time (in hours), description of food (of basic ingredients), brand name, amount (the number) and measure (in portions). The latter was quantified using household measures like teaspoons, spoons, cups and dishes in fractional amounts (¼, ½, ¾, 1, 2 and so on) to ensure simplicity and thus maximal adherence by the players. This procedure has been widely used by an array of researchers in collecting energy intakes from soccer players (Briggs et al. 2015b; Reeves and Collins 2003; Caldarone, Teanquilli and Giampietro 1990; Jacobs et al. 1982). Examples of common household measures and types of activities undertaken were provided in the footnotes on the page of each day in the diary to facilitate ease of use by the players. A detailed sample of one day of the diary (Appendix 6) was also provided to assist the players during the data collection period. The weighed method of reporting energy intake is considered the gold standard (Burke and Deakin 1994) when compared to household measures, even though it is acknowledged that even this method of measuring dietary intake has inherent limitations and may still be affected by errors of precision and validity (Livingstone and Black 2003; Black 2000). The household measures method was ultimately selected due to its practicality (Bingham 1987) especially when considering the sample group consisted of adolescent soccer players (Reeves and Collins 2003; Caldarone, Teanquilli and Giampietro 1990; Jacobs et al. 1982) who had immediately expressed their concerns about possibly having to weigh their food during the initial information meeting. In order to standardize the household methods dietary collection measure, a standard guideline was created indicating the typical household measures and their respective portion sizes in grams, which the researcher converted to grams or millilitres in the analysis stage for each documented day, for each player.

The diaries were disseminated individually so that a one-to-one explanation could be further provided, at which stage each player was briefed about the common food portion sizes using household measures such as cups, spoons, teaspoons, and dishes in fractional amounts to ensure simplicity and maximal adherence. Before starting the analysis of data, the researcher calculated the EI:BMR ratio (Livingstone and Black 2003; Black 2000) for each player. This was done to detect any suspected under-reporters, which is a common research limitation in such studies (Caccialanza, Cameletti and Cavallaro 2007; Magkos and Yannakoulia 2003; Livingstone et al. 1992). For this study, players with an

energy intake to basal metabolic rate ratio of less than 1.27, which is the minimum value for survival and not compatible with long term health (Goldberg et al. 1991), were eliminated from the study.

The quality and quantity of the foods and drinks consumed were analysed using Microdiet Downlee Systems (2005), Derbyshire, UK for the total caloric intake and the absolute measures of the quantity of each macronutrient in terms of $g \cdot kg^{-1}$ BM and their corresponding percentage of TDEI depending on the specific requirements of each study. As regards the duration of the data collection period, while it is accepted that a single week represents limited insight into a player's customary intake, it is nonetheless considered optimal for preserving reliability and validity by minimising the burden of excessively longitudinal collection periods (Bingham 1987).

In this research, the factorial method of estimating energy expenditure in soccer players provided an accurate measure of the TDEE of participants who filled in the 'exercise' part of the Food and Exercise Diary with intricate detail. Used in the second study, whereby the researcher evaluated the energy balance of the international soccer players, the 'exercise' diary demanded information about each of the players' energy expenditure in terms of activity, intensity and time spent engaged in given activities. Common examples of typical daily activities such as walking, showering, eating, watching television, driving and other natural daily tasks were given by the researcher during the verbal explanation of the procedure. While other methods of measuring energy expenditure such as doubly labelled water and accelerometry are well-contested, the nature of this research required a simpler method of monitoring expenditure throughout seven typical days for a semi-professional soccer player. The doubly-labelled water has been rendered too expensive apart from not being available for measure on the local community, while accelerometry was not cost-effective. The advantage of the recording method chosen of reporting energy expenditure is that it is carried out continuously by the participant so there should be no need for the individual to make guesses to cover gaps of memory. This information was then used to calculate energy expenditure as MET, where energy cost of physical activities as multiples of RMR were calculated (Ainsworth et al. 2000). Each activity was calculated using the formula 0.0175 x MET x weight in kilogram x time in minutes (Heyward 2006). Each day was tallied to 1440 minutes, and the TDEE for each player calculated. The researcher allocated standard durations for eating (30 minutes) and showering (15 minutes), unless otherwise stated. Soccer training, which was normally logged at 120 minutes, was instead logged as 90 minutes, to more accurately reflect the actual time spent training. All the equations used during the data analysis phase took into

account subjective accounts of activity volume, while also acknowledging considerable potential for error in the case of participants failing to keep intricately detailed records. To counteract underestimations of players' energy expenditure levels, the researcher validated the data in a one-to-one player meeting on the day of the activity log submission. Furthermore, it should be mentioned that energy expenditure was calculated based on equations of BMR, and certain activities reported by the players were not matched on the MET compendium list. In such cases, an activity of similar intensity was chosen, a practice potentially influencing the accuracy of the final energy expenditure values calculated.

2.5 BEAST90$_{mod}$ soccer match replicating exercise protocol

The BEAST90$_{mod}$ validated as soccer-performance replicating protocol by Akubat, Barret and Abt (2015) was chosen as the protocol that most closely replicates the internal intensity and external performance (total distance covered 10, 810 ± 664 m) of a player (Akubat, Barret and Abt 2015). This is similar to the documented motion analysis date described in various literature (Clemente et al. 2013; Osgnach 2009; Rampinini et al. 2007; O'Donoghue 2002) and as described in the literature review section.

The reason for not choosing a real match as a performance parameter to the nutritional intervention tested on this soccer-specific protocol was the tendency of match to match variation to be as high as 30% (Williams, Abt and Kilding 2010) rendering the effects of the nutritional intervention immeasurable. A standard protocol was therefore needed, and the BEAST90$_{mod}$ was considered to fulfil this criterion on account of a reported reliability of 2% coefficient of variation, and a test-retest reliability that has been shown to match a cardiovascular function of <2% for total distance covered (Akubat, Barret and Abt 2014). The full version of the BEAST90 (Williams, Abt and Kilding 2010) includes some technical aspects from soccer within the circuit such as heading and shooting, however opting for this version would have compromised the reliability of the circuit, something with which present research is not in conformity. While other protocols used in soccer research, such as Loughborough Intermittent Shuttle Test (Nicholas, Nuttall and Williams 2000) were considered, none replicated the demands of soccer match-play in terms of time, movement patterns, distances, mean heart peak values, aerobic load as well as physical demands in terms of volume and intensity as closely as the BEAST90$_{mod.}$

The selected protocol, conducted on synthetic turf, consists of two identical forty-five minute halves separated by a fifteen-minute half-time. It includes bouts of walking (49 metres; 28.6%), forward running (45 metres; 26.3%), sprinting (12 metres; 7%), backward running (7 metres; 4.1%), decelerations (30 metres; 17.5%), and slalom running (6.4 metres; 3.7%) as well as the two 15 second stops per lap as indicated in Figure 1.

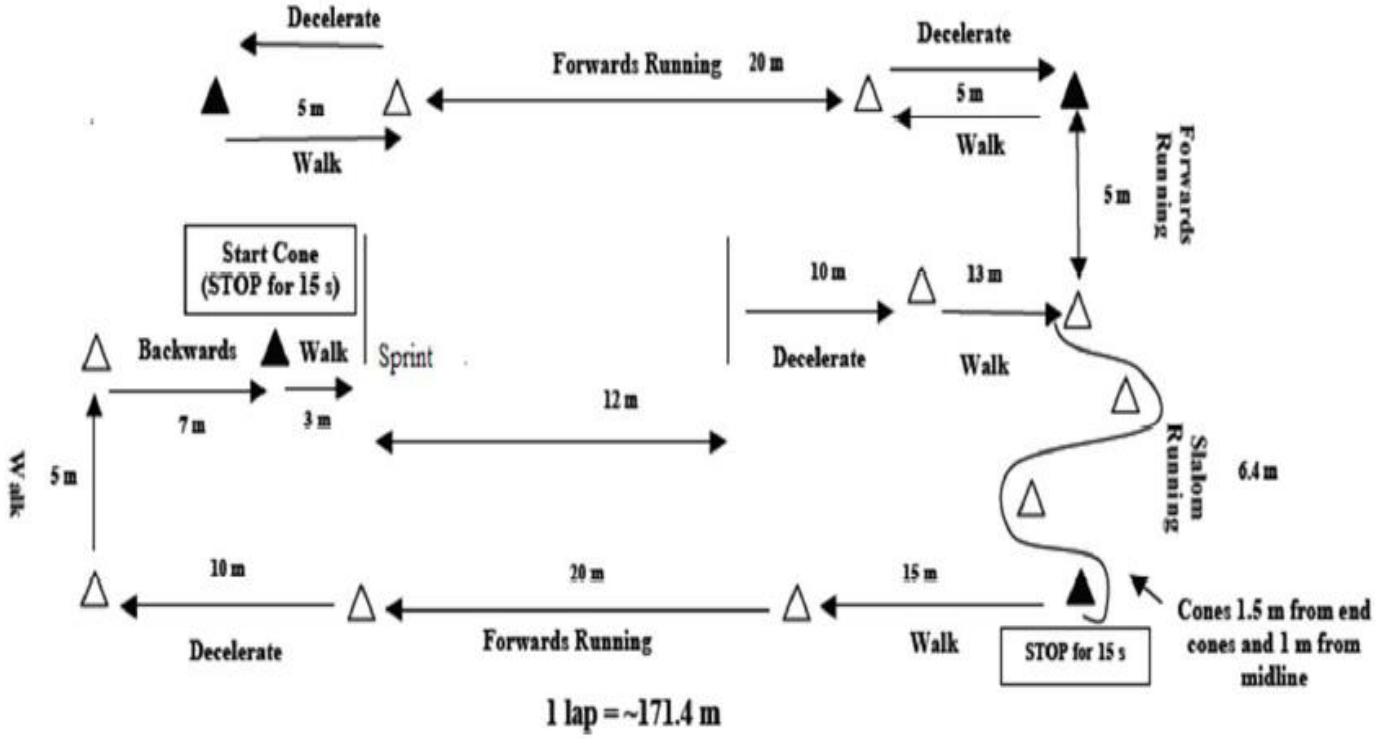

Figure 1: BEAST90$_{mod}$ protocol

A week before the actual testing, participants were familiarised with the BEAST90$_{mod}$ for twenty minutes split into two ten-minute halves with a stop of five minutes in between, during a scheduled club training session. This helped to familiarise them with the circuit, in order to eliminate performance decrements which might arise from unfamiliarity with the protocol, and hence affect interpretation of the result of the nutritional intervention. The familiarisation trial was conducted in order to ensure that robust and reliable data is collected, and appeared to be sufficient for the participants

to understand the essential nature of the running course. Due to the match-play, training and work schedules of the players further familiarisation was not possible.

Participants were assigned to each circuit and issued coloured bibs, identification numbers and start times. Each tester was then assigned to an individual participant, responsible for timing the two fifteen-second stop stages, ensuring all the stages of the circuit were conducted as required (i.e., do not cut corners in slalom, stop where required etc...), confirming the number of laps done, recording the Rating of Perceived Exertion (RPE) reading using Borg's (1998) 6 – 20 point scale at the end of each half and otherwise assisting when and where required. The Borg Rating of Perceived Exertion (RPE) is a way of measuring physical activity intensity level based the players' physical sensations of physical activity taking into consideration their increased heart rate, respiration, breathing rate, amount of sweating and muscular fatigue. Each of the circuits was checked by the researcher prior to the initiation of the exercise protocol validation. The researcher then mounted a heart rate monitor on each participant and, together with another tester, conducted final checks by instructing the participants to perform a number of initial runs and observing heart rate fluctuation on the live computer data. A separate individual tester was recruited to assist the researcher in monitoring the live heart rate monitor data on a laptop to ensure that the connection was not lost. Heart rate monitoring using short-range radio telemetry (Polar Coach, Polar Electro, Kempele, Finland) was used to assess the participant's effort in relation to the demands and movement patterns required by the protocol, thus ensuring reliability and validity of the exercise test.

When all heart rate monitors were assigned and functioning, the participants were given ten minutes to conduct their own warm-up. An explanation of the RPE scale was presented to the participants at the end of the warm up. They were asked to comment on their perceived exertion at this time, and compare it to the beginning of the exercise in order to be able to outline the difference in RPE at the different stages of exercise as reflected using the RPE scale.

There were four participants in each circuit, and a staggered start involving two minute intervals was used to avoid 'pacing' among teammates. The protocol ran smoothly as a result of good preparation and organisation both prior to and during its implementation. Recommended areas for improvement in the test procedure may include the use of colour-coded cones corresponding with each relevant activity, for instance, clear colour differentiation for the 'stop' cone specifically. A horn instead of a whistle could be used by the researcher to signal the start and end of each half, as the whistle may risk becoming inaudible, particularly on a windy day.

Prior to using the BEAST90$_{mod}$ exercise protocol as a performance parameter, the test was required to be practised and validated as a protocol replicating the specialised demands and activity patterns of soccer match-play. To do so, the protocol was performed by ten students following a sports course at the Malta College of Arts and Technology (MCAST), on three concurrent BEAST90$_{mod}$ circuits six weeks before the scheduled main research testing was due to be conducted. The validation lasted for forty-five minutes and consisted of two twenty-minute halves with a five-minute break representing half-time. Since a number of assistants are required in order to carry out the test accurately, the researcher recruited three assistants for each of the four circuits, with four players a-piece assigned to a total of fifteen assistants. In each circuit; the first assistant took the fifteen seconds rest at the start/stop cone and counted the number of laps covered by two of the players; the second assistant had the same responsibilities as the first but with the remaining two players, while the third assistant timed the fifteen seconds scheduled half-way through the lap of each circuit for all four players. This arrangement was clearly explained in a standard lecture and practical trial simulation ahead of one of the training sessions in the week of testing. The group was also required to set up their circuit using accurate distances and appropriate signage affixed to sand-filled cones in a maximum time of twenty min, since on the actual testing days this was the maximum allotted time for setting up due to pitch congestion and other organisational and logistical factors.

2.6 Soccer performance diet

The players undergoing the 90 h nutrition intervention were prescribed a standardized 'soccer-performance diet' consisting of 10 g·kg^{-1} BM of CHO and 1.7 g·kg^{-1} BM of protein. Fat did not exceed the 30% of TDEI, with no more than 10% sourced from saturated fat (FIFA 2010). Translated to percentage values, the nutritional plans were in the range of 65%, 15% and 20% of TDEI for CHO, protein, and fat, respectively. This ratio was divided across breakfast, mid-morning snack, pre-training lunch, snack, post-training snack and post-training dinner. An appropriate pre-match nutritional strategy was prescribed on the day of the exercise protocol (eighteen hours) consisting of 7 g·kg^{-1} BM of CHO and 1 g·kg^{-1} BM of protein divided into breakfast, mid-morning snack, lunch, and a pre-match meal and snack three hours and one hour before the commencement of the exercise protocol, respectively. Research shows that 90 hours is enough time for muscles and liver to supercompensate with muscle glycogen and hence render the player fully fuelled for performance to undertake the soccer-replicated intervention (Collins and Rollo 2014; Hawley 2014; Res

2014). A lengthier rigid nutrition intervention of this sort would have increased the risks of such semi-professional soccer players not following it fully, being in a relatively uncontrolled and unsupervised setting, as the setting. To counter this potential risk, the participants were asked to take photos of their main meals and send them to the researcher via email throughout the intervention. Also, players were bound to complete an adherence diary and return it to the researcher prior to the exercise protocol to further encourage adherence to the prescribed plan.

The soccer-performance dietary plan calculations were made using Microsoft Excel® (Microsoft Corporation 2007) while the content was computed using a common nutrition package software (Microdiet Downlee Systems 2005). Several food and drink items were added to used software's compendium in order to cater for food available locally. The foods selected were high in CHO and/or protein, low in fat, high in fibre content, and fresh wherever possible. Considering the semi-professional status of the players, the researcher was bound to accurately plan food and meal plans according to each of the players' work and training schedules in terms of both preparation and ingestion. The content of each diet was also adjusted according to the culinary likes and dislikes as required. Canned and packaged foods were avoided. The content of the nutritional plans generally consisted of the same food and drink items throughout, adjusting quantity according to the players' BM and corresponding total daily energy requirements.

Within fifteen minutes of waking up, participants were instructed to consume an oat-based cereal with skimmed milk, honey and dried fruits for breakfast. Freshly squeezed orange juice also accompanied this first meal. The mid-morning snack always included a serving of fruit, while lunch was CHO-based, comprising whole-grain bread, pitta bread or wrap with an added protein-based source, namely turkey breast or tuna with a mix of in-season vegetables. The mid-afternoon snack included a dose of protein, normally a dairy source such as a low-fat Greek yoghurt. The pre-match meal always included brown pasta with a protein source such as minced beef or chicken breast, tossed in fresh tomatoes. The pre-training snack included a medium to high-GI fruit, usually a banana. Players were instructed to consume a sports drink halfway through the sessions, supplying the necessary sugars and electrolytes. The post-training snack included CHO and protein in the form of an oat bar coupled with cranberry juice. The post-training meal included mixed in-season vegetables, sweet or new potatoes, and white meat in the form of rabbit, pork steak, fresh fish, or chicken. Cooking preparation requirements included steaming and grilling - no frying or boiling (except for pasta). Players were instructed to drink at least three litres of water throughout the day. A one-day 90 h dietary plan

sample is provided in appendix 24. Timing of meals varied where necessary according to the participant's lifestyle and work/college schedule. A number of rules were nonetheless retained throughout to ensure uniformity among participants, and issued as follows;

- Breakfast within fifteen minutes of waking up
- Mid-morning snack spaced evenly between breakfast and lunch
- Lunch between 12:00 and 13:00
- Pre-training meal three to four hours before training
- Pre-training snack one hour before training
- Isotonic sports drink half way through the session
- Post-training snack up to fifteen minutes from the end of the session
- Post-training meal up to one hour after training

On Thursday (the day of the exercise protocol intervention), the participants followed a similar plan to the previous days, with only slight adjustments taking into account recommended match-day nutrition guidelines. It included an oat-based breakfast with dried fruits, coupled with freshly squeezed orange juice, an apple as a mid-morning snack, and a couscous salad with vegetables for lunch. A fat-free Greek yoghurt was prescribed as a mid-afternoon snack before whole grain spaghetti with minced chicken breast, vegetables and fresh tomatoes of the pre-match meal. One hour before the commencement of the soccer-specific protocol replicating a soccer match, the participants consumed a slice of brown bread with multi-seeded jam and a banana. Players were reminded to drink up to two litres of water during the day, including an additional compulsory 500 millilitres one hour before the exercise protocol. Throughout the $BEAST90_{mod}$, players were allowed to sip water as they pleased during the 'stop' stations. At half-time they were instructed to drink the 500 millilitres sports drink provided.

2.7 Nutrition knowledge in soccer test

In order to understand the player's knowledge with relation to soccer, the researcher created a "Nutrition knowledge in Soccer test". The test consisted of twenty-seven multiple-choice questions divided into five sections gathering information about the players' specific knowledge on energy intake, nutrients, hydration, supplements, and nutritional strategies in relation to soccer. An English and Maltese version was provided as a choice (Appendice 11 and 12). A time allocation of thirty minutes was given, and prior to the initiation of the test, the researcher explained the marking system

in detail, clearly indicating that one mark was to be awarded for each correct answer, no marks for answers left blank, and minus one point for each wrong answer. Each question had four choices of answers, of which the last one always included a 'Do not know' answer.

Prior to its actual use with the research population, the created Nutrition Knowledge in Soccer Test needed to be tested as a valid data collection measure for soccer players. In effect, the test was disseminated to a total number of thirty-seven players on two occasions separated by one week. A total of thirty-three players completed the first trial, out of which twenty-one also went on to complete the second trial, constituting the total size of the sample group used for the final analysis. The researcher met each participant at their training grounds one hour before the scheduled testing session. Players with at least one season of local Premier League experience at any point during their career were selected, ensuring the nutrition assessment was validated with players of semi-professional status. Results of both trials were provided to the players who were interested in knowing their final result. In the majority of cases, players fared slightly better in the second trial, likely due to researching difficult questions encountered in the first sitting, which is considered normal practice in such validation trials. Inferential statistics was run to show the similarity between the two sets of answers. The correlation of data shows a strong correlation of $r=0.78$, and there was no statistical difference between the two sets of responses ($t_{40} = 0.93$, $p>0.35$). A number of minor changes to the questions were made following individual consultation and feedback with each participant in the trial, as well as personal professional analysis and synthesis upon its implementation. Some questions presented were adjusted in order to facilitate better understanding by participants in the actual data collection period. The answer choices associated with each question remained relatively consistent. Slight shifts in sentence structure were made to some of the questions to promote better understanding (Appendix 9). The adjusted answers shown are the only ones that required change (Appendix 10). Figure 2 below indicates the number of correct results obtained at both trials.

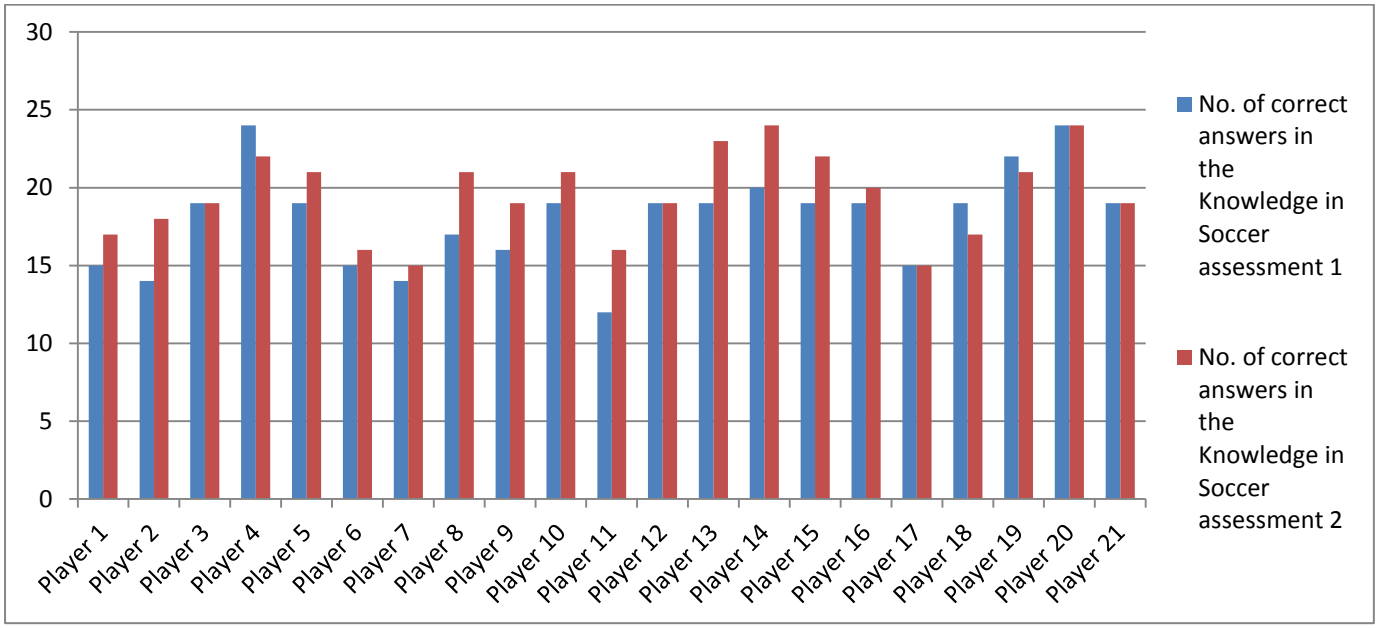

Figure 2: Number of correct answers in the Nutrition knowledge in soccer test out of 27 questions between the two trials

The now validated Nutrition in Soccer Knowledge Test was conducted with the research participants at the MFA premises before a scheduled training session. The final mark was expressed as a percentage both with and without negative marking. The negative marking system was selected in order to discourage players from guessing answers, thus permitting a more accurate assessment of actual knowledge. This reasoning is based on the premise that if participants do not trust their knowledge enough to answer, then they do not functionally possess that knowledge. A copy of the same test written in Maltese instead of English was issued to those players who requested it (Appendix 12). The completed test papers were collected by the researcher after expiry of the allotted thirty minutes.

2.8 Habits, attitudes, perceptions and barriers semi-structured Interviews

A one-to-one semi-structured interview with each participant was formulated as a means of gathering information about the attitudes, habits, perceptions and barriers with regards to nutrition in soccer. According to Bernard (1988), this type of interview is best used when the researcher does not get more than one chance to interview the members of the research population and hence an inclusion of open-ended questions will give a better insight to the themes posed.

The interview included thirty-seven pre-determined open-ended questions (Appendix 13), although the interview could unfold in a conversational structure giving the responders the chance to fully explore particular topics of interest. Each interview was conducted in a private room in a one-to-one set-up and was scheduled for a duration of approximately

sixty minutes, all of which was audio-recorded. The interview was organised across six areas. The first phase of the interview focused on the players' evaluations of their current nutritional habits, and included questions about the perceived quality of their current dietary intake. The interview then progressed into a more in-depth exploration of actual dietary patterns including pre- and post-match nutritional routines. The third phase aimed to gather information about the player's attitudes towards sound nutritional planning, including questions related to their willingness to adhere to an effective dietary plan supportive of soccer training and match-play. The fourth phase of the interview included questions designed to probe perceptions of nutritional planning, and the extent of their beliefs or lack thereof in the efficacy of nutrition as a factor influencing improved performance in soccer. In the penultimate phase, players were asked to identify and elaborate on inhibitory barriers to effective dietary practice. In the final phase of the interview, the participants were given an in-depth presentation and analysis of their seven-day Food and Exercise Diary in terms of TDEI, % of macronutrient share, respective g · kg^{-1} BM per macronutrient, hydration intake, and energy balance. Players were encouraged to comment on and discuss the results which were also presented in hard copy, and finally invited to ask any questions in conclusion of the session. In the development of the interview themes, the researcher used probes as opposed to prompts and cues in order to encourage the interviewee to elaborate when required (Sparkes and Smith 2014). The interviewer used a mixture of probes starting from detail-oriented probes in the first section and moving to elaboration and clarification probes as the interview themes progressed. Nonetheless, the majority of the questions were formulated with an 'elaboration probe' set-up as the interviewer sought the interviewees' thoughts, beliefs, perceptions and attitudes on a number of nutrition-related issues and practices in soccer (Sparkes and Smith 2014).

The semi-structured interview also required validation prior to its use as a data collection instrument. It was therefore conducted with five players to test effectiveness, determine flow, confirm duration and finally, upon analysis, evaluate the trustworthiness of the data collected; ultimately ensuring the interview was fit for purpose. Indeed, following the validation trial, a number of questions were adjusted in order to improve the flow of the interview, and address any concerns related to grammar and sentence structure. The researcher followed Guba's construct of credibility, transferability, dependability and conformability for the overall trustworthiness of the study (Shenton 2004). Potentially

leading questions were altered to ensure minimal influence over the answers (Appendix 13). In terms of duration, the validation interviews conformed to the maximum planned time-allocation of sixty minutes.

Participating players met the researcher at a time of their preference within a stipulated two-week period once in study three, and again in study four. The questions were asked consistently and in the same order to all players even though the semi-structured nature of the interview allowed the interviewer to exercise discretion, using standardised questions and probing further when required in order to fully explore the research aims. The researcher retained flexibility in arranging convenient times and locations according to the participants' preferences, provided the chosen environment was quiet enough to facilitate improved concentration and a clear audio recording. In view of the open-ended and divergent nature of the questions, the interviewer recorded all the interviews for the purpose of efficient transcription and in-depth analyses (Wengraf 2001). Interviews were transcribed within a week to ensure accuracy and effective coding of the data. Completed interview transcriptions were made available to each participant for confirmation purposes, to reduce human error and rectify any transcription disputes. While the compilation of interview notes was considered as an additional data-collection tool, it was deemed potentially detrimental to the development of rapport between the interviewer and the player, thus detracting from the quality of the interview data itself. The researcher then proceeded to transcribe each interview over a maximum span of one week. During the transcription process, the researcher immediately translated the interview answers from Maltese to English, since the participants felt more comfortable answering in Maltese as their first language, despite the questions being initially read out in English. The written transcription in English was presented to each of the participants in word document format. All players duly signed and confirmed the correct translations and transcriptions of the interviews. To analyse the participants' interview replies, the researcher used thematic analysis (Braun and Clarke 2006) whereby data was identified, examined, analysed and reported in different patterns (or 'themes'). The set themes were then used to interpret and discuss the data as necessary in order to group common replies and comments in order for the data to be truly reflective of its essence and meaning.

2.9 Coach and Assistant Coach semi-structured Interview

In a flowing one-to-one interview, the researcher asked a total of eleven pre-determined questions to the Coach and Assistant Coach promoting in-depth discussion in most instances in an attempt to gain a deeper understanding of their

views about various aspects of nutrition in soccer (Appendix 14). Through a series of carefully formulated questions, the researcher prompted the coaches to express their opinions about the current nutritional support provided to players, and on any proposed measures to improve such support in the near future. Interviews were recorded, translated to English and transcribed within a week. They were sent to the coaches via email who in turn confirmed their replies.

2.10 One-to-one semi-structured post-match interview on perceived individual and team performance following no nutritional intervention with players in the starting line-up of an international match

The researcher met players who formed part of the starting line-up and played at least 80 minutes of the away fixture against an international side, for a one-to-one semi-structured interview within one week of the upcoming away match. A total of thirteen questions (Appendix 15) were asked for which the researcher sought information about the players' perceived fatigue, as well as individual and team performance in the previous match. Interviews were recorded so that the researcher could once again transcribe and translate to English. The translated transcriptions were then given to the players in soft copy to confirm and sign their verbal replies. The researcher then analysed each of the interviews qualitatively, eliciting comments and answers for discussion.

2.11 Nutrition Education and Support Intervention

The Nutrition Education and support intention spanned over nine months and included four main nutrition education interventions which are explained in detail below.

2.11.1 Tailored Soccer Performance Diet (training days)

Used in the fourth and last diet, each player was prescribed a tailor-made soccer-performance diet to be implemented over a nine-month period. The players were given a nutritional plan consisting of 10 $g \cdot kg^{-1}$ BM of CHO and 1.7 $g \cdot kg^{-1}$ BM of protein, except for goalkeepers, whose CHO and protein amounts were reduced to 8 $g \cdot kg^{-1}$ BM of CHO and 1.6 $g \cdot kg^{-1}$ BM of protein respectively, to match their typical activity profile. Fat did not exceed 30% of TDEI, with no more than 10% sourced from saturated fat (Appendix 17). Each of the soccer-specific performance diets were formulated using the same nutrition package software (Microdiet Downlee Systems 2005) as in the first study. Translated into percentage

values, the nutritional plan consisted of the approximate percentages of 65, 15 and 20 of TDEI for CHO, protein and fat, respectively.

The nutritional plan included a variety of foods during the first week, while the remaining weeks were a replica of the first, divided into breakfast, mid-morning snack, pre-training lunch, pre-training snack, post-training snack and post-training dinner. The main components of the diet were generally consistent among the selected participants, limiting adjustments predominantly to the quantities of foods, at times adding snacks to meet each of the players' requirements according to their BM. Times and types of meals were individually scheduled in view of the semi-professional status of the players, taking into account college, work, or any other personal commitments as well as specific dislikes or allergies to general food sources as prescribed by the researcher.

Each personalised soccer performance nutrition plan included five steps or phases, as described in the schematic representation (Figure 3) and descriptive information below. The five steps are presented in respect of a male soccer player who trains semi-professionally, five to six times per week, with a competitive match at the weekend, is 24 years-old, weighs 78 kilograms, and is 184 centimetres tall.

Figure 3: Stages for the player's tailor-made soccer performance diet.

Step 1: Determine the player's Basal Metabolic Rate

The researcher calculated Basal Metabolic Rate (BMR) using the Harris and Benedict Formula (1919) which factors in height, BM, gender, and age, where BMR for men is equal to 66 + (13.7 X weight in kilograms) + (5 x height in centimetres) – (6.8 x age in years).

Table 11: BMR calculation for a 70 kg player

BMR = 66 + (13.7 X 78) + (5 x 184) – (6.8 x 24)

66 + 1068.6 + 920 – 163.2

1891.4 kcal

The player's BMR is 1891 kcal. The player needs this amount of energy to just sustain life.

Step 2: Determine the player's total daily energy requirement

In order to estimate the players' total daily energy requirement, total daily activity was added to the BMR. The BMR was then multiplied by an activity factor, where 1.725 corresponds to "extremely active" for a value of 1.725, or a person who trains six to seven times a week (Table 12).

Table 12: TDEE for a 70 kg player

Example using activity factor table:

TDEE = 1891 X 1.725

3261.9 kcal

The player's TDEE is 3262 kcal. The player needs this amount of energy to sustain life together with the training and daily needs

Due to the semi-professional status of the players and differing amounts of unknown activity occurring in the mornings however, the researcher acknowledged that this calculation was too generic, and an additional method was needed to increase its accuracy. The researcher therefore instead included a specific MET system for each player, dependent on the specific activities carried out daily. MET is a physiological measure expressing the energy cost of physical activities, and is defined as the ratio of metabolic rate (and therefore the rate of energy consumption) during a specific physical activity in reference to a baseline rate (Ainsworth et al. 2000). MET values of activities range from 0.9 (sleeping) to 23 (running at 22.5 km/h). For standardisation purposes, players were each given fifteen minutes for having breakfast,

thirty minutes for lunch, thirty minutes for dinner, fifteen minutes for showering and 90 minutes for soccer training, of which sixty minutes was considered as high-intensity and thirty minutes as low to moderate. These values were developed by the researcher following three visits to club training sessions, based on observations and timing of the various phases of the sessions. Player's daily activity information was gathered via the Lifestyle questionnaire, where participants outlined their lifestyle patterns in hourly format. Each activity was then factored into the equation by using the formula 0.0175 x MET x weight in kilograms x time in minutes (Heyward 2006). The activities were then added up to a total number of Calories representing the final Total Daily Energy Expenditure (TDEE) per player, to be used for the purpose of dietary prescription.

Step 3: Determine caloric and macronutrient requirements

In order to ensure accuracy of the calculations, the researcher used two different methods to establish nutrient ratio goals (Table 13). The values derived from each method were then combined for use as a range for the purpose of dietary planning.

Table 13: Daily caloric and macronturient requirements for a 70 kg player

Method 1	**Method 2**
a. The researcher multiplies the recommended pre-set standard CHO (10 g) and protein (1.7 g) requirements by the player's BM. Daily CHO needs for a 70 kg player in grams = 70 kg x 10 g = 700 g of CHO per day Daily protein needs for a 70 kg player is = 70 kg x 1.7 g = 112 g of protein per day *The player's daily* CHO *and protein requirements in terms of total grams are 700g and 112g, respectively*	a. The researcher works the % of TDEI (3262 kcal) for CHO (65%), protein (15%) and fat (20%) Daily energy needs from CHO for a 70 kg player = 65% x 3262 kcal = 2120 kcal of CHO per day Daily energy needs from protein for a 70 kg player = 15% x 3262 kcal = 489 kcal of protein per day Daily energy needs from fat for a 70 kg player = 20 % x 3262 kcal = 652 kcal of fat per day *The player's daily* CHO*, protein and fat requirements in terms of energy are 2120 kcal, 489 kcal and 652 kcal, respectively*
b. The researcher then multiplies the answer in grams for CHO and protein by 4 kcal reflecting their energy values in kcal.	b. The researcher then divides the answer in kcal for CHO, protein and fat by 4 kcal, 4 kcal, and 9 kcal reflecting their energy values in grams, respectively.

Daily energy needs from CHO for a 70kg player =
700 g x 4 kcal = 2800 kcal of CHO per day

Daily energy needs from protein for a 70kg player =
112 g x 4 kcal = 448 kcal of protein per day

The player's daily CHO *and protein requirements in terms of energy are 2800 kcal and 476 kcal, respectively*

Daily CHO needs for a 70kg player in grams =
2120 kcal / 4 g = 530 g of CHO per day

Daily protein needs for a 70kg player in grams =
489 kcal / 4 g = 122 g of protein per day

Daily fat needs for a 70kg player in grams =
652 kcal / 9 g = 72 g of fat per day

The player's daily CHO*, protein and fat requirements in terms of total grams are 530 g, 122 g and 72 g, respectively*

Range of daily nutritional requirements
TDEI: 3262 kcal ± 400 kcal
CHO per day: 530 g – 700 g; 2120 kcal – 2800 kcal
Protein per day: 112 g – 122 g ; 448 kcal – 489 kcal
Fat per day: 20 to 30% of TDEI of which not more than 10% should come from saturated and/or trans fat

Step 4: Soccer-performance Diet calculations on training days

Dietary intake for each day of the week was calculated using the figures from step 1. Daily diet was translated in terms of total kcal, total number of grams and kcal for each macronutrient, as well as the g · kg^{-1} BM and % of TDEI for each macronutrient (Table 14).

Table 14: Performance Diet calculations on training days over a week of a 70 kg soccer player

Amount per day	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	MEAN
CHO (g per day)	664	660	695	630	690	679	660	**668**
Protein (g per day)	121	118	120	122	122	121	118	**120**
Fat (g per day)	31	41	64	43	54	44	55	**47**
CHO (kcal per day)	2656	2640	2780	2520	2760	2716	2640	**2673**
Protein (kcal per day)	484	472	480	488	488	484	472	**481**
Fat (kcal per day)	279	369	576	387	486	396	495	**426**
CHO (g·kg^{-1} BM)	9.5	9.4	9.9	9	9	9.7	9.4	**9.4**
Protein (g·kg^{-1} BM)	1.7	1.7	1.7	1.8	1.8	1.7	1.7	**1.7**
Total kcal per day	**3419**	**3481**	**3836**	**3395**	**3734**	**3596**	**3607**	**3581**

Step 5: Performance diet planning

The prescribed personalised diets were tailor-made for each individual based on the calculations shown in steps 1 to 3 above, and checked for compatibility with participants' lifestyles and work/college and training commitments. The daily plan was divided into 6 different meals and/or snacks, starting off with a hearty breakfast consisting of a slow-release source of glucose via whole grain sources such as whole grain cereal with low-fat milk and/or other condiments such as honey and dried fruits. The morning drink was usually freshly-squeezed orange juice, due to its water-soluble vitamin content. The mid-morning snack intended for consumption at around ten o'clock in the morning included a serving of fruit as a vitamin, mineral and glucose supply. Lunch was based on a whole grain source be it wraps, rice or bread. Pasta was best avoided at this stage and reserved instead for the pre-training meal. Lunch was accompanied by a lean protein source such as chicken, turkey or tuna, and plenty of vegetables. Some exceptions to the main plan were made, as a result of players' specific likes and dislikes of foods, and food preparation times. Players were then provided with a pre-training meal to be consumed between three to four hours before training, generally consisting of whole grain pasta with vegetables and a protein source in order to effectively load the muscles and liver with glycogen. This was more or less standard and repeated over the course of the intervention to promote familiarity with the system. A pre-training snack, usually fruit, was given at the appropriate time with the aim of topping up the glycogen stores. During training, players were advised to consume an isotonic sports drink as a top-up supply of glucose. After training, players were prescribed a post-training snack, usually an oat bar and unsweetened cranberry juice to be ingested within fifteen minutes after the cessation of training. High CHO sources were chosen in conjunction with some protein to promote muscle recovery. The evening meal, intended for consumption up to two hours after the cessation of training, included a portion of vegetables, potatoes and meat, as a mixture of CHO and protein sources, favouring the former. Prescribed meats were generally white, in order to reduce saturated fat intake. This meal essentially aimed to replenish glycogen stores and promote effective muscle recovery. The hydration plan in terms of water intake involved approximately 3 litres, with a standard 500 millilitres intake minutes before training. Cooking methods for the prescribed food varied between steaming, boiling, grilling, and baking. Frying was strictly forbidden. Players were instructed to drink between three to four litres of water per day. Dietary plans were given in both hard and soft copies. An adherence table for each day of the dietary plan was also provided, so that the players could tick each food off as they consumed it.

2.11.2 Tailored Soccer Performance Diet (match days)

An appropriate pre-match nutritional strategy consisting of 7 g · kg · BM of CHO and 1 g · kg · BM of protein was prescribed for matches scheduled to start at 18:00 hours (Table 15). This was to be implemented during the league ahead of their club games, and not during international duty for which a separate strategy would be prescribed, as explained later on in this chapter (Appendix 20). The meals leading up to the match were divided into breakfast, mid-morning snack, lunch, and a pre-match meal and snack three hours and one hour before kick-off, respectively. Where matches started earlier, proportional hourly adjustments to the prescribe calculations of each macronutrient were made accordingly.

Table 15: Performance Diet calculations on match days over a week of a 70 kg soccer player

Pre-match CHO needs for a 70 kg player	**Pre-match protein needs for a 70 kg player**
Pre-match CHO needs in grams = 70 kg x 7 g = 490 g of CHO	Pre-match protein needs in grams = 70 kg x 1 g = 70 g of protein
Pre-match energy value in terms of CHO where 1 g of CHO is equal to 4 kcal = 490 g x 4 kcal = 1960 kcal of CHO	Pre-match energy value in terms of CHO where 1 g of protein is equal to 4 kcal = 70 g x 4 kcal = 280 kcal of protein

The match-day nutritional plan was calculated regressively, working back from the scheduled kick-off time of the match. A pre-match meal consisting of whole grain pasta with fresh tomatoes and chicken, turkey or tuna was prescribed for three hours before the match. This meal was intended to effectively load muscle and liver glycogen stores ahead of the match. This was accompanied by a snack in the form of fruit, usually a banana sixty minutes before kick-off and 500 millilitres of water ten minutes later. A light lunch in the form of brown bread with tomatoes, avocado and tuna or turkey was prescribed for consumption two hours before the pre-match meal. A hearty breakfast consisting of whole grain cereal with honey and dried fruits was always prescribed for breakfast, along with a serving of fruit as a mid-morning snack. When match days had an early morning kick-off, as was the case for some of the players who also competed at U19 level, the focus of nutrition shifted to the evening meal of the day before the match, and a breakfast choice of either high fibre cereal with milk, honey and banana, scrambled eggs on whole-wheat toast and yoghurt, a high CHO

smoothie, porridge with milk, honey and fruit, and/or oat pancakes with honey, or banana and yoghurt. A soccer-performance dietary plan for match day can be found in appendix 18.

2.11.3 Fat-loss intervention

Following the body composition tests, players who were found to be overweight were provided with tailor-made fat-loss nutrition plans to be implemented throughout the off-season period, prior to beginning the soccer-specific performance diet with the rest of the team during the upcoming in-season period. The prescribed total Calorie-intake was equal to the BMR. While such a strategy may have represented a significant challenge, it was made clear to the players that it would only last four weeks, and the start of pre-season would see their dietary intake increase, but more fat-loss would still be required in order to achieve a basic optimum body fat level prior to embarking on the soccer-performance diet. Calculations were based on 5.0 to 5.2 $g \cdot kg^{-1}$ BM of CHO and 1.1 to 1.3 $g \cdot kg^{-1}$ BM for protein. Plant-derived protein and white meats constituted the primary sources of protein, while fruits were included as snacks. Dinner was intended to be consumed by 20:00 hours at the latest. Water intake was set at three litres per day, with no soft-drinks or alcohol permitted. Sweets and sugary snacks were totally omitted except for a once per week, in the form of a two-hundred Calorie treat. Fat was derived mostly from unsaturated sources and did not exceed 10% of TDEI. The day started with a hearty breakfast composed of whole grain, complex CHO foods for a slow release of glucose. A serving of fruit was prescribed as a mid-morning snack. Lunch was based on CHO from whole grain bread, rice, wrap or pasta in portions not exceeding hundred grams, combined with fresh vegetables and a low-fat protein source like turkey breast, chicken breast or tuna. The pre-training meal was based on brown rice with vegetables for those players engaging in some form of exercise during their off-season. The pre-training snack was another serving of fruit, while dinner was composed of meat, one potato and plenty of vegetables. For each of the five players, the personalised fat-loss diet was tailored to their schedules, and timings of snacks and meals varied accordingly. Some of the players found it difficult to cope with such a restricted diet, and following consultation with the researcher, some gave up, while one player did not follow the diet at all. Weekly feedback questionnaires, weigh-ins, and a daily adherence diary were the chosen methods for monitoring adherence to the fat-loss diet. In the daily adherence diary, players marked an ‘x’ next to each food consumed. A space for writing additional foods to those prescribed was provided if needed. Weighing in took place at their homes, using digital scales provided by the researcher every Sunday morning following the first urine pass,

barefooted, and bare-chested. The weekly feedback questionnaire was given to the players with the diet, to be filled in each Sunday and returned at the next scheduled training session on the Monday. The weekly performance diet implementation feedback questionnaire (Appendix 19) included nine statements for which participants ticked their preferred choice between always, often, sometimes, rarely or never. A comments box was provided for any additional information the players wished to communicate. The aim of this weekly feedback questionnaire was to provide information that may have helped inform any required adjustments to the nutrition plan. A five-minute feedback session was conducted with each player upon handing in the questionnaire each Monday, to discuss any issues that may have arisen during the week that were not already covered via the other support channels open to them. The researcher made sure that the feedback provided via the weekly questionnaire was addressed and implemented with immediate effect.

2.11.4 Facebook Group: Malta U21 Soccer Nutrition

A “closed” Facebook group was created by the researcher to provide constant nutritional information and support to the players. One informative post per day would generally include diagrams, videos, explanations, pictures or a poster. The topics receiving the majority of coverage include energy balance, nutrient management with special reference to CHO and protein, hydration, supplementation, snacking, time management, food labelling and eating out choices among others (Appendix 21). The questions selected for the Nutrition Knowledge in Soccer Test were based on these primary content areas, which participants could access in their own time and at their own convenience. Continuous contact with the players was maintained using this medium, since modern social media networks have been determined as an optimal means of communication with the selected age-group (Brug, Campbell and Can Assema 1999). A total number of eighty-two posts were made via this medium of communication, which later on proved to be one of the most successful aspects of the nutrition intervention throughout the nine-month study period, chosen by the players themselves, following consultation regarding their preferences. Players were instructed to “like” each post they read, in order to track their adherence and progress. In some cases discussions ensued via the comments boxes. Each post was explained in simple words, and followed by an informative video, article or photo. Out of the 29 players in the group, there was an average of twenty-eight views and twenty-two likes per post, indicating healthy engagement with the content. There were a number of requests from other soccer players in the local league requesting to join the group,

however access was restricted to the research participants and technical staff only. From time to time, the participants were invited to provide feedback on the information provided, in order to address any issues and suggest additional topics of interest. Ultimately, the group served as an effective means of facilitating constant contact between the participants and the researcher.

2.11.5 Nutrition in soccer lectures

The researcher organised three one-hour lectures at each of the three-day period of residency preceding home international matches. The lectures provided support to the information provided on the Facebook page, and covered various aspects of nutrition with relation to soccer (Appendix 22), typically branched out into additional areas as a result of the numerous ensuing questions from the players, and often stimulating lively discussion and debate. Players and technical staff had the opportunity to ask questions during the talks and clarify any misconceptions or difficulties.

2.11.6 Three-day controlled nutritional intervention in preparation for home international matches

Based on feedback provided by players, and observations made by the researcher, the buffet-style meals provided previously by team medical staff were determined as unsuitable for adequately fulfilling the nutritional requirements of the players for various reasons including uncontrollable portions, unsuitable food sources such as sweet desserts or sweetened fruit juices, freedom to consume any desired snack, and an irregular schedule including on match day. For these reasons, the researcher assumed control over the entire nutritional preparation for the team ahead of international matches, which typically started two days before match-day while temporarily resident at a local hotel. Three primary considerations guiding the efforts of the researcher throughout the residency period included food sources in the three day menu, match-day strategy, and portion control.

2.11.6.1 Three-day prescribed team menu

The researcher prepared a complete menu plan for the team for the three-day period, and liaised with the hotel chef accordingly. The menu was first planned and discussed with the team doctor and medical staff so as not to change current team practices entirely. The menu was the same for all the players adjusting portion sizes as necessary. Meals on training days included breakfast, mid-morning snack, lunch, mid-afternoon snack or meal (depending on the time of the training session which was determined by the kick-off time of the particular international match), and dinner. A

consistent pattern of food content for lunch and dinner was requested, so as to include four courses; soup first, pasta second, a mixture of meat, potatoes and vegetables third, and finally, dessert. This was deemed as excessive consumption for a single meal, and all parties eventually agreed to exclude the dessert, and serve a smaller portion of pasta in the second course. The menu was to be as varied as possible in terms of food choices, avoiding repetition of specific foods across the daily meals. Scheduled pre- and post-training snacks were included on training days. Snacking between meals was not allowed unless specifically prescribed by the researcher. Whenever players felt the need to snack in between meals, they were instructed to contact the researcher, who duly issued preferred varieties of fruit. Meal times were adjusted so as to curb the consumption of voluntary snacks. At the designated meals, sweetened juices were replaced with water and freshly squeezed orange juice. The overall size of servings was reduced. White pasta was replaced with brown and regular potatoes replaced with sweet potatoes. Sugary cereals were substituted by multi-grain and oat-based cereals and dried fruits. Bread, cured meats, fatty cheeses, and sweet desserts were eliminated altogether. Upon approval of the final menu by the staff, its feasibility was confirmed with the hotel chef, and the appropriate adjustments made. Since snacks were not previously provided by the hotel, the possibility was discussed and fruit snacks were introduced. It was agreed that other snacks such as oat bars and packaged unsweetened cranberry juices would be provided by the researcher. The team ate together in a separate dining room from the hotel guests, and a dedicated chef was assigned to the team, in order to prepare the food according to instructions. The researcher planned a hearty breakfast acknowledging this as the most important meal of the day. Food sources high in complex CHO were prioritised, in order to release energy slowly, thus sustaining players until the next meal at lunch time. The first course of lunch included soup, considered a fair intake of vegetables and complex CHO, protein, vitamins and minerals. The second course included a small portion of complex CHO-rich whole grain pasta to replenish glycogen stores. In the main course, a mixture of carbohydrate and protein was provided via a side dish of potatoes and a choice of two types of meats, contoured with vegetables as a source of macronutrients, vitamins and minerals. The pre-training snack was provided one hour before training and given to the players in the hotel lobby while waiting for the bus. The aim of this snack was to top up glycogen stores with a glucose boost using a high GI source. The post-training snack was provided to the players in the dressing room as they returned from the session, before showering. A high-GI snack with a light protein source in liquid or mashed form was provided to quickly replenish

depleted glycogen stores and repair muscle fibres. For the post-training meal/dinner, the set-up was identical to lunch, with soup as a starter, a small portion of whole grain pasta for the replenishment of glycogen stores second, and as a main dish, a mixture of CHO and protein via a side dish of potatoes, and a choice of two types of meats, contoured with vegetables. This meal was to be consumed within a maximum of two hours after the cessation of training, with the primary aims of replenishing glycogen stores and rebuilding muscle tissues. Cooking methods used included grilling, broiling, steaming or baking. Potatoes were mashed, baked or boiled. Appendix 20 outlines the food choices provided across the three days leading up to the match. Finally, as regards to hydration, the players were instructed to drink around three litres of water per day, depending on weather conditions.

2.11.6.2 Match-day strategy

With regard to pre-match preparation, planning was worked regressively from kick-off time, thus determining the timing and content of meals. This typically resulted in a snack, usually in the form of a serving of fruit, sixty minutes before kick-off for a quick and high-GI source of simple glucose. A complex CHO meal with some protein usually in the form of brown pasta with fresh tomato sauce and chicken breast was prescribed three to four hours before kick-off. The aim of this meal was to top-up glycogen stores in the muscles and liver. A hearty breakfast based on muesli and oat-based cereals together with honey and dried fruits for a mixture of simple and complex CHO sources, was required to start the process of filling up glycogen stores. Depending on the time of the match, further snacks or a meal such as lunch or brunch was included accordingly, all with the express aim of filing liver and muscle glycogen stores with carbohydrate in preparation for the match. At half-time players were provided with an isotonic drink for an immediately absorbed glucose supply in liquid form and replenishment of electrolytes. Throughout the match, players were encouraged to sip on water by the sideline whenever possible during injury time, substitutions, and any other stoppages. After the match players were provided with a ready-made smoothie and/or serving of unsweetened cranberry juice within 15 min of the cessation of activity, in a bid to replenish carbohydrate stores drained throughout the course of a match, at a time when the muscle is mostly activated to replenish what has been lost. Provision of ready-made smoothies and/or unsweetened cranberry juice depended on the amount of time, intensity and positional role played. The quantities required by each of the players were calculated by the researcher using the Nutrition Software Programme. While the buffet-style format was maintained for logistical reasons as per agreement with the hotel staff, the researcher maintained direct control

over the portion sizes of each player at every meal according to the players' BM, health and positional play requirements.

2.11.6.3 Portion control

A vital and significant change with regard to portion control was affected. While players were initially free to consume whatever and however much they liked, they were now only allowed specific portions at each meal according to the researcher's pre-determined calculations. The calculations were made in such a way whereby the food on the menu remained the same for all players, while the portion size varied according to individual player's needs, based on 10 g · kg · BM of CHO and 1.6 g · kg · BM of protein. On match-days this was adjusted accordingly depending on the time of the match. At mealtimes, players were divided into four groups, organised according to prescribed portion sizes. Players kept this same order throughout all courses at each meal. While players did not initially enjoy this, they got used to it by time, understanding the rationale behind such portion control in avoiding the heaviness and "bloatedness" during training and match-play they had experienced previously, very likely due to over-consumption.

2.11.7 Post-intervention tests

The researcher needed consistency in order to measure the success of the intervention, hence baseline data collection measures alluded earlier in methods section and henceforth outlined below were conducted. The researcher needed this consistency to analyse the findings longitudinally in order to effectively evaluate the success of the intervention.

The same format of the 7-day Food and Exercise Diary as described in the methods section was undertaken to reveal the dietary practices of the players at this stage. The researcher used this information to analyse and compare the players' quality and total amount of daily energy intake at pre- and post- nutrition education and support intervention stages. Then, the one-to-one semi-structured interview designed to understand the full, part or non-adherence to the Soccer Performance Diet as well as the habits, perceptions, attitudes and barriers towards nutrition at this stage was also conducted with each of the players. The knowledge test was again administered to the players after the intervention. This information was important in order to analyse the players' nutrition knowledge in soccer longitudinally, and identify any differences between the pre- and post- intervention phases.

2.12 Content and statistical analysis

An inductive approach to analysing qualitative data was used, considering that research with regards to nutrition in soccer with semi-professional soccer players in Malta is limited, and hence new, unique, and grounded data was predicted to emerge from the study. The inductive approach was intended to capture and delineate the units of meaning from the extensive and varied raw data gathered from each of the players' interview responses. The units of meaning were then used to construct a composite summary, with a view to establishing clear links with the original research objectives, namely the exploration of players' attitudes, perceptions and beliefs towards nutrition in soccer. The researcher used key themes and incidents (thematic analysis) provided in the renditions and transcripts of research participants as they attempted to provide their perspectives of the given phenomenon. The researcher followed Braun and Clarke's (2006) guide to the six phases of conducting thematic analysis by familiarising oneself with the data, generating initial codes, searching for themes, reviewing them, defining and naming them, and finally producing the report of findings. Emerging themes must be coherent, consistent and distinctive whereby they are analysed and not merely described. The research also aimed to present emerging data-grounded findings to inform the development of a nutrition intervention programme based on the underlying structure of experiences and processes reported by the sample population. Cohen's *d* (1988) for effect size was used to measure the size of differences between pre- and post-intervention parameters. This was done by comparing two means and one can then see the difference in the two group's means divided by the average of their standard deviations. This would mean that if a *d* of 1 is reported, the two groups' means differ by one standard deviation. Cohen suggested that *d*=0.2 be considered as a 'small' effect size, 0.5 represents a 'medium' effect size, and 0.8 a 'large' effect size and 1.30 represents a 'very large' effect size.

Chapter 3

The effect of optimal nutrition on physical performance in soccer

3.1 Introduction

Soccer is a physically demanding sport (Bangsbo 2014; Mohr et al. 2003; Bangsbo 1994) that represents a significant challenge to a range of physiological systems (Alghannam 2013), imposing various demands on players such as running at high intensity (Mascio and Bradley 2013), undertaking energy-intensive activities such as short accelerations, turns, tackles and jumps (Osgnach et al. 2010), as well as performing skill-related efforts such as shooting, passing and dribbling (Carling and Dupont 2011). In general, throughout a whole match players are required to perform activities ranging from sub-maximal or moderate running, to irregular changes of pace and maximal anaerobic efforts (Bangsbo 2014; Reilly and Doran 2006; Bangsbo 1994; Hargreaves 1994). All of this contributes to a high energy turnover (Ekblom 1986) placing a significant demand on the body's liver and glycogen stores (Saltin 1973), required as essential fuel sources for training and match-play (MacLaren 1996).

Current research reports that the total distance covered during a match is typically between 10 to 13 kilometres (Mascio and Bradley 2013; Bangsbo et al. 2006; Mohr et al. 2003; Bangsbo et al. 1992). At high standards of training and competitive play, players experience noticeable fatigue (Bangsbo et al. 2006; Reilly 1997) particularly during anaerobic phases (Bangsbo et al. 2006), constituting a major limiting factor in soccer performance. This tends to occur during and toward the end of matches (Bangsbo et al. 2007; Mohr, Krustrup and Bangsbo 2005) manifested in a reduction of high-intensity running, sprinting, and total distance covered (Bradley et al. 2009; Bangsbo, Iaia and Krustrup 2007; Mohr, Krustrup and Bangsbo 2005; Mohr, Krustrup and Bangsbo 2003; Reilly and Thomas 1979), along with the distance covered specifically at high intensity (Mohr, Krustrup and Bangsbo 2003; Bangsbo 1994; Van Gool, Van Gervan and Boutmans 1988; Reilly and Thomas 1979), which is lower in the second half of a match when compared to the first, at both elite and sub-elite levels (Krustrup, Mohr and Bangsbo 2006 Mohr, Krustrup and Bangsbo 2005; Mohr, Krustrup and Bangsbo 2003; Reilly and Thomas 1979). Although it is unclear what causes temporary fatigue during a soccer match, low muscle glycogen levels are considered a strong candidate (Mohr, Krustrup and Bangsbo 2005) as most valid casual factor affecting soccer fatigue, especially towards the end of a match as described in the review of literature. Following similar publications of research on the utilisation and depletion of glycogen, attempts have been made to optimise CHO stores before a match by increasing dietary intake of CHO, as also reported in the review of literature.

Cumulatively, these studies highlight the importance of ingesting sufficient CHO to maintain adequate levels of muscle glycogen prior to an intermittent field sports activity like soccer.

Among the principal nutritional objectives for players are; consuming a well-balanced diet containing a wide range of foods to accommodate daily energy expenditure, promoting rapid recovery, and achieving adequate hydration. In order to optimise muscle glycogen levels, the provision of diets with high-CHO content is advised. Dietary guidelines for CHO intake suggest that soccer players may require 5 to 7 $g \cdot kg^{-1}$ BM of CHO during periods of moderate training (Bangsbo et al. 1992; Giada et al. 1996; Maughan 1997), or up to between 10 $g \cdot kg^{-1}$ BM to 12 $g \cdot kg^{-1}$ BM of CHO during periods of intense training or match play from nutrient-rich complex CHO food sources (FIFA 2010). A protein intake of 1.4 – 1.7 $g \cdot kg^{-1}$ BM is generally recommended (Lemon 1994; Tarnopolsky et al. 1992) depending on the intensity and duration of training. Energy from fat should not exceed 30% of TDEI (Clark 1994). General fluid guidelines can be adapted to fit the needs of training and match-play depending on the intensity of exercise and the environmental temperature (Reilly 1997). Moreover, it is vital for glycogen stores to be maximised before a match (Williams and Serratosa 2006), considering the history of glycogen depletion and fatigue profiles in the latter stages of a match (Hargreaves 1994) as evidenced in the literature. This can be facilitated via adequate CHO intake during training in the days immediately preceding matches, and inclusion of a high CHO meal consisting of low-GI foods three to four hours before a match (Williams and Serratosa 2006).

Current research tells us that nutrition is fundamental in soccer training and match-play, but it doesn't tell us how and by how much, and this is precisely what the researcher will seek to find in this study. FIFA, the sport's governing body, has provided a simple nutrition guidebook with basic nutritional information, recommendations, and guidelines that date back however to 2010 (FIFA 2010). The lack of enrichment or revision of such guidelines raises some concerns as to whether nutrition is truly valued or considered to be as an integral component of high performance in soccer. Such dearth in the literature constituted a primary motivation behind the researcher's investigation into the effects of optimal nutrition, represented by a 90 h dietary intervention, on physical performance in soccer.

It is also worth noting that, considering the popularity of the sport, very few studies investigated the influence of nutrition on performance have been carried out, presumably in part due to the difficulties associated with accessing populations in light of ethical reasons, competition between clubs, as well as the availability of players amidst highly congested

fixtures. Many of the interventions, reported in the literature review, were conducted in laboratory-based settings, with only a few occurring in field-based settings. What is more, none of the performance parameters tested included a 90-minute soccer-replica protocol.

The aim of this phase of the study was to examine the influence of a 90 h performance dietary intervention on the typical distances covered by semi-professional soccer players in a soccer-specific replicated protocol. This was based on the hypothesis that optimal nutrition marks a positive effect of physical performance in soccer.

3.2 Materials and methods

3.2.1 Study Participants

Twenty-two male soccer players from an established top division club, all of whom play soccer on a semi-professional basis training once a day in the evening with a single weekly competitive match on the weekend, were recruited for the study (Age: 27.1 ± 4.2 years [range: 20 – 33]; Body height: 174.8 ± 6.7centimetres [range: 168 – 185]; BM: 75.5 ± 8.3 years [range: 63.8 – 91.3]; %BF: 11.7 ± 1.3% [range: 9.9 – 13.8]). All participants were informed verbally and in writing about the nature and demands of the study, wherein the test procedures and associated health risks were explained via a participant information sheet. Participants were then screened for contraindications in preparation for the exercise and nutritional intervention using the Physical Activity Readiness Questionnaire (PAR-Q) (Thomas, Reading and Shephard 1992). Finally, the participants returned the provided written informed consent to participate, in accordance with Edge Hill University's ethical procedures.

The study was carried out over a two week period towards the end of the competitive season in March, while international competition was in progress, and hence no local league games were scheduled for the weekend between the two official trials of the soccer-specific protocol. Participants were asked to avoid any strenuous exercise apart from their regular training sessions during the two-week period. The researcher agreed with the team coach to have identical moderate-intensity training sessions for the first three days of each week. Nine players concluded the entire research design as other participants were eliminated from the study due to poor food records, failure to complete the exercise protocol due to injury or sickness, and/or failure to implement the prescribed dietary plan. Nine players completed the entire experimental procedure.

3.2.2 Experimental design and procedure

The researcher met the participants for an introductory meeting to outline the study hypothesis, explain the aims and objectives, and clarify their own roles and responsibilities as research participants. At this meeting, the researcher disseminated the Participant Information Sheet and Consent Form as well as the Health and Lifestyle Questionnaire that were to be returned within a week. Anthropometric data from the participants was also collected. Age, height and BM were collected from all participants as explained in methods section 2.3. The overall design of the study consisted of two phases, designated week one and week two, occurring in the third and fourth weeks of May, respectively.

In the first week, the participants filled in a Food and Exercise Diary (details in methods section 2.4) from Monday to Thursday leading up to the first soccer-specific exercise protocol. A detailed sample of the completion of one-day of the Food Diary (Appendix 6) was provided as a guide. On Thursday of each week at 18:30 hours, the players performed a modified version of the Ball-Sport Endurance and Sprint Test ($BEAST90_{mod}$) by Akubat, Barret and Abt (2013), a protocol adapted from Williams, Abt and Kilding (2010), of which soccer-specific test description, administration and organisation is described in detail in methods section 2.5.

The Friday, Saturday and Sunday separating the two weeks were scheduled rest days during which time the researcher met each participant individually to meticulously explain the prescribed tailored soccer performance nutrition plan, explained in methods section 2.6. This allowed them to purchase the necessary food and drink items in advance according to their individualised plans, and a comprehensive shopping list was duly provided. This was divided into food items required per day and classified by food group, with the relevant quantities required clearly indicated, offering maximal assistance in the successful preparation and implementation of the dietary intervention. Throughout the following Monday, Tuesday, Wednesday and Thursday preceding the second trial of the soccer-specific protocol, the participants implemented their prescribed tailor-made diets. In order to minimise the circadian variation of the measured variables (Reilly and Brooks 1986), both runs of the exercise protocol were conducted at the same time (18:30 hours). Weather conditions were similar with a temperature of eighteen degrees Celsius and North West wind at nineteen knots during the first trial, and twenty degrees Celsius and North West wind at sixteen knots during the second trial. On both occasions, players were instructed to arrive at the field approximately one hour early so that the necessary preparations in terms of donning of bibs and identification numbers, attaching and pairing of heart monitors, and assignment to the

individual testers could be carried out. The researcher also reserved time during this period to repeat and explanation of the exercise protocol via verbal and visual demonstration. A standard individual ten-minute warm up was carried out before the commencement of each protocol.

3.3 Analysis and results

The data was analysed via IBM SPSS statistics 22 software (SPSS TM Inc., Chicago III, USA). Descriptive sample data are presented as mean (± SD), median, and range. The effect of condition (pre vs post) are analysed using marginal models with SPSS mixed procedure. Unlike repeated measures ANOVA they allow for missing data to be analysed and a different covariance structure to be assumed. Effect size was measured using Cohen's *d.*

3.3.1 Dietary record

The 90 h dietary record was analysed for the total caloric intake and absolute measures of macronutrient quantities in terms of $g \cdot kg^{-1}$ BM together with corresponding percentages of TDEI. A number of foods were inserted into the software as raw data, to cater for the consumption of distinctly local foods, otherwise the McCance and Widdowson's latest version of foods within the software was the most commonly used. The dietary analyses of the players' customary intake are shown in Table 16 below. Two players were omitted from the study at this stage since they did not present their Food Diary.

Table 16: Dietary intake of the twenty players completing the 90 hour food record

Player	CHO		PRO		FAT	TDEI
	% of TDEI	$g \cdot kg^{-1}$ BM	% of TDEI	$g \cdot kg^{-1}$ BM	% of TDEI	Kcal
1	42%	3.8	21%	1.6	36%	2175
2	47%	1.8	25%	0.8	29%	1149
3	49%	4.4	23%	2	28%	2196
4	59%	3.3	15%	0.8	27%	1796
5	50%	2.9	22%	1.2	27%	1618
6	59%	2.3	17%	0.3	24%	1010
7	56%	2.6	20%	0.9	24%	1504
8	52%	4.2	16%	1.2	33%	2021
19	41%	3.3	24%	1.8	35%	1959

10	50%	4.2	14%	1.1	37%	2923
11	40%	5.5	20%	2.6	36%	3287
12	48%	3.1	23%	1.4	29%	1767
13	53%	3.7	12%	0.8	35%	1932
14	49%	3.8	20%	1.5	24%	2383
15	54%	4.8	17%	1.5	29%	2291
16	32%	2.5	23%	1.7	45%	2747
17	54%	3.4	19%	1.1	25%	1741
Mean	**49%**	**3.5**	**19%**	**1.3**	**31%**	**2029**
SD	**7.1%**	**1.0**	**3.9%**	**0.6**	**5.9%**	**611**

As a team, the mean CHO intake was 49 ± 7.1% of TDEI or 3.5 g ± 1.0 g·kg^{-1} BM with the highest and lowest intake recorded being 59% or 5.5 g·kg^{-1} BM and 32% or 1.8 g·kg^{-1} BM, respectively. Mean protein intake was 19 ± 3.8% of TDEI or 1.3 g ± 0.5 g·kg^{-1} BM, with the highest and lowest intake recorded being 25% or 2.6 g·kg^{-1} BM and 12% or 0.3 g·kg^{-1} BM, respectively. Mean fat intake was 31% of TDEI. Mean TDEI value of the participants was 2029 ± 593 kcal, with the highest intake being 3287 kcal, and the lowest being 1010 kcal.

3.3.2 BEAST90$_{mod}$ exercise protocol

Nine out of twenty-two players were used for this analysis since as outlined earlier two players did not complete the initial food record, one player did not perform the pre-intervention BEAST90$_{mod}$ trial, five players did not perform the post-intervention BEAST90$_{mod}$ trial, while another five players did not follow the prescribed 90 h intervention diet. The exercise protocol data was analysed for the total number of laps performed by the participants in each of the two BEAST90$_{mod}$ trials, and translated into total distance covered in metres. In the pre-intervention protocol players ran an average of 5, 324 ± 135 metres in the first half and 5, 628 ± 313 metres in the second half, for a total distance of 10, 952 ± 365 metres in 90 minutes. Minimum and maximum distances for the first and second halves were 5, 085 metres and 5, 485 metres; 5, 009 metres and 6, 170 metres, respectively. In the post-dietary intervention protocol, players ran an average of 5, 886 ± 153 metres in the first half 5, 953 ± 227 metres in the second half, and 11, 839 ± 369 metres for the full 90-minute soccer-specific protocol. Minimum and maximum distances for the first and second halves were 5, 599 metres and 6, 170 metres; 5, 604 metres and 6, 278 metres, respectively. Individual values for each participant

performing the trial at pre- and post- dietary intervention stsges are shown in tables 13 and 14 below. Mean RPE values at the end of the 90-minute protocol for the first and second trials were 18 and 14, respectively.

The data indicated that players ran further in the second half than they did in the first at both pre-intervention (5, 628 ± 313 metres vs 5, 324 ± 135 metres, $p<0.01$) and post-intervention (5, 953 ± 227 metres vs 5, 886 ± 153 metres, $p<0.01$) stages. Furthermore, in the first half players covered a significantly greater distance after the implementation of the diet than they did in the pre-intervention test (5, 886 ± 153 metres vs 5, 324 ± 135 metres, $p<0.01$). In the second half, players also ran significantly further post-intervention than pre-intervention (5, 953 ± 227 metres vs 5, 628 ± 313 metres, $p<0.01$). A comparison of the total distance completed by the players in the pre, versus post $BEAST90_{mod}$ test indicated that players ran significantly further overall in the post-intervention test as compared to the pre-intervention test (11, 839 ± 369 metres vs 10, 952 ± 365 metres, $p<0.01$). The interaction effect was also significantly different ($p<0.05$), suggesting that the dietary intervention played a bigger part in the first half than in the second half ($p<0.01$). It is also interesting to note that the maximum distance covered in the second half at pre-intervention is the maximum distance covered in the first half at pre-intervention. All participants registered an increase in the distance covered in the 90-minute protocol following the implementation of the soccer-specific performance diet. There was an average 887 ± 233 metres or 8.1% increase in distance following the dietary intervention. The greatest and least increase was of 1, 377 metres and 619 metres, respectively. The pre- and post-intervention values for all participants are shown in Table 19 below. Cohen's *d* was ran in order to measure the size of difference between the pre- and post- intervention trials and hence the total effect size of the nutritional intervention. This (*d)* was achieved by subtracting one mean from the other, divided by the pooled, or average, of the two groups' standard deviations. Upon calculation, an effect size of 2.4 was revealed, representing a statistically "very large difference". This statistical method indicates that the nutritional intervention was successful. In practical terms, the prescribed soccer-performance diet essentially improved the physical performance of players in a 90-minute soccer specific protocol. In terms of carbohydrate, there was a very large effect on the undertaken prescribed intake vis-a-vis the habitual intake (mean difference= 6.5; SE difference=0.2; p=<.001; 95%CI=6.0 to 7.0; ES=6.8, very large). For the same comparison, protein intake had a moderate effect (mean difference 0.4; SE difference=0.1; p=0.01; 95%CI=0.1 to 0.7; ES=0.7, medium).

Table 17: Distance covered in BEAST90$_{mod}$ at pre-intervention stage (*n*= 9)

	1ST half (45 minutes)			2nd half (45 minutes)			Full match (90 minutes)
Player	**Laps (number)**	**Distance covered in last lap (metres)**	**Total Distance covered in 1st half (45 minutes)**	**Laps (number)**	**Distance covered in last lap (metres)**	**Total distance covered in 2nd half (45 minutes)**	**Total distance covered in 90 minutes (minutes)**
1	31	15	5, 328	32	103	5, 588	10, 916
2	32	0	5, 485	33	43	5, 699	11, 184
3	30	25	5, 167	29	38	5, 009	10, 176
4	31	0	5, 313	33	0	5, 656	10, 969
5	31	108	5, 421	32	0	5, 485	10, 906
6	30	114	5, 256	33	38	5, 694	10, 950
7	31	129	5, 443	32	0	5, 485	10, 928
8	29	114	5, 085	34	38	5, 866	10, 951
9	31	107	5, 420	36	0	6, 170	11, 590
Mean	**31**	**68**	**5, 324**	**33**	**29**	**5, 628**	**10, 952**
SD	**1**	**56**	**135**	**2**	**34**	**313**	**365**

Table 18: Distance covered in BEAST90$_{mod}$ at post- intervention stage (*n*= 9)

	1ST half (45 minutes)			2nd half (45 minutes)			Full match (90 minutes)
Player	**Laps (number)**	**Distance covered in last lap (metres)**	**Total distance covered in 1st half (45 minutes)**	**Laps (number)**	**Distance covered in last lap (metres)**	**Total distance covered in 2nd half (45 minutes)**	**Total distance covered in 90 minutes (metres)**
1	34	0	5, 828	35	0	5, 999	11, 827
2	34	33	5, 861	34	114	5, 942	11, 803
3	32	114	5, 599	32	119	5, 604	11, 203
4	34	113	5, 941	35	43	6, 042	11, 983
5	35	0	5, 999	36	114	6, 284	12, 283
6	34	78	5, 906	34	0	5, 828	11, 734
7	34	0	5, 828	34	0	5, 828	11, 656
8	34	15	5. 843	33	114	5, 770	11, 613
9	36	0	6, 170	36	108	6, 278	12, 448
Mean	**34**	**39**	**5, 886**	**34**	**68**	**5, 953**	**11, 839**

SD	**1**	**49**	**153**	**1**	**56**	**227**	**369**

Table 19: Comparison of BEAST90$_{mod}$ results at pre- and post- dietary intervention (*n*= 9)

Player	TDC at pre-dietary intervention (kilometres)	TDC at post-dietary intervention (kilometres)	Difference in TDC between the pre- and post- dietary intervention (metres)
1	10, 916	11, 827	911
3	11, 184	11, 803	619
5	10, 176	11, 203	1027
9	10, 969	11, 983	1014
11	10, 906	12, 283	1377
13	10, 950	11, 734	784
14	10, 928	11, 656	728
17	10, 951	11, 613	662
18	11, 590	12, 448	858
Mean	**10, 952**	**11, 839**	**887**
SD	**365**	**369**	**233**

3.4 Discussion

The main aim of this study was to investigate the effects of a soccer-specific performance diet on physical performance in soccer. The dietary practices of semi-professional soccer players were evaluated, and the BEAST90$_{mod}$ was validated as a performance measure replicating the physical demands of soccer match-play. The main finding of the study revealed that a dietary intervention based on the ingestion of 10 g·kg^{-1} BM of CHO, 1.7 g·kg^{-1} BM of protein, and less than 30% fat per day, improved physical capacity and delayed the onset of fatigue, reflected by a 887 ± 233 metre increase in distance covered in a protocol replicating the physical demands of a 90-minute soccer match.

The players' customary TDEI was 2029 ± 593 kcal, which may be considered comparatively low. Chryssanthopolous et al. (2009) reported an intake of 2818 kcal among Greek soccer players of the same level. Data for Danish, Italian and English players shows a higher energy intake of 3738 (Bangsbo 1994), 3066 (Santilli 1990) and 3127 kcal per day (Reilly 1994a), respectively. Reeves and Collins (2003) reported a TDEI of 3057 ± 191 kcal among English players slightly younger in age. The reason for the low TDEI and variability in the literature may be attributed to players under-

reporting their food consumption (Livingstone and Black 2003; Magkos and Yannakoulia 2003;) as busy schedules, lack of interest, and negligence present common difficulties with the use of dietary recalls and food diaries as data collection methods (Burke and Deakin 1994). Additional causal factors possibly influencing the large inter-individual variability may include the nutrient quantification software used, the restricted dietary intake during the recording period owing to self-awareness of food and drink consumed, weather factors, the particular preparation phase when the study was performed, the low-energy intake itself, and the use of mean values (Macdiarmid and Blundell 1998; Maughan 1997). Nevertheless, irrespective of such limitations, the irregularity of intake for optimal performance still stands, despite salient research indicating the benefits of optimal nutrition to soccer performance (Ono et al. 2012; Hassapidou 2001; Rico-Sanz et al. 1998; Maughan 1997; Jacobs et al. 1982).

Despite carbohydrate being the main energy source in soccer, it is often under-consumed (Ruiz et al. 2005; LeBlanc, LeGall and Grandjean 2002). In this study, mean CHO intake was as low as 3.5 g ± 1.0 g·kg^{-1} BM, which is lower than other similar studies (Ruiz et al. 2005; Reeves and Collins 2003). Furthermore, the team's CHO intake showed a large discrepancy in comparison to the recommended guideline of 7 – 12 g·kg^{-1} BM for players engaged in moderate to high intensity training (Burke, Kiens and Ivy 2004). Low consumption of CHO typically corresponded to a generally low overall energy intake. Inaccurate recording of CHO intake could also be a factor, though in this case, such an error would have also similarly affected overall macronutrient intake readings. On some occasions, fat replaced CHO intake. The highest reported mean individual CHO intake was 5.5 g·kg^{-1} BM showing that none of the players met the minimum recommended guidelines. Such figures raise some concerns due to the fact that players are not only limiting their exercise capacity, but also forcing the body to work with very limited energy sources. The team's mean daily protein intake (1.3 ± 0.5 g·kg^{-1} BM) did not meet the recommended guidelines 1.4 - 1.7 g·kg^{-1} BM according to Lemon (1994). The discrepancy between actual intake and recommended guidelines tend to be greater in the case of CHO than that of protein. The two players who exceeded the recommended intake (2.0 and 2.6 g·kg^{-1} BM) used protein shakes in their daily diet. Also of some concern, fat sources (31% of TDEI) not only met the recommended (Clark 1994) amounts (<30% of TDEI), but exceeded maximal recommendations by 1%. Players tended to over-consume this nutrient in their daily diets mainly as a result of excessive junk food intake. The highest percentage recorded was 45% of TDEI which is well over the recommended guidelines, while the minimum intake (24%), whic was at par with recommended levels. The

fat intake in this study was analysed homogeneously, and thus detailed information about what type of fat was consumed is unknown. Nonetheless, in the data inputting stage, fast foods and saturated-fat sourced food trends were duly identified, indicating that out of the 31% of fat recorded as a mean of the team's intake over the seven days, a significant percentage came from saturated and trans fats.

The literature affirms performance enhancement outcomes in soccer in the technical (Russell and Kingsley 2014; Ali et al. 2007; Abt, Zhou and Weatherby, 1998) and physical aspects as a result of consuming a high-CHO diet. This study showed that players on a tailored soccer performance diet high in CHO improved distance covered at high intensity in a soccer-specific protocol by 887 ± 233 metres or 8.1%. The increased availability of muscle glycogen as a result of increased CHO consumption before the soccer-specific protocol may explain the longer distances covered at high intensity (Alghannam 2012). Unlike other studies however, the testing parameter used was a full 90-minute protocol replicating the activity patterns and intensity of soccer, following the preparation of a specific tailor-made diet for each participating player. An improvement in total distance covered (1.3 kilometres) was also found by Sougilis et al. (2013) in players who followed an 84 h high CHO diet (8 g·kg^{-1} BM), as opposed to players who followed a low CHO (3 g·kg^{-1} BM) diet for three days prior to an eleven-a-side soccer match. Apart from improvements in soccer-simulation tests as documented above, researchers have also seen improvements in the laboratory environment (Balsom et al. 1999b), showing that players on high CHO diets (65% of TDEI) performed at higher (33%) intensity during a 90-minute four-a-side indoor soccer match than those on low CHO diets (30% of TDEI). In addition to these findings, Bangsbo, et al. (1992) demonstrate an increase of 900 metres in the distance covered during intermittent running to fatigue by the high-CHO group (8 g·kg^{-1} BM of CHO) at the end of the protocol when compared to the control group (4.5 g·kg^{-1} BM of CHO), as tested on a field-treadmill high-intensity intermittent test to exhaustion. Previous studies also report improvements in endurance during continuous exercise after increased dietary CHO intake (Williams, Brewer and Walker 1992; Karlsson and Saltin 1971). Nicholas et al. (1999) and Leatt and Jacobs (1989) similarly report reduced muscle glycogen depletion when CHO are ingested both before and during exercise, as well as an improvement in the ongoing maintenance of blood sugar levels, according to Ali et al. (2007). In contrast, Krustrup, Mohr and Bangsbo (2006) argue that despite eating breakfast and a meal two hours prior to a friendly soccer match, research participants still exhibited significant muscle glycogen depletion, with 47% of muscle fibres being almost completely depleted of

glycogen. In a more recent study, while challenging the need for greater specificity in such nutritional recommendations, Hulton et al. (2013) found no difference in the performance of soccer players following the ingestion of either high-fat or a high-CHO pre-exercise meal. In this study, soccer players followed a standardised breakfast and an adequate CHO intake over a period of twenty-four hours. Ingesting a high- or low- fat pre-exercise meal resulted in similar performances over a one-kilometre trial following a 90-minute soccer-simulated protocol on a treadmill, despite variations in CHO and fat oxidation. Under these conditions, soccer players may actually have a broader choice of foods than previously thought.

3.5 Conclusion

This study reduces the paucity in literature with regards to a nutrition intervention among a group of semi-professional soccer players, tested using a field-based soccer-specific 90-minute protocol. In contrast to existing research, this study intervenes with a lengthy nutrition intervention culminating in a standard soccer-replicating protocol, thus avidly testing the effect of the nutrition intervention. It has been clearly shown that the ingestion of a soccer-specific performance diet for 90 hours leading up to a match improved the total distance covered at high intensity by 887 ± 233 metres, or by a total of 8.1%. The study therefore provides further supporting evidence that soccer players should consume a high-CHO diet in order to sustain performance and delay fatigue during the course of a match. Future research might examine the design of a variety of optimal meal plans in order to support semi-professional players while taking into account their daily routines, positional play, and other practical logistical concerns. As this study affirms the benefits of optimal nutrition for soccer, the next chapter explores the energy balance, quality of energy intake and match-day nutritional practices of semi-professional cohort forming part of an U21 national team.

Chapter 4

Dietary habits and energy balance in an U21 male international soccer team

4.1 Introduction

The International Society of Sports Nutrition suggests that a fundamental nutritional consideration for maximising performance and training involves making sure athletes consume enough Calories to offset TDEE. Soccer training and competition result in an increased energy requirement that simply must be accompanied by an increase in energy intake in order to sustain performance capacity and prevent the onset and development of excessive fatigue (FIFA 2010; 2006; Clark 1994).

The energy cost of soccer training has been reported to be in the region of 1433 to 1791 kcal per day (Galloway 2010). Similarly, the energy cost of a standard 90-minute match ranges from 1195 to 1434 kcal, depending on the total distance covered (approximately 10 to 11 kilometres) and the style of play (Bangsbo 1994; Ekblom 1986). The addition of work and/or education commitments plus other lifestyle factors during the day add to the daily total energy cost of the semi-professional soccer player (Galloway 2010), who must in turn adapt energy intake to maintain optimal nutritional status. Since soccer players generally train at moderate to high intensity, the estimated mean daily energy demand for senior male players has been estimated at between 3500 kcal and 4000 kcal on training days (Rico-Sanz et al. 1998; Reilly and Thomas 1979). Specific individual energy requirements also come into play, as factors such as training volume and intensity, body size, phase of the season, and the player's overall physical status must be taken into consideration when estimating energy requirements and planning a successful nutritional strategy (Garcia-Roves et al. 2014).

Of primary concern for soccer players should be ensuring energy intake equally balances energy expenditure. The nutritional objectives of soccer players should therefore include the consumption of a well-balanced diet containing a wide range of foods that cover daily energy expenditure requirements, promote rapid recovery, and achieve adequate hydration. Typically, it should be high in CHO and low in fat. The typical macronutrient values expressed as a % of TDEI are 65%, 15% and 20% for CHO, protein and fat, respectively (FIFA 2010) with specific dietary guidelines for soccer players provided in the review of literature. Most importantly, players should aim to consume high-CHO diets based on nutrient-rich complex CHO food sources to maintain performance, meet the energy demands of training, as well as maintain and restore muscle glycogen stores for training and competition (Clark 1994; Hargreaves 1994; Hawley,

Dennis and Noakes 1994; Kirkendall 1993; Jacobs et al. 1982). Players who do not consume adequate quantities of CHO may be nutritionally jeopardising their training capacity and ability to engage in a progressive exercise programme (Burke, Loucks and Broad 2006; Reilly and Doran 2000). As regards to protein, according to Boisseau et al. (2007), protein supplementation is crucial for recovery from strength training, and plays a key role in adaptive training responses, including tissue repair. The metabolism of amino acids also serves as an auxiliary fuel source during the prolonged phases of a soccer match (Burke, Kiens and Ivy 2004). This energy is predominantly supplied by branched-chain amino acids, at an estimated 2 to 3% of total energy metabolism. Even though it receives less attention than the other macronutrients, fat is nonetheless an important source of fuel. It is required when aerobic energy production is called into play during certain phases of soccer training and match-play (Bangsbo, Mohr and Krustrup 2006), and derived from intramuscular triglycerides or via the blood as free fatty acids (FFA). Indeed, fat oxidation from FFA constitutes an estimated 40% of total energy expenditure during a match (Bangsbo 1994). Additional essential roles of fat include the provision of insulation, and transportation of fat-soluble vitamins (Clark 1994). Finally, it is important for a player to be well hydrated during soccer training and match-play, as dehydration to a level equivalent to 2% loss of BM (Cheuvront et al. 2005; Cheuvront et al. 2003), will result in impaired performance (Reilly, Bangsbo and Franks 2000), and cognitive function (Shephard 1999).

Research shows that players who follow a sound nutritional plan are able to compete at higher intensities, more effectively maintain technical abilities, retain mental focus, and continue to make sound decisions when fatigue sets in (Alghannam 2013). Nonetheless, despite the existence of basic nutritional guidelines for soccer, most studies on nutritional intake among soccer players still show that players tend to follow an unbalanced diet and reflect a state of overall daily energy deficit in contrast with nutritional recommendations designed to sustain performance during soccer training and match-play. Early dietary surveys of soccer players have revealed such inadequacies in dietary intake with respect to basic nutrients as described in the review of literature, ranging mainly between 2500 to 3100 kcal (Garcia-Roves et al. 2014), although intakes as high as 3738 kcal have also been recorded (Bangsbo et al. 1992). A more recent study (Ingram and Davies 1996) confirms that a majority of soccer players do not consume diets compatible with peak physical performance, particularly in terms of the basic amounts of CHO required (Kirkendall 1993). With regard to protein intake, nutritional assessment of soccer players generally reveals that consumption is sufficient to accommodate

even the highest of estimates (Rico-Sanz et al. 1998). Fat is generally over-consumed. As was found with protein intake, hyper ingestion of fat is also common among soccer players. Contrary to the case of excess protein consumption however, excessive fat intake tends to be involuntary. As per hydration status, it has been reported that soccer players can lose up to three litres of fluid during matches played in temperate thermal environments (Reilly 1997). Nutritional strategies in terms of pre-, inter- and post-match meal, snack and fluid plans are crucial for performance in soccer with the aim of complementing the ongoing training diet. In conclusion, it is worth noting that the majority of studies have focused on 'elite', 'top class', or 'international' players (Carling et al. 2008), with little attention paid to lower-level professional, semi-professional, or amateur players, who ultimately represent the vast majority of practising soccer players.

In light of this evidence, understanding the players' dietary practices on both training and match days is vital to address this modifiable factor of performance. The aim of this study was to investigate the energy balance and the quality of energy intake in terms of TDEI, CHO, protein, fat and hydration of players forming part of the U21 Malta national soccer team, and how such data compare with recommended guidelines. Pre- and post- match intake was also investigated in-depth, and a comparison made between training and match days was also investigated. The study is based on the hypothesis that players generally tend to be in a negative energy balance, and that the quality of their intake is not compatible with recommendations for semi-professional soccer players.

4.2 Materials and methods

4.2.1 Study participants

Twenty-five semi-professional soccer players forming part of the Maltese U21 national soccer team served as the participants (age=20.7 ± 1.1 years; height= 178 ± 5.7 centimetres; BM = 76.1 ± 6.6 kilograms; %BF = 11.0 ± 1.3 %), each compiling a seven-day Food and Exercise diary, which included a match day.

4.2.2 Experimental design and procedure

At the start of the two-week testing period, the researcher measured the players for height, BM and %BF, ahead of their scheduled training sessions as detailed in methods section 2.3. From basic anthropometry information, the Basal

Metabolic Rate (BMR) was calculated using the Harris and Benedict (1919) formula where BMR is equal to 66.47 + (13.75 x weight in kilograms) + (5 x height in centimetres) – (6.76 x age in years). Participants were asked to fill in a seven-day Food and Exercise diary (methods section 2.4) and return it to the researcher within a week. The researcher examined the record upon receipt to ensure it was filled in correctly, and to clarify any aspects of the data prior to analysis. The diary also represented an opportunity to analyse pre- and post- match nutritional strategies since players had one competitive league match during the study period.

Prior to the data collection period, the researcher organised two, thirty-minute informative sessions ahead of the scheduled training sessions on Monday and Tuesday, to explain the aims and objectives of the study as well as to provide all necessary technical information to the participants. The Monday information session included support on filling in the Food and Exercise diary, supported by a one-day sample including an information sheet on typical household measures. Each player was also individually briefed about common food portion sizes using household measures such as cups, spoons, teaspoons and dishes in fractional amounts to ensure simplicity and thus maximal adherence by the players. The Tuesday information session included a practical workshop wherein participants carried out the actual process of filling in data based on the present day, filling in the energy intake and expenditure sections of the Food and Exercise Diary. This trial was necessary to ensure players were able to fill in the record correctly and accurately, and to address any problems or difficulties ahead of the actual testing period. The researcher concluded the session by issuing participants with a hard copy of the Food and Exercise Diary, which was the primary data collection instrument to be used throughout the coming week. A soft copy of the template was also sent to all participants as an attachment via email. On each day of the following week from Monday to Sunday, the players kept and completed the seven-day Food and Exercise Diary which provided information on the players' habitual energy intake and energy expenditure, so that the energy balance for each player could then be calculated. The researcher personally collected all the records at the end of the data collection period.

4.3 Analysis and results

The quality and quantity of the foods and drinks consumed were analysed for the total caloric intake and the absolute measures of quantities of each nutrient in terms of $g \cdot kg^{-1}$ BM, and their corresponding percentages of TDEI. Twenty-

eight players initiated the study, while twenty-five data sets were actually used for final analysis. One player did not submit the Food and Exercise diary, while two were excluded due to poor intake and expenditure records which resulted in an excessively low EI to BMR ratio. The players' average BM was 76.1 ± 6.6 kilograms, while their body fat percentage was 11.0 ± 1.3 %. The U21 national team's EI, EE and EB are presented in Table 20 below. The team's mean energy intake was found to be 2164 ± 498 kcal per day when averaged over the seven-day period, with the highest and lowest values reported at 2998 kcal and 1341 kcal, respectively. The players' mean daily TDEE over the seven-day period varied between 1904 and 2799 kcal, with a mean TDEE of 2799 ± 382 kcal per day. The team's mean daily energy balance was found to be in a deficit of 705 ± 648 kcal, ranging from a surplus of 567 kcal to a deficit of 1790 kcal.

Table 20: Player's and Teams' EI, EE and EB over an average of seven days

Player	Energy Intake (kcal)	Energy expenditure (kcal)	Energy Balance (kcal)
1	2046	2939	-893
2	2058	2652	-860
3	2064	3053	-985
4	2718	2618	100
5	2998	3266	-909
6	1641	2670	-1028
7	1859	2111	-821
8	2406	3121	-715
9	1427	3217	-1790
10	1432	2676	-1244
11	2773	2994	-221
12	1341	2766	-1425
13	2962	2754	208
14	1912	2763	-1088
15	1621	3282	-1662
16	1691	2292	-600
17	2795	2359	436
18	2471	1904	567
19	2364	2311	53

20	2413	2874	-461
21	2005	3137	-1132
22	2740	2651	89
23	2386	3148	-762
24	2187	3218	-1069
25	1786	3202	-1417
Team mean	**2164**	**2799**	**-705**
Team SD	**498**	**382**	**648**
Team Max	**2998**	**3282**	**567**
Team Min	**1341**	**1904**	**-1790**

Macronutrient share as a % of TDEI, and the g·kg^{-1} BM values for each macronutrient are considered crucial factors in determining the quality of players' diets. The average daily CHO and protein intake of the players was 48% of TDEI, or 3.7 g·kg^{-1} BM, and 21% of TDEI, or 1.5 g·kg^{-1} BM, respectively. Even the highest recorded daily CHO intake (5.6 g·kg^{-1} BM) was not sufficient to match the minimum recommendation for soccer players. Indeed, low values were reported for a number of players, with the lowest daily intake of all recorded at 1.8 g·kg^{-1} BM. The highest daily protein intake was reported at 2.3 g·kg^{-1} BM, which exceeds the maximum recommendation. The lowest daily protein intake recorded was 0.8 g·kg^{-1} BM, which is still relatively close to the minimum recommended guidelines. Fat intake reached a mean of 30% of TDEI, while fluid intake was found to be 1648 ± 784 millilitres. When a comparison between intake quantities at weekdays as opposed to weekends was made, the researcher found no statistically significant differences. Table 21 below shows the values of the players' individual macronutrient and fluid intake per day into more depth.

Table 21: Player's and team's PRO, CHO, FAT and fluid intake during a week of competitive training

Player	PRO intake (% of TDEI)	PRO intake (g·kg^{-1} BM)	CHO intake (% of TDEI)	CHO intake (g·kg^{-1} BM)	FAT (% of TDEI)	Hydration (millilitres)
1	20	1.4	45	3.4	34 %	1957
2	19	1.5	45	3.9	35 %	1714
3	16	1.0	54	3.7	30 %	1283
4	20	1.7	51	4.8	29 %	3000
5	19	1.7	47	4.6	34 %	4069

6	23	1.3	42	2.5	35	1286
7	26	1.9	48	3.6	25	1000
8	20	1.3	49	3.5	30	729
9	30	1.2	38	1.8	32	2375
10	16	0.8	56	2.8	27	1000
11	17	1.6	50	5.0	34	1657
12	18	0.8	51	2.3	31	750
13	24	2.3	46	4.9	30	1776
14	20	1.3	54	3.6	26	2425
15	27	1.5	54	3.1	18	1000
16	23	1.3	39	2.6	38	1000
17	19	1.9	44	4.7	37	1643
18	19	1.6	42	4.1	39	2254
19	20	1.8	61	5.6	19	1750
20	22	1.6	48	3.9	28	1143
21	25	1.7	50	3.6	25	2489
22	22	1.9	50	4.8	28	1556
23	23	1.7	50	4.0	26	1170
24	17	1.2	51	3.8	31	1000
25	30	1.4	41	2.1	26	1171
Team average	**21**	**1.5**	**48**	**3.7**	**30**	**1648**
Team SD	**4**	**0.4**	**5**	**1.0**	**5**	**784**
Team Max	**30**	**2.3**	**61**	**5.6**	**39**	**4069**
Team Min	**16**	**0.8**	**38**	**1.8**	**18**	**729**

The quality and quantity of food intake was analysed in still greater depth per individual player in order to learn more about their habits across the different meals of the day. Breakfast was analysed first, after being consumed by the players up to two hours following wake up time. Tea, coffee, milk with cereal, and drinks other than freshly squeezed fruits and sugar-containing drinks were excluded from the seven-day food frequency analysis. One of the players did not have breakfast for a whole week while four players skipped it four times each. Eight players missed breakfast at least once a week, with the majority of misses occurring during the weekend due to waking up late. Only six players consumed a healthy breakfast that included oats and/or grain-based cereal or muesli. Two of the players took a sugary

cereal every morning during the week, while five consumed this food at least twice. The remaining participants had toasted white bread with a variety of fillings such as ham, cheese, tuna, butter, and even eggs and sausages.

Lunch was analysed as the next major meal, consumed by the players at any time between 11:30 hours and 14:00 hours. All players consumed white, not brown or multi-grain pasta. One of the players never had lunch. Four players had a sandwich more than three times for lunch. A majority of the players (*n*= 11) had white pasta with a variety of different sauces at least twice a week. At least six players took an unhealthy lunch more than twice a week which included fried items such as fries, hot dogs, chicken nuggets and burgers among others. Only one player had beef for lunch, while as many as ten players ate a chicken wrap at least once a week.

Food consumed up to three to four hours before training time was analysed as the pre-training meal. The majority of players (*n*= 15) did not consume any pre-training meal for the whole week, while six players only did so twice. Only two players consumed a plate of pasta before training, but this was only done four times during the week. A standard meal consisting of a serving of meat with vegetables and potatoes was taken by four players once a week. Other players missed a number of pre-training meals during the week, but when they did not, the foods consumed varied considerably and included wraps, cereals, pizzas, bread rolls, noodles, and packaged soups among others.

The next analysis concentrated on the pre-training snack, considered as food and/or drink (excluding water) consumed for up to one hour before the start of scheduled training. Nine players did not consume any snacks before training throughout the entire week. Sources varied, however the snacks consumed were mostly high in sugar content and fat, such as sugary cereals and especially chocolates. Cases of good pre-training snack habits were only observed in four players who consumed a multi-grain cereal or serving of fruit, however this was not repeated consistently throughout the entire week, but rather only twice a week on average. Only one player opted for a drink, which in this case was a sports drink.

The post-training snack was considered as any food or drink excluding water consumed up to thirty minutes after the cessation of training. Snacking after training was not common among the players. Nine players did not consume any snacks at all throughout the week. For those who did, they were mainly comprised of foods high in sugar and fat, such as cakes and biscuits. Only three players chose fruit as a post-training snack. Other random snacks consumed sporadically by some of the players included sports drinks, almonds, figs, and yoghurt.

As a post-training meal, the standard meal consumed for up to two hours following the cessation of training was analysed. One of the players did not consume such meals at all throughout the week. Three players had white pasta with an assortment of sauces at least three times a week, while thirteen players consumed an appropriate post-training meal consisting of a serving of meat with potatoes and vegetables, at least three times a week. None of the players however maintained such habits every day. Some of the players (*n*= 3) chose junk food such as burgers, sausages, or fries at least twice. Some players (*n*= 6) included dietary supplements in their diet, the most common form of which (*n*= 5) were protein shakes at least once a week, with two players using protein shakes four times a week. The other player supplemented with Vitamin C and Cod liver oil daily.

The consumption of pre-packaged and pre-prepared food high in Calories and of little nutritional value, commonly referred to as 'junk food' was common across the sample. Only six players did not consume any of such food during the week. As many as eleven players consumed fries at least twice a week, with one player having them every day. Healthy snacks were common among ten players, who consumed at least one serving of fruit daily. Other healthy snacks included yoghurt, unsalted nuts, and oat bars. Fatty snacks were also common, with only four players not reporting such intake throughout the week. Ten players had more than one fatty snack per day, mostly chocolates, cakes or biscuits. Other high-fat sources included waffles, nachos, sausage rolls, and ice creams. Sugary drinks were common among the majority (*n*= 22) of players, especially as an accompaniment to one of the three main meals. These predominantly took the form of sodas, energy drinks, or packaged sweetened juices. Incidentally, sports drinks were not popular (*n* = 14) among the sample group, with only four players consuming sports drinks daily around training times. Alcohol was only minimally consumed by the players (*n*= 12). Those who reported alcohol consumption did so in quantities of only one unit or less, usually in the evening following a match.

On match-days players exhibited more appropriate nutritional practices, with most hydrating themselves well and consuming pasta around three to four hours before kick-off, practices in line with the standard recommended guidelines (FIFA 2010). Such differentiation in nutritional habits between training and match days is commonly reported in the literature, with nutrient intake being closer to optimal on match days, probably due to a specific dietary regimen (Burke, Loucks and Broad 2006*).* Holway and Spriet (2011), on the other hand suggest that stress, travel and match schedules

can alter the eating habits of team-sport athletes, causing them to eat less on match days than on training days, resulting in inadequate levels of energy and macronutrient intake for competition and recovery.

4.4 Discussion

The primary aim of the study was to assess energy balance and macronutrient intake in male international U21 soccer players. The findings demonstrate that over a seven-day period players were in a negative energy balance, with energy intake being insufficient to meet the demands of training and match-play. Mean daily energy intake was significantly lower than mean daily energy expenditure, resulting in a daily energy deficit. Additionally, players only met just over half (3.7 g·kg^{-1} BM) of the minimum daily CHO guidelines of 7 to 12 g·kg^{-1} BM (FIFA 2010), and reached the maximum recommended values for fat intake (30% of TDEI). Protein intake was adequate (1.5 g·kg^{-1} BM) and in conformity with recommended guidelines of 1.4 to 1.7 g·kg^{-1} BM (Lemon 1994; Tarnopolsky et al. 1992).

The team's mean daily energy intake (2164 ± 498 kcal) was well below the levels recorded for Italian and English players who show total caloric ingestion values of 3066 (Santilli 1990) and 3127 kcal · day (Reilly 1994a), respectively. Reeves and Collins (2003) also report a higher TDEI, namely that of 3057 ± 191 kcal among English players of the same age, as do Iglesias-Guitierrez et al. (2012) among U21 Spanish players, with an intake of 2796 kcal. Reasons for the low TDEI findings in this study, as well as the variability in findings across other studies, may include under-reporting of food consumption by participants, inappropriate fit of selected data collection methods, differences in nutrient quantification software used, or actual restriction of dietary intake during the study period owing to increased self-awareness of food and drink consumed (Macdiarmid and Blundell 1998). Under-reporting of food consumption indeed is one of the key cited limitations, with busy schedules, lack of interest, and negligence also representing common factors affecting the reliability of dietary recall as a data collection method (Burke and Deakin 1994).

Daily CHO intake among the research population (48% of TDEI – 3.7 g·kg^{-1} BM) was lower than that reported in some other studies on soccer players of the same age. Reeves and Collins (2003), Ruiz et al. (2005) and Iglesias-Guitierrez et al. (2012) report CHO intakes of 5.9 g·kg^{-1} BM, 4.6 g·kg^{-1} BM and 4.7 g·kg^{-1} BM, respectively. Renon and Collado (2013) however also noted an insufficient amount of CHO consumption among a sample of semi-professional soccer players. Jacobs et al. (1982) reported the closest findings, specifically 46.3% of TDEI from CHO among Danish players.

The physical nature of the sport however has since changed, and the last two decades have witnessed an increase in the energy demands of soccer rendering CHO percentages below half of TDEI insufficient.

More recent guidelines recommend a total CHO intake of 60 to 70% of TDEI (Maughan 1997; Clark 1994) or 7 to 12 $g \cdot kg^{-1}$ BM for players undertaking moderate- to high- intensity training (Maughan and Shirreffs 2007; Burke, Kiens and Ivy 2004), thus confirming the intake of Maltese national U21 players as insufficient. This low intake corresponded with low energy intake overall, regardless of macronutrient source. Inappropriate recording of CHO intake could also be a factor; however this would have similarily affected all other macronutrient values, which does not appear to be the case. On other occasions, fat was found to replace CHO intake. The highest reported mean individual CHO intake was 5.5 $g \cdot kg^{-1}$ BM, indicating that none of the players met the minimum recommended guideline. The least CHO intake was as low as 1.8 $g \cdot kg^{-1}$ BM, which does not even meet the standard minimum recommended guidelines for sedentary adults.

This low CHO intake accentuates a decrease in the glycogen stock of the players, triggering the accelerated onset of fatigue, particularly in the second half of a match. Increased fatigue has been correlated with decreases in the number of successful passes and distance covered, and increases in the incidence of injuries to the locomotor system (Reilly and Williams 2003; Reilly 1997). CHO intake must be sufficient to enable the sustainability of training loads at the intensity level required to elicit the desired adaptive training responses (Backhouse et al. 2007).

Unlike CHO intake, which did not meet the minimum recommendations for soccer players, the sample group reported a mean protein intake of 1.5 $g \cdot kg^{-1}$ BM, which is within the recommended range of 1.4 to 1.7 $g \cdot kg^{-1}$ BM (FIFA 2010; 2006; Boisseau et al. 2002; Lemon 1994; Clark 1994). This recommended range is considered sufficient to optimise training, accelerate recovery following exercise-induced muscle damage (Tipton et al. 2007), as well as support gains in lean mass (Tipton and Wolfe 2004). In terms of % of TDEI, the team's mean intake (21% of TDEI) slightly exceeded the recommended guideline of 20% (FIFA 2010; 2006; Lemon 1994; Clark 1994).

Recent research appears to support these findings. Briggs et al. (2015a) also report adequate protein intakes, despite participants being in a negative energy balance. Ruiz et al. (2005) and Iglesias-Guitierrez et al. (2012) report similar values, with an average intake of 1.8 $g \cdot kg^{-1}$ BM and 1.6 $g \cdot kg^{-1}$ BM respectively, among soccer players of the same age. Slightly lower values were reported by Korkmaz (2004) in a study on the protein intake of Turkish National Team players. The mean protein intake was 14% of TDEI with as many as eleven players individually meeting the

recommended range. Five players exceeded it, while nine fell short. It is worth noting that a significant number of the participating players took protein supplements, which could explain how some players were able to meet the guideline and not others.

Mean dietary fat consumed by the participants in this study (30 ± 5% of TDEI) matched maximal soccer-specific recommendations by FIFA (2010; 2006) and Clark (1994). Given the high-intensity nature of soccer, fat recommendations are based on facilitating CHO intake, rather than on contributing to energy metabolism (Clark 1994). Eleven players exceeded this percentage, with the highest recorded percentage of TDEI calculated at 39%, and the lowest at 18%. The fat in this study was analysed homogeneously, so data on the various types of fat consumed is not available. In the data inputting stage however, fast foods and saturated-fat sourced food trends were nonetheless identified, and indicated that from the 30% mean value of fat recorded across the entire sample over the seven-day period, a significant percentage came from saturated fats. Other studies report mean values of fat intake percentages of TDEI ranging from 29% to 38% (Iglesias-Guitierrez et al. 2012; Caccialanza, Cameletti and Cavallaro 2007; Ruiz et al. 2005). When compared to studies of similar-aged players however, the Maltese national side consumed an overall lower percentage of fat than their European counterparts as indicated by Ruiz et al. (2005) and Iglesias-Guitierrez et al. (2012), reporting values of 38% and 37% of TDEI, respectively. Similar fat percentages (31%) were seen in an investigation of Turkish national team players (Korkmaz 2004). In the case of the Maltese players, the mean fat intake may explain why consumption of optimal levels of CHO was limited, since fat approached the upper limits set out by recommended guidelines. Furthermore, the quality of fats is an important consideration in view of recommended guidelines stipulating that a maximum of only 10% of TDEI should derive from saturated fatty acids (Garcia-Roves et al. 2014).

TDEI on training days (2155 ± 504 kcal) did not vary much from that of weekends (2209 ± 663 kcal) when a match day was scheduled on either a Saturday or Sunday. Similar minor differences were also consistent in protein (1.5 vs 1.4 g · g·kg^{-1} BM), CHO (3.6 vs 3.9 g·kg^{-1} BM) and fat (29.6 vs 31% of TDEI) consumption on week and weekend days. The mean TDEE of the sample group (2799 ± 382 kcal) was low when compared to the daily energy expenditures cited in other studies, where estimated TDEE values ranging from 3100 to 4050 kcal per day have been recorded (Ebine et al. 2002; Rico-Sanz et al. 1998).

As regards to the players' energy balance, few studies have analysed this parameter, with those that did tending to produce highly variable results, possibly due to the use of diverse methodologies and experimental designs, or differences in the ages, competitive levels, and training loads of the participating players (Garcia-Roves et al. 2014). They also tend to report sub-optimal energy intake relative to estimates of energy expenditure (Briggs et al. 2015a; Iglesias-Guitierrez et al. 2012; Ruiz et al. 2005). The Maltese U21 players were found to be in a mean daily energy deficit of 705 ± 648 kcal during a week of intensive training. Only six out of twenty-five were found to be in an energy surplus. Two players were close to a state of energy balance, while the remaining participants were all shown to be training and performing at a total energy deficit. In an attempt to quantify the magnitude of the mean energy deficit, the findings provided a considerably greater deficit in comparison to Briggs et al. (2015a) [311 ± 397 kcal · day^{-1}], but was at par with Caccialanza et al. (2007) and Russell and Pennock (2011), who reported a total energy deficit of 891 ± 734 kcal per day and 788 ± 174 kcal per day respectively. Both studies similarly involved the use of a seven-day dietary and activity diary as a data collection tool during a selected week of the competitive season. The findings in this study show that the players' dietary practices are inadequate to sustain the demands of training and competition. Such chronic and sub-optimal CHO and total energy intake during periods of high training volumes have been shown to negatively affect performance (Alghannam et al.2016; Burke et al. 2011).

Players' hydration levels varied considerably across the sample group, with 4069 and 729 millilitres per day representing the highest and lowest values recorded, respectively. Mean daily hydration levels (1648 ± 784 millilitres) were considerably low when compared to the standard recommendations of three to four litres per day, depending on climate and temperate conditions (Shirreffs, Sawka and Stone 2006; Aragon-Vargas 2004). While failing to accurately document hydration in the intake section of the Food and Exercise Diary could be a contributing factor influencing this discrepancy, all the players advocated that the Food record was a true representation of their food and drink intake. One may conclude therefore that hydration must be a major limitation for the team, given that adequate hydration is largely considered a basic and standard requirement for any soccer player competing at international level.

In summary, TDEI; TDEE; Energy Balance; daily CHO, protein, fat and hydration intake, as well as the weekdays for training sessions versus weekends for match-day intake practices of the Maltese U21 international male soccer players were the principle data variables investigated in this study.

4.5 Conclusion

The study revealed nutritional malpractice among soccer players of this national side, and highlights the need for improved nutrition strategies among this population. Mean intake of CHO fell short of minimum recommended guidelines, a cause for concern considering that CHO is the main substrate for soccer. Moreover, the players were found to be in a negative energy balance, resulting in an insufficient supply of energy for optimal performance in training and match-play. While acknowledging the discrepancies between the nutritional practices of this U21 national team cohort and the recommended guidelines, further research is needed in order to understand the true implications of such nutritional behaviour. The study described in the next chapter was designed to address this phenomenon by investigating the players' nutritional beliefs, barriers, and knowledge.

Chapter 5

Nutritional attitudes, habits, perceptions, barriers and knowledge in an U21 male international soccer team

5.1 Introduction

The dietary practices of the researched population in this study tend to confirm those found in other studes whereby a marked incompatibility between actual dietary practices, which leave much room for improvement, and peak physical performance is shown (Iglesias-Guitierrez et al. 2002; Rico-Sanz et al. 1998; Ingram and Davies 1996). Despite widespread knowledge of this phenomenon and the existence of a large body of evidence effectively proving the relationship between poor nutrition and diminished performance on the field (Burke, Kiens and Ivy 2004), very little research has been conducted to investigate the causal factors influencing such inappropriate performance-inhibiting dietary consumption among professional soccer players.

Research in other sports has uncovered various barriers that inhibit athletes at all levels (Heaney et al. 2011; 2008) from achieving optimal dietary practices, which include loss of appetite after training, regularly missing meals, and the temptation to consume take-away or fast foods, among others. Financial limitations affecting the ability to purchase nutritious food represent another common barrier to good nutritional practice in athletes, tending to cause players to purchase cheaper foods which are not normally as nutritious (Heaney et al. 2008). Time-management issues and living arrangements have also been found to commonly influence athletes' nutritional intake, as do lifestyle issues, which remain a consistent problem for athletes in transitional phases between home and more independent settings (Heaney et al. 2008). Younger athletes who can no longer rely on their parents or guardians to provide meals, may lack the skills necessary for preparing and cooking their own nutritious meals (Heaney et al. 2008). Lack of effective time-management in this instance compounds the problem further, as challenging academic/work and training schedules leave the athlete with insufficient time to shop for food and prepare it (Heaney et al.2008).

The literature, as discussed earlier in the literature review section, generally shows that athletes lack awareness of their nutritional needs, as well as the knowledge or skills required to actually meet such needs in practice. Despite the causal factors influencing this scenario, athletes nevertheless appear to understand that effective nutritional practice supports improvements in sports performance, and constitutes the primary source of fuel for working muscles (Ono et al. 2012). In soccer, the situation appears very much the same (Burke, Kiens and Ivy 2004; Jonnalagadda et al. 2001), as a minority of players actually employ sound dietary practice, and a majority remain poorly educated about nutrition, and

unskilled in making appropriate daily nutritional choices. Lack of nutritional support by professional people has also been identified as a contributing factor to poor dietary behaviours in athletes (Alaunyte, Perry and Aubrey 2015).

Nutrition information is imparted to athletes from diverse sources including coaches, teammates, athletic trainers, fitness trainers, parents, supplement manufacturers, and the media. Unfortunately not all of these sources are evidence-based, and many are considered unsuitable, unreliable, and not based on fact. Such sources may be actively contributing to the persistence of various popular myths surrounding nutrition, and may ultimately negatively affect the dietary practices of athletes. In the case of coaches, many are former players, whose knowledge of nutrition is often limited by personal beliefs, what they learned via the same channels as the players, or through anecdotal experiences encountered throughout their own professional careers (Ono et al. 2012). As a result, adequate attention to nutrition is often excluded from the clubs' and players' regimes. According to Ono et al. (2012), many professional clubs still do not enlist the services of sports nutritionists, or do so infrequently. This notion however does not appear to have been explored further in other studies. Since only a handful of clubs utilise the expertise of dietetic professionals to enhance their team's performance, the responsibility for nutrition in the majority of cases tends to fall under existing members of the support staff, themselves subject to the same limitations afflicting coaches and players. The coach remains for many players, a primary source of nutrition education, and suspicion rarely arises that such nutritional knowledge may be incomplete (Walsh et al. 2011). Traditional schools of thought have preached various erroneous myths about nutrition in soccer including exaggerated claims and inflated recommendations concerning the importance and intake of protein, abstinence from fluids during training and match-play to avoid the onset of a "heavy stomach", indiscriminate ingestion of fluids regardless of their composition, consumption of simple sugars like chocolate before training or match-play, and ultimately the denial of effective nutrition (Wallinga 2012) as a factor leading to improved performance in soccer. Players acquiring such knowledge tend to internalise it as soccer habitus, and unconsciously embody it throughout their careers just as their coaches did before them. Unfortunately much of the prevalent misinformation and misconceptions persist to date, with the internet now further substantiating this pool of questionable data. Compounding the issue further are the trends initiated by sports supplements manufacturers, influencing players to purchase products based on commercially-driven rather than evidence-based nutritional practices. Dubious nutritional practices pervaded via mass media, perpetuate the challenges of promoting sound and consistent nutrition education. With such an easily-accessible wealth

of information at hand, misinformation is rife. Unregulated websites and news articles about commercial products often present opinion as fact, supplying misleading, skewed or incorrect information about nutrition, nutritional products, and diets, which is in turn received by players who accept it as fact (Williams 2012). Players must understand that performance and fitness gains occur as a result of long-term changes in the diet and improved training, and not through short-term, quick-fix solutions as suggested by much of the marketing and promotional material published by sports supplements enterprises (Williams 2012).

The aim of this study was to understand players' habits, perceptions and barriers towards optimal nutrition in soccer, as well as their current nutritional knowledge with relation to soccer. Other objectives included understanding the players' perceived performance following an international match without nutritional support, and to explore the views of the team manager and assistant manager towards nutrition in soccer. The study is based on the hypothesis that the nutritional knowledge of the soccer players with relation to soccer is poor, and that their attitudes and perceptions towards nutrition is equivocal in a way that they are uncertain of its effect on performance.

6.2 Materials and methods

6.2.1 Study Participants

Twenty-five semi-professional soccer players forming part of the Maltese U21 national soccer team were recruited for this study (age=20.7 ± 1.1 years; height= 178 ± 5.7 centimetres; BM = 76.1 ± 6.6 kilograms; %BF = 11.0 ± 1.3%). All participants were informed verbally and in writing about the nature and demands of the study and data collection procedures via a participant information sheet. The participants duly returned the provided written informed consent to participate, in accordance with Edge Hill University ethical procedures.

5.2.2 Experimental design and procedure

The data collection period spanned over two months, starting with the nutritional knowledge assessment, continuing with the player's individual semi-structured interviews regarding habits, perceptions, attitudes and barriers towards a sound nutritional plan in soccer, and ending with an interview with the coach regarding the team's current nutritional awareness and preparations. The study period preceded an international match, in preparation for which, no specific

nutritional support or intervention was implemented. After the match, players in the starting formation were interviewed regarding their own performance, as well as that of the entire team, with specific focus on nutritional aspects.

5.2.2.1 Nutrition in soccer knowledge test

The team manager called the players 90 minutes before a scheduled training session to undertake the soccer-specific nutrition assessment in the team's lecture hall at the MFA technical centre, as explained in methods section 2.7. As agreed with the researcher, the true reason for being called was not disclosed. The players were instead informed they would be participating in a team-building activity. Had the players known they were to undergo a nutrition knowledge test, any preparations made thereupon would have affected the validity of the results, given that a true assessment of current knowledge was the primary test objective. One of the players was illiterate, so the researcher assumed the role of a reader, asking the questions verbally. The completed test papers were collected by the researcher after expiry of the allotted thirty minutes. The results of the test were communicated to the players one week later; however no additional information regarding their performance was issued, namely which answers were correct or incorrect since the same test was to be repeated after the implementation of the nutrition education and support intervention programme. The nutrition knowledge in soccer test was previously validated as explained in methods section 2.7 among players who currently play or have played at Malta's top division.

5.2.2.2 Habits, attitudes, perceptions and barriers semi-structured interview

The researcher met each of the participants individually throughout a four-week period for the one-to-one semi-structured interviews investigating habits, attitudes, perceptions, and barriers to optimal nutrition. Details of the interview design and structure as well as its validation prior to use as a data collection measure in this study are found in method section 2.8.

5.2.2.3 Team coach and assistant coach semi-structured interview on nutrition in soccer

The researcher next interviewed the team manager and assistant manager as explained in methods section 2.9 regarding nutrition related topics as well as current practices of the team in the area. The aims of these interviews were to understand the current nutritional practices of the team on a managerial and administrative level, and the coaches' views on nutrition as an integral part of the team's overall preparation.

5.2.2.4 One-to-one semi-structured post-match interview on perceived individual and team performance following no nutritional intervention with players in the starting line-up of an international match

Finally, players in the starting formation who played the entire 90 minutes (*n*= 9) of an official international fixture were interviewed individually as they returned to Malta following a recent away fixture. The interview as described in methods section 2.10, sought information about the players' perceived individual and team performance in the match, as they followed the standard buffet-style three-day menu prescribed by the team doctor. The menu in question was acquired for the purpose of analysis in order to understand the nutritional practices adopted by the team ahead of the match, as yet without the additional nutritional support of the researcher.

5.3 Analyses and results

5.3.1 Nutrition knowledge in soccer test

Below are the descriptive statistics of the nutrition knowledge assessment. Out of twenty-seven questions, the mean tally of correct answers was sixteen, equating to 60% correct answers. The mean number of wrong answers was eight, and the 'Do not know' answers, three. When expressed in terms of negative marking, which was the chosen method for quantifying the final results, the final mean test score of the team was just 30%. The highest and lowest marks obtained were 56% and 10%, respectively. Only four players scored more than 40%. The results clearly indicate an overall poor knowledge of soccer-related nutrition among the sample population (Figure 4 and Figure 5).

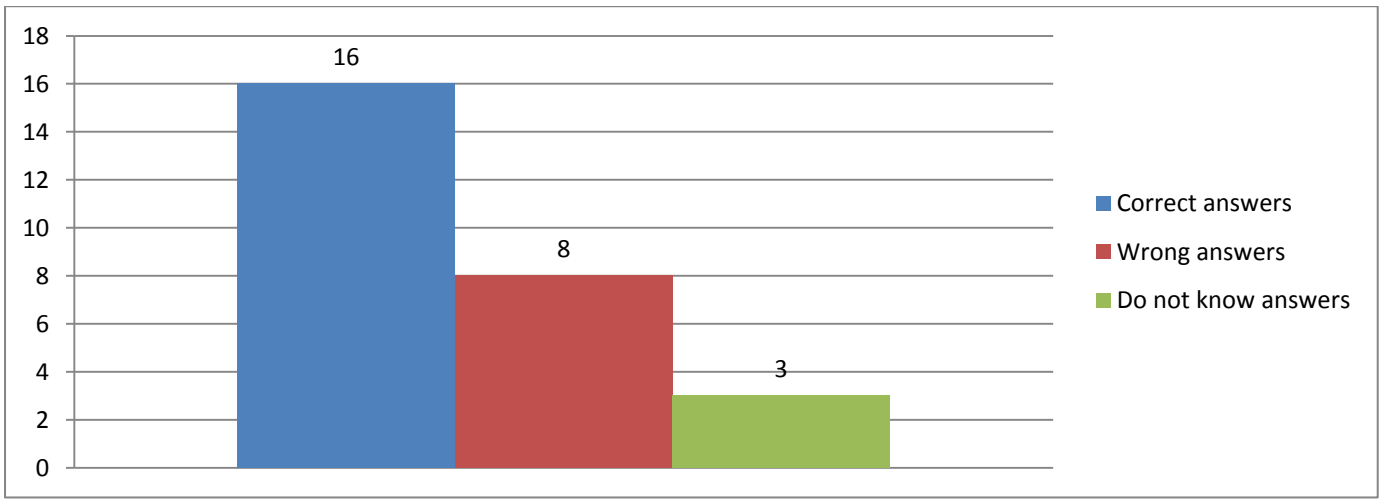

Figure 4: Players' distribution of answers to the nutrition in soccer knowledge test

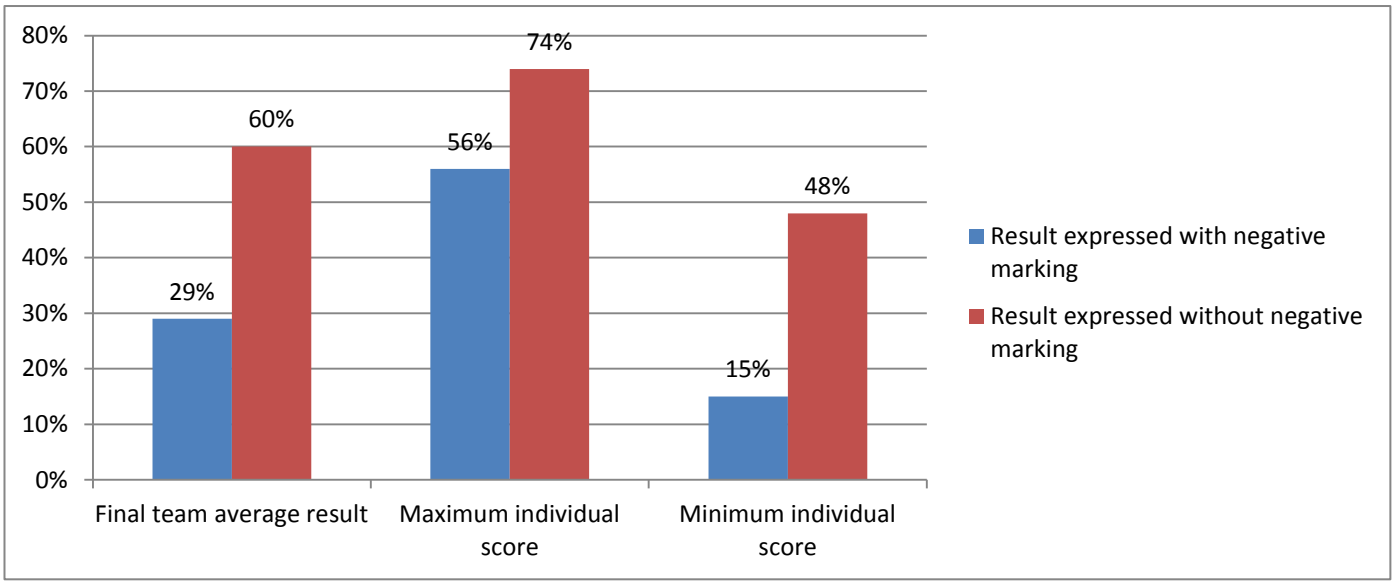

Figure 5: Players' % of correct answers expressed with and without negative marking in the nutrition knowledge in soccer test

The first section of the nutritional assessment included the following four questions about energy.

Energy Q1 Where does the most valuable source of energy in soccer come from?

The majority of the players answered correctly choosing CHO as an answer (*n*= 24). Only one player singled out protein as the most valuable energy source in soccer. None of the players were uncertain about this answer and neither did any of them chose fat as their answer.

Energy Q2 Which of the following macronutrients release the same amount of energy per gram?

The answers in this question varied considerably, however the right answer was selected by the highest number of participants (*n*= 9) as both CHO and protein are equivalent to 4 kcal per 1 gram, unlike fat that is equivalent to 9 kcal per 1 gr. Six players chose 'protein and fat' as an answer, while five players each chose 'CHO and fat' as well as the "Do not know" option, showing that answers to the question varied considerably.

Energy Q3 How should the optimum daily distribution of energy from macronutrients for a soccer player be?

The majority of the players (*n*= 14) erroneously chose the distribution choice of 60% CHO - 30% PRO - 10% FAT as the ideal macronutrient distribution for a soccer player. It seems that players value the importance of protein in their diet while understanding that fat intake should be limited. Nevertheless, the optimal distribution has been shown to be 60%

CHO, and 20% each for protein and fat (FIFA 2010; 2006), given that excessive protein intake may result in failure to ingest the appropriate amount of fats, which are required for energy in soccer (FIFA 2010; 2006). Players appear to experience difficulty in differentiating between saturated and unsaturated fats, of which the latter of course is widely known to be an absolute requirement for various essential bodily functions. In fact, only one player answered correctly, with another choosing the CHO 50% – 20% - FAT 30% option and a total number of nine players indicating that they "did not know".

Energy Q4 What is the best strategy to reduce your total daily energy intake?

Most of the players (*n*= 23) were right in saying that the best strategy to reduce daily energy intake was to consume small portions at frequent intervals throughout the day. Only two players chose the wrong strategy of taking three big meals a day as a means of reducing TDEI.

The second section of the nutritional assessment included the following twelve questions about nutrients.

Nutrients Q1 If a soccer player wants to reduce the amount of fat in his diet, which food should he not take?

Most of the players (*n*= 17) correctly identified that sausages contain the most amount of fat among the food options available. A significant number of players (*n*= 8) however felt that excluding turkey would be the best option, when this is actually one of the leanest selections of animal protein. Some players (*n*= 9) were undecided, but all players agreed that steak should not be omitted in such a scenario, indicating that players wrongly believe that steak does not contain any fat.

Nutrients Q2 Which of the foods below have the highest CHO content?

The majority of the players (*n*= 19) answered correctly, identifying that from the food choices available the pasta-bread-vegetables option contained the highest concentrations of CHO. Only six players did not answer correctly, where four of them chose the pasta-bread-sweets option and two of them chose the meat-vegetables-potatoes option. None of the players chose the "do not know" option, likely meaning that they were relatively of their answers.

Nutrients Q3 Which of these foods below have the highest protein content?

The highest number of players (*n*= 17) rightly chose dairy-meat-nuts as the correct answer. The nuts-meat-potatoes answer was the second most popular choice (*n*= 7), followed by vegetables-fruit-meat (*n*= 3), and two players were unsure of their answer. More than half of the players in this instance chose the wrong answer.

Nutrients Q4 Which of the foods below would be the best choice for a low fat - low sugar - high CHO snack?

This question was considered to be a tricky one, as players had to choose a snack high in CHO but low in fat and sugars, implying a complex CHO or polysaccharide snack as the correct answer. Most of the players (*n*= 12) however answered correctly, choosing the muesli bar as the most appropriate snack. The rest of the players shared their answers between having diet strawberry yoghurt (*n*= 5) and wholemeal crackers with cheddar cheese (*n*= 6) as their preferred choices, except for two players who were unsure of any of the food options provided.

Nutrients Q5 If a soccer player would like something sweet but wants to cut down on sugar, what food should he consume from the choice below?

Despite also being considered a tricky question, the majority of players (*n*= 16) answered correctly, choosing a moderate-GI option consisting of a banana with some plain yoghurt. Honey would be a high-GI option and therefore should not have been selected (*n*= 2) due to its high sugar content, while a cereal snack bar, chosen by five players, contains less sugar than the other two choices. Two players did not indicate any preferred choice.

Nutrients Q6 What is the function of the vitamins we take in from foods?

With the exception of a few players, most (*n*= 17) correctly identified the main functions of various vitamins that assist and facilitate energy transfer processes. Only one player thought that vitamins help increase muscle strength, while two believed them to be a source of energy. The rest (*n*= 5) opted not to commit to any answer, selecting the “do not know” option.

Nutrients Q7 What would be the best breakfast that a soccer player can take from the choice below?

The absolute majority of players (*n*= 23) agreed that muesli/oats with skimmed milk, dried fruit and honey constitute the best breakfast choice for soccer players. Only two opted for cornflakes with full-fat milk, while none chose the ham and cheese sandwich option. Since there were no ‘Do not know answers’, it seems that players were all certain of their choices.

Nutrients Q8 What would be the best mid-morning snack that a soccer player can take from the choice below?

All players except for one, who chose a cereal bar as the best mid-morning snack, correctly opted for fruit as the ideal mid-morning snack.

Nutrients Q9 What food group sources should the mid-day lunch of a soccer player be based on?

This question sought to address knowledge and application with respect to food sources. The majority of the players (*n*= 11) this time failed to select the correct answer. Meat and poultry as a food group category was chosen as the best source for mid-day lunch. Considering the importance of CHO in soccer, the breads-grains-cereals food group was the correct answer, selected by only six players. Four players opted for each of the remaining two choices (fruit-vegetables, and "do not know").

Nutrients Q10 What would be the best source of fat that a soccer player can take from the choice below?

The participants were generally knowledgeable on the optimal sources of fat, as twenty players chose "avocado-olive oil-salmon" as their answer. No players chose "olive oil-fries" as their answer, three chose the butter-cheese-milk option, while two players did not commit to a choice.

Nutrients Q11 Which of the foods below have the highest protein content per gram?

Seventeen players knew that the highest protein concentrations could be found in fish, broccoli and eggs. Almost a third (28%) of players mistakenly believed the highest protein quantities could be found in chicken, rice cakes and apples. The "beef-potatoes-muffin" option was not chosen by any of the players, while one player did not make any selections.

Nutrients Q12 What is the most important function of protein for a soccer player?

Answers to this question were highly variable, with the majority of answers divided equally (*n*= 8) between building muscle mass and promoting recovery from training. While one of the functions of protein is indeed to build muscle mass, the promotion of recovery is considered its most important function for soccer players. While protein is also an energy source for training, other nutrients are considered better equipped for this role, so energy provision was also deemed incorrect, despite 20% of the participants selecting it as their preferred answer. Four players did not commit to a choice.

The third section of the nutritional assessment included the following three questions about hydration.

Hydration Q1 What is the minimum amount of water that a soccer player training in moderate temperate weather should conditions drink on average per day?

The majority of answers were divided between the '2 to 3 litres' (*n*= 12) and '3 to 4 litres' (*n*=11) answers. The question was specific in highlighting the minimum amount required in moderate temperature weather conditions, while acknowledging that intake may vary according to the individual, and weather conditions. None of the players did not make a choice, nor thought that one to two litres of water suffices as a minimum amount of intake for a soccer player.

Hydration Q2 How is dehydration likely to affect the performance of a soccer player in training and match-play?

All the players except for one agreed that dehydration limits performance in soccer.

Hydration Q3 What is the most important ingredient in a sports drink consumed by a soccer player?

Maintaining focus on hydration as a topic, the researcher was keen to find out more about player's beliefs regarding the use of sports drinks. The answers to this question varied considerably. Twelve players correctly identified that sugar is the most important ingredient, while the rest of the sample group (*n*= 8) were evenly distributed among the remaining two options being creatine and sodium. While sodium is also an important ingredient in sports drinks it not considered the most important, since it is sugars that provide the required energy boosts throughout the course of a match. Despite being largely non-existent in commercial sports drinks, some participants (*n*= 5) also nominated creatine as a primary ingredient. Five players did not make a choice.

The fourth section of the nutritional assessment included the following three questions about sports supplements.

Supplements Q1 How important are supplements for a soccer player?

The knowledge test also sought to assess beliefs and behaviours surrounding the use and need of sports supplements in soccer. The majority of players (*n*= 13) correctly indicated that supplements assume diminishing importance when a complete and balanced diet devoid of specific nutritional deficiencies is consumed. Six players said that supplements are very important and should be taken daily, while another six players were unsure of their importance.

Supplements Q2 What is the best source of protein that a soccer player can take?

All players except for two agreed that the best source of protein is protein-rich foods. From these two players, one chose protein shakes while another opted for the “Do not know” option.

Supplements Q3 In which sources is creatine normally found?

Answers varied in comparison to Supplements Q3, showing some confusion in the area. Indeed, over a third of the participants (36%) opted for the "do not know" option. Seven players rightly chose meat and fish as the correct answer, with the same number of players wrongly choosing "supplements only" as their correct answer. Only two players opted for "meat and beans" as an answer to this use of supplements related question.

The fifth section of the nutritional assessment included the following five questions about match-day nutrition.

Match-day nutrition Q1 Which of the foods below should a soccer player primarily take within 15 minutes after a match?

The majority of players (*n*= 17) erroneously selected banana as the optimal food for ingestion by soccer players within fifteen minutes after a match. While banana is indeed a valid choice, two players selected the more suitable answer for this question i.e cranberry juice. Apart from comprising 100% CHO, cranberry juice is already in liquid form, facilitating rapid digestion and absorption. Surprisingly, five players opted for chocolate, while one player did not commit to a choice.

Match-day nutrition Q2 Which of the foods below should a soccer player take as a pre-match meal?

There was almost unanimous consensus among the sample group (*n*= 24) that the best pre-match meal choice for soccer players from the choices provided consists of pasta with low-fat tomato sauce. The participants were able to correctly identify this answer despite the remaining answers representing relatively credible options. Only one player chose meat-potatoes-vegetables as the best pre-match meal.

Match-day nutrition Q3 How many hours before a match should a soccer player consume the pre-match meal?

A majority (60%) of the participants selected the correct answer of timing the pre-match meal between three to four hours before the scheduled start of a match. The remaining participants (*n*= 9), except for one who did not make a choice, nominated two to three hours as the optimal time-frame.

Match-day nutrition Q4 Which of the foods below should a soccer player take as a post-match meal?

Twenty-two players correctly identified meat, potatoes and vegetables as the preferred primary constituents of an effective post-match meal. Only one player felt that any food could be eaten at this time, while two players opted for the "bread-cheese-dairy" option as their preferred choice.

Match-day nutrition Q5 What should the average amount of water that a soccer player consumes 60 minutes before a match be?

While the correct answer to this question will depend on individual requirements, standard guidelines recommend ingesting 500 millilitres around sixty minutes prior to kick-off. Eight players correctly identified 500 millilitres as the right answer, while seven felt that two litres of water would be the ideal amount. Some players (*n*= 4) thought that one litre is the optimal amount while the remaining players (*n*= 6) could not nominate a definitive answer.

5.3.2 Habits, attitudes, perceptions and barriers semi-structured interview

The first section of the interview gathered general information about their current exercise practices.

Sec 1 Q1 How would you describe the experience of filling in a daily Food and Exercise diary?

A majority of the participants reported that completing the diary was relatively easy, and found the one-day template easy for reference in case of difficulty and particularly helpful. Many commented that after the first three days of the study period, the process of filling in the Food and Exercise diary became boring and "dragging". They confirmed that despite such motivational setbacks, they continued to make the required entries in full for the sake of completing the research. Other interview data suggested the process was time consuming, and some participants would forget to make timely entries, opting to fill in the missing parts of the diary at the end of the day. One participant reported some difficulties in interpreting the household portions.

Sec 1 Q2 Did you come to terms with any nutritional habits as you were penning down your daily nutritional intake?

The majority of the players commented that the act of recording entries in the diary helped them acquire a more realistic picture of their dietary intake. Only two claimed that the process had no effect on their nutritional awareness, as they were already quite familiar with their own dietary habits, which in general varied widely across the sample group. While positive habits were noted, negative habits were more common. Drinking plenty of water and making healthy choices when eating out represented the majority of positive habits. A high incidence of skipping breakfast, eating late, lacking food preparation time, snacking on unhealthy foods and drinks, consuming too little overall, over-consuming from a single food group (usually chicken breast in an attempt to ingest higher amounts of protein), and eating large and infrequent as opposed to smaller and more frequent meals were noted in the data set for negative habits.

Sec 1 Q3 How do you rate the quality of your daily nutritional intake before you started filling in the Food and Exercise

diary?

When asked to rate the quality of their diet, many players made positive self-assessments, describing their habits as "fairly good", but with room for improvement. Only two players acknowledged poor personal dietary habits, recognising an excessive consumption of junk and sugary foods. Some of the players stated that while they knew how to eat well, they found temptations difficult to resist and that, "The tasty food is normally not too nutritious." Some also recognised discrepancies between weekdays and weekends, admitting a rather sporadic intake during the latter as a result of a lack of structure during the respective day.

Sec 1 Q4 Is there anything in your daily nutritional intake that you would change in terms of both quality and quantity?

When asked if they would make any changes in the quality or quantity of the food and drink comprising their diets, the participants offered a range of varied responses. In terms of quality, some players mentioned eating less junk and sugary food, having a timely pattern for food consumption, eating healthier during the weekends, consuming more fruit and vegetables, drinking more water, improving the quality snacks, and starting off the day with a healthy breakfast. Three players considered their diets to be satisfactory, and said they would not change anything. As regards to quantity, the majority of players felt they were eating enough, with a majority recognising that they needed to eat smaller portions more frequently. Work and college restrictions tended to distort desired eating patterns, forcing players to eat large portions at the few remaining times available. Another observation from the sample group included the desire to reduce quantities of junk food, sugary snacks, sugary drinks and white pasta portions consumed throughout the day. Some participants discussed the need to increase portion sizes of certain food sources like fruit, vegetables, and even meats, believing the latter to be essential for obtaining adequate amounts of protein. Less than 10% of the participants estimated they were consuming the correct amount of food each day.

Sec 1 Q5 How willing are you to improve your daily nutritional intake, provided that the support will be given to you by the researcher as your Soccer Nutrition specialist?

Finally, this section aimed to establish the degree of willingness of players to attempt the development of an improved dietary status, with researcher support. A majority of 71% of the sample group expressed considerable enthusiasm at the prospect of improving their nutritional habits, citing various motivating factors including a lack of existing knowledge, failed attempts in the past to improve dietary practice, a desire to look and feel better, and determination to improve

performance in soccer training and match-play. The remaining players were not as convincing, revealing their apparently limited commitment via comments such as, “I will try.” Some of the concerns registered by participants included difficulty in adhering to the diet due to full-time work commitments, likes and dislikes of prescribed foods, self-assessed “laziness”, aversion to additional commitments, time restrictions particularly with regard to food preparation, and reluctance to sacrifice various junk and sugary food items. One player insisted that he already eats “perfectly well,” and hence there was absolutely no need to change his current dietary plan.

The second phase of the semi-structured interview gathered information about the players’ current dietary habits and patterns.

Sec 2 Q1 Please describe your daily customary eating pattern

A high degree of variance across the sample group was once again noted. Of some concern was the prevalence of breakfast omission from the customary eating pattern among 62% of the sample group. Only 33% of the players claimed to eat breakfast, which in all cases consisted of cereal. The remainder consumed only a quick glass of milk, or cup of tea or coffee to start off the day. Dinner was consumed by every member of the squad, while lunch and pre-training meals were consumed interchangeably by a number of players. Players based these latter two meals predominantly on CHO sources, and their snacks on fruit and sugary options like chocolates. Mid-morning snacks were common, whereas pre-training snacks were consumed by only few of the players. None of the participants took advantage of post-training snacks.

Sec 2 Q2 How do you describe unhealthy food? How often do you take it in a week?

Players’ perceptions about unhealthy foods were explored in Sec 2 Q2, as well as the frequency of their consumption. The vast majority of players described unhealthy food as “junk,” “take-away,” or “deep-fried,” foods containing, “lots of fats”. One player hypothesised that even the healthiest of food can be unhealthy in the event of over-consumption. One player revealed some of the psychological aspects of his perspectives towards the consumption of junk food, describing feelings of happiness he associated with various unhealthy foods, conceptualising such “treats” as rewards for the completion of yet another hectic day. Others commented on the role of unhealthy food as a reward to be enjoyed only during the weekend, after faithfully adhering to a healthy eating regimen throughout the entire week, normally saving

such a treat for immediately after competitive matches. Examples of unhealthy foods cited by players for the most part included meals from major burger franchises, pizzas, burgers, hot-dogs, and fries. Others mentioned sugary soft-drinks, sweets, Chinese food, deep-fried chicken, donor kebabs, and traditional Maltese cheesecakes made of puff pastry filled with either soft white cheese, or dried marrowfat peas. One of the players also felt that eating pasta in the evening was also unhealthy. A striking and recurrent theme emerging throughout the data analysis process however remained players' tendencies to consume certain foods or drinks knowing full well that they were unhealthy. Only two players abstained totally from unhealthy food. Half of the players consumed unhealthy food at least twice a week, while the remainder consumed it only once. It was interesting to note that while some players reported eating unhealthy food twice per week, they classified this frequency as “rarely”.

Sec 2 Q3 Please describe your pre-match nutritional routine

When asked about their pre-match nutritional routines, all but one noted they noted that they did indeed tend to consistently eat a standard pre-match meal. Most of the meals were based on a substantial portion of white pasta with tomato sauce between three to five hours before the start of a match. Other players chose chicken with vegetables as their preferred pre-match meal. What's more, a significant number of players claimed to pay due and diligent regard to remaining adequately hydrated on match day. Some complimented their meal with fruit, cereal bars, or energy drinks approximately thirty minutes before kick-off. One player commented that a “good” meal the night before a match was also vital.

Sec 2 Q4 Please describe your post-match nutritional routine

Post-match consumption appeared a little more haphazard throughout the sample group. Many players assumed they could “eat anything” after a match, mostly resorting to junk food from major fast-food franchises, as a treat for “being good all week,” and a means of stress-relief and relaxation. Very few players actually reported consuming a “proper” post-match meal that includes portions of protein, starch and vegetables. All the players claimed that unlike the pre-match meal, there is no standard routine at the post-match stage, reasoning that once a match is over, one can “relax and let go for a while,” until of course a new week of work and training starts again.

Sec 2 Q5 Please describe your hydration pattern. Is there a particular time that you need to hydrate yourself more apart from during training and/or matches?

When asked about hydration patterns, many claimed to drink approximately two litres per day, depending on weather conditions. They also specified that they usually tend to hydrate themselves more thoroughly in the hours before, rather than after, a training session.

Sec 2 Q6 Please describe your alcohol consumption. How often do you drink alcohol in a week and how many units? Does this interfere with your training and match schedule?

Excessive alcohol consumption did not appear to be an issue across the sample group. The majority of participants stated that they either did not consume any alcohol at all, or did so only when socialising at the weekend following a match. They all recognised that alcohol consumption and soccer training are not complimentary to one another, but little to no harm is likely to arise as a result of consuming some alcohol after a match to socialise with friends.

Sec 2 Q7 What do you normally do when you are extremely hungry but find no ready prepared meals at home?

This question represented a practical scenario for the players. Many players admitted they would either order a take-away or open the freezer in search of food that can be heated up quickly, like frozen pizzas. Only a few players said they would cook their own food, such as a plate of pasta, depending on the severity of their hunger. Some players said they would opt for a bowl of cereal or prepare a toasted sandwich. A significant number also admitted they would open the savouries drawer filled with sweets, chocolates and biscuits and snack on whatever they find in order to suppress their hunger. Another strategy adopted by one of the players involved drinking dense juices such as pear and banana juice to “feel full,” in order to “kill time” until a proper meal becomes available.

The third and fourth section sought information about the players’ attitudes and perception towards nutrition in soccer.

Sec 3 Q1 What does a ‘nutritional plan’ mean to you?

This question aimed to explore players' interpretations of nutritional planning. Among the definitions provided were, “A way of eating with scheduled patterns,” “Something that improves health, gives you more energy, and improves body composition,” and adopting a routine that becomes a, “Way of life”. Other replies included the development of eating habits that can help facilitate improved performance both mentally and physically. In terms of the practical specifics of a nutritional plan, participants suggested eating a wide range of food sources, eliminating unhealthy food, and striking an

overall energy balance. Three players clearly explained that a structured nutritional plan represented a “huge sacrifice” for them, further stating that being careful about what to eat was, “Not a nice feeling.”

Sec 3 Q2 What are you expecting from the Soccer Nutrition Specialist?

This question was important for the researcher in order to clarify participants' expectations throughout the course of the study, as well as their expectations of prospective nutrition specialists throughout the course of their careers. Many of the players specified that they expected a personalised nutritional plan that meets their energy demands, food likes and work or college schedule, and will ultimately help them to, “Train and perform better.” Other replies included the provision of nutritional knowledge, an analysis of their current energy intake and balance, ongoing support, and reassurance that nutrition does indeed improve performance. Few players were uncertain of their expectations, but maintained that the researcher’s nutritional support would most likely help them to attain optimal body composition, and have enough energy to sustain them through training and match-play.

Sec 3 Q3 Comment on the statement ‘One diet fits all the team’. Do you agree? Why?

When asked to comment on their views on a standard diet applicable to the entire team, every participant asserted that every player has different needs, energy requirements, food likes and dislikes, sweat rates, lifestyles, commitments, body composition status, as well as different positional roles within the team, all requiring tailor-made adjustments.

Sec 3 Q4 Have you ever had some information relayed to you on nutrition? Do you feel that this is important? Why?

A majority of participants (81%) claimed that they had never received formal instruction related to nutrition. Some said they had been present at occasional talks here and there in the past, or had received some nutritional advice from trainers, coaches, physiotherapists, or indeed peers encountered at the fitness centre. The cited sources raise questions about the quality of advice given, as well as the credentials and expertise of those imparting it. Two players said they had conducted their own research, mainly online. One participant described his experience of visiting a nutritionist with the aim of losing weight. The personalised weight-reduction diet however later proved ineffective, as it did not accommodate the specific demands of soccer players. None of the players had ever been prescribed personalised performance diets before, affirming they had little idea about what to eat to support their training and maximise their performance.

Sec 3 Q5 What type of nutritional support do you get from the national team and club?

None of the players had ever received nutritional support from the national team staff, while a few had received some guidance from their respective clubs. One of the participants described how his coach had encouraged players to take protein supplements and meal replacements when they did not find time to eat, but individual guidance on quantities required was not forthcoming.

Sec 3 Q6 Do you feel that it is necessary to have someone telling you what to eat? Or would you find this unnecessary and a sort of hassle? Why?

The majority of players said they found ongoing support necessary. Indeed, they registered concerns that without it, the majority of players may struggle to adhere to the intervention due to lack of motivation or practical knowledge.

Sec 3 Q7 Do you have any food or drink, or meal preferences, traditions or superstitions in relationship to training and/or matches?

The majority of participants appeared to have some pre-conceived notions about pre-match nutritional routines, stating they usually opted for a plate of pasta. Few however expressed any unwillingness to change these habits. Simply eating healthily on the day of the match appeared to be their top priority.

Sec 3 Q8 Do the people around you influence your food choices? How? Why?

Due to the fact that all participants were still resident at their parents' family home, most were heavily influenced regarding their food choices. Most described a traditional setting at home where, “Mum cooks for the whole family.” The players' food choices were therefore largely dependent on what their mothers chose to prepare. When eating out, the majority stated that they were not influenced by friends, possessing the apparent maturity to make their own decisions, even when this involved resisting “tasty” junk food, despite peer pressure from friends. Some admitted to occasional episodes of getting, “carried away,” although such occurrences were rare. Some of the players stated their parents were receptive and willing to prepare separate meals exclusively for them should they produce a specialised nutritional plan, maintaining that their families were consistently, “Very supportive”.

Sec 3 Q9 Do you find yourself thinking about the nutritional content of the food or drink being consumed? Why?

This question aimed at establishing the degree of conscious awareness players tended to have about the content of foods they ate. The majority admitted they did not usually consider the matter of food content in particular depth, and consumed what they actually felt like eating at that particular time. Some players explained that they considered food

content by checking food labels for the item's nutritional content, paying particular attention to the amounts of Calories, fats, and sometimes sugar. The majority claimed however, that when meals from a particular major burger franchise were at stake, while they were indeed aware of it being a poor nutritional choice, appetite surpassed the will, and they often tended to succumb.

Sec 3 Q10 Would you dedicate some time to prepare meals? How? Under which conditions?

The willingness to dedicate time to prepare meals may be considered crucial in determining one's attitude towards a sound nutritional plan. Only 38% of the players however said they were willing to prepare their own food. Some players commented that preparing their own food was not possible due to time restrictions and/or their inability to cook. Some players admitted they were too lazy to prepare their own meals, while others remained confident they would always find someone, usually a family member, to prepare food, making it a readily and easily available commodity.

The fourth section of the semi-structured interview gathered information about the players' perceptions with regard to nutrition via the following questions.

Sec 4 Q1 Do you think that proper nutrition can help you perform better? To what extent?

When questioned about their belief in proper nutrition constituting a means to enhancing performance, and to what extent, all players but one agreed that appropriate nutritional practice does indeed improve performance. As regards to what extent they considered this to be true, the players highlighted both physiological and psychological aspects as benefits. In respect to the former, the players cited better overall personal fitness, delayed onset of fatigue, the ability to endure a whole match without getting tired, faster and more effective runs, increased strength and power, increased energy, improved cardiovascular and local muscular endurance, and an overall feeling of being lighter, quicker and more agile. In respect to the psychological benefits, players described some of the perceived benefits of an effective dietary plan as greater alertness, improved decision-making ability and at least in one instance, feeling, "More comfortable playing because I do not have think about not getting tired, I just think about the match."

Sec 4 Q2 If you were given a nutritional plan would you follow it? Under what conditions?

In Sec 4 Q2, players were asked about their willingness to follow a personalised nutrition plan, if provided. While all the players acknowledged this as no easy task, all but one agreed it was necessary to improve performance, and if the

nutritional strategy addressed their specific barriers, then they would be willing to make the necessary attempts to adhere to it. The conditions varied according to each player's preferences, however across the entire sample group, it was specified that any prescribed personal strategy would need to be realistic, and address the needs of semi-professional soccer players occupied by work and/or college commitments in the morning. Individual players highlighted other specific requirements, such as not having to wake up very early before work just to have breakfast, limiting the amount of fruit and vegetables, including some sugary treats or having a "cheat day", and including a sufficient overall quantity of food to avoid feeling constantly hungry.

Sec 4 Q3 Are you aware of how many Calories you need to consume per day to have enough energy for training?

All the players stated that they were unaware of the total amount of calories they consumed per day. Some pointed out various difficulties in establishing the nutritional content of certain foods, since while they were able to check the nutrition labels of packaged or canned items, they did not know the Calorie content of fresh foods, and thus felt limited in their abilities to accurately determine their daily caloric intake.

Sec 4 Q4 What sort of self-talk/decision-making choices do you engage yourself in when choosing foods/snack through a typical day?

This interview question aimed to explore players' thought processes when selecting foods. Many players admitted to choosing what to eat based on taste and appetite, rather than on a food item's nutritional soundness. They also commented however, that ever since the researcher began providing them with tips and ongoing nutritional support, they were more consciously aware of their choices. Some also began to differentiate their approaches depending on whether incidences requiring nutritional decision-making occurred before or after a match, dedicating greater attention to the pre-match choices as opposed to those made post-match.

Sec 4 Q5 How is your nutritional plan at training camps/competitions usually? What sort of snacks do you consume at this time?

This question aimed to find out more about players' nutritional habits during national team duty. All the participants reported an increase in the quality and quantity of available foods at such times, and therefore they tended to eat more. The pattern of dietary intake however also changed, as food was provided via three large meals in the form of breakfast, lunch and dinner, as opposed to smaller meals spaced evenly throughout the day, which was the preferred format

during weekday training days when residing in their own homes. Their response to this discrepancy in routine involved, eating as much as possible during the three designated meal times, in order to avert the onset of hunger throughout the remainder of the day. This also tended to increase the incidence of snacking on sugary foods, a probable outcome given an environment devoid of imposed nutritional guidance or control. They reported that lunches and dinners generally tended to include a first and second helping, ending with a dessert, a pattern not followed when at home. They admitted that the food provided was typically, "Good," causing them to, "Take a bit of everything," as a result. They also reported a lack of any portion control in the buffet-style set-up, leaving everyone free to eat as much as they liked, including during dessert following the main meals. Finally, players commented that they usually felt bloated and "heavy" for training due to the amount of food consumed, a state not typically experienced throughout the course of normal weekday training sessions.

Sec 4 Q6 If you had to prescribe a nutritional plan for your own consumption, what would this include?

When asked about what they might include if they were to create a nutritional plan of their own, many players said they would eat more chicken, fish, fruits, and vegetables. Other considerations included eating small portions every three to four hours, limiting extra snacking (particularly those high in sugar or fat), introducing the new habit of having breakfast, and limiting portion sizes.

Sec 4 Q7 Do you believe that a Soccer Performance Diet marks a positive effect on performance in soccer? Outline a comparative scenario to explain this, if any.

Players were encouraged to talk about their own experiences, if any, which had caused them to feel their performance was enhanced as a result of good nutritional practices. Some players admitted that they never ate so well as to notice positive effects on performance. Others reported that when they ate healthily, they felt lighter, had more energy, were able to make better decisions, and felt physically stronger overall in terms of quality of runs, kicks, shots, and resistance of the onset of fatigue.

The fifth section explored the players' current barriers towards following optimal nutrition.

Sec 5 Q1 What do you consider as barriers to following a prescribed nutritional plan?

Players were asked to explain the barriers they face when attempting to adopt an effective personal nutritional strategy. The cited barriers were varied. The most influential barrier, identified by 62% of the players, was lack of time for food preparation. A lack of cooking knowledge was another significant barrier, experienced by 33% of the participants. Other barriers included dislikes and restrictions of foods in the diet, being restricted to eat the food prepared at home for the whole family, and lifestyle schedules permitting only limited and specific time-frames for eating, particularly at weekends. Three players said they faced no barriers, as they were certain their mother would cook anything they requested, even if exclusively for them, indicative that attitude tended to represent the sole barrier preventing them from adopting and adhering to a personal nutritional strategy.

Sec 5 Q2 and Q3 How can you counteract these barriers? If the planned nutritional plan addressed all the barriers identified, would you be willing to implement it?

The willingness to counteract these barriers appeared somewhat light across the sample group. Many expressed a sense of powerlessness towards changing their nutritional habits. Among those who cited an inability to cook as their predominant barrier, some commented they would try to learn, although not much enthusiasm was shown, and concerns about lack of time were duly re-iterated. The players were then asked, hypothetically speaking, whether in the event of all their barriers being addressed, they would indeed be willing to adopt a new personal nutritional strategy. While the majority said that this would be ideal, and would hence do their best to implement it, three players still found objection, insisting too much dedication and discipline would be required without guarantee of any worthy return.

Sec 5 Q4 How would you make this nutritional plan become a norm?

When asked about how they might incorporate a new nutritional plan into their routines as a permanent lifestyle change, the players expressed some concerns. It was stressed that the nutritional strategy should become the norm, and not be reduced to a temporary measure, or “Sacrifice” to be maintained or endured for only a week or so, and then terminated. The participants feared such behaviour-change might be simply too demanding. They admitted a preliminary change in attitude was indeed necessary to facilitate such a process, and eventually incorporate nutritional practice into their routine in the same way as their daily training. The participants recognised various challenges, including the need for preparation and dedication, but also commented that the feat was not an impossible one.

The sixth and final section of the semi-structured interview explored players' reactions to their current dietary intake based on analyses of the seven-day Food and Exercise diary data.

Sec 6 Q1 Is the result of the seven-day Food and Exercise Diary analysis what you expected it to be?

Following the seven-day Food and Exercise diary data collection period, the researcher calculated the energy intake, expenditure and balance of each player, as well as the quantities and percentages of each macronutrient consumed. Players were each presented an in-depth analysis of their nutritional intake, and their initial and honest reactions to the results observed. The majority of players exhibited surprise when listening to a clear explanation of their results. Most assumed they were over consuming CHO and under consuming protein, when in reality, precisely the opposite was true. Some players confirmed and agreed that their current diet was not ideal. Players who were in a negative energy balance were typically surprised, stating they definitely did not expect this outcome.

Sec 6 Q2 What are your reactions to this result?

When asked how concerned they were about the results given, some players did indeed register their concerns, stating that they looked forward to receiving the necessary nutritional support in order to affect the required changes to their diets. Others accepted the results, and expressed only marginal interest in seeking positive change.

Sec 6 Q3 Are you planning to make any changes on the basis of these results? Why?

After receiving their individualised dietary analyses, the participants were questioned about their motivation to initiate prospective changes in their dietary behaviours. A majority of the participants appeared to acknowledge the fact that they needed to do something about their diets due to the likely negative influence on their performance. They said they needed to be more aware of their dietary intake, and increasingly careful about what to consume as per the nutritional guidelines provided to them. It was interesting to note that the player who consistently affirmed his non-belief in the positive effects of nutrition on performance, combined with an unwillingness to change his current nutritional practices, also registered concern upon hearing his energy intake analysis, since it was not the result he expected. For the first time he began to associate his diet with a noticeable general lack of energy for training, early onset of fatigue specifically in the legs, onset of cramps usually occurring approximately seventy minutes into a match, and an apparent reduction in total distance covered during the second half of a match as opposed to the first.

Sec 6 Q4 Has your interest in nutrition before and after giving you the results of the seven-day Food and Exercise Diary analysis changed? How?

Players reported that as a result of the nutritional support provided by the researcher thus far, they had become more aware of their daily nutritional choices, and felt more responsible for their nutritional practices. They also became more knowledgeable and appreciative of the support being provided, taking it seriously and acknowledging nutrition as a valid and modifiable contributing factor to improved performance. Some of the players commented that their lack of consideration towards nutrition prior to participating in the study was not entirely their own fault, but rather mainly due to a general lack of previous nutritional guidance throughout their careers.

5.3.3 Team coach and assistant coach semi-structured interview on nutrition in soccer

Q1 What are your views towards nutrition in soccer?

The coaches were openly asked about their views on nutrition in soccer. The team coach stated his belief that nowadays nutrition has become an important factor in the game of soccer. He claimed that some years ago, few believed in the benefits of effective nutrition in soccer. He offered an example of English players (previously) taking sausage, bacon and eggs with chips and a glass of beer before a match, a standard pre-match routine they claimed provided energy. He concluded by saying that, “Nowadays [we are] 100% sure that nutrition affects performance of soccer players”. The assistant coach commented that in his opinion, eating right is just like, “fuelling a car – if you have a car which runs with diesel, it will seize [up] if you fill it with petrol”.

Q2 Do you believe that practising optimal nutrition marks a positive effect on the performance of the soccer player?

The interviewees were asked to voice their opinions about whether optimal nutrition marks a positive effect on performance in soccer. The coach quickly answered, “Without any doubts!” He referred to an interview with the physical trainer of a top UK Premier League team, saying that a lot of research in the area of nutrition in soccer has been conducted in recent years, and improvements in training and match-play as a result of players eating well, have indeed been empirically proven. The assistant coach seconded the coach by saying that this is indeed what the literature says.

Q3 If you believe in the benefits on nutrition in performance in soccer, in what aspects of performance do you think the player and the team benefits?

The coaches were then asked to elaborate on the specific aspects of the game affected by nutrition. The coach began by specifying that improvements are definitely, “not achieved overnight”. He continued to explain that this was a process involving a distinctive willingness on the part of the player to embark on a “proper” nutritional plan, and proceed to give the body sufficient time to adapt before witnessing the desired effects on performance. Improvements would not happen in a “day or two,” but rather only once the player has taken it seriously and adhered to the nutritional strategy with consistency. Only then will his body start to react positively, in turn helping him to perform better in training and matches. He concluded by stating that such a nutrition plan must be personalised, and not a homogeneous one for everyone, in respect to every individual player' different nutritional needs. The assistant coach added that adopting and adhering to a nutritional strategy would also have psychological implications for the players. He explained that when players make an effort to eat well, without necessarily knowing about the direct physiological benefits, they can also achieve improved performance indirectly due to improved psychological preparedness.

Q4 What is your opinion about nutrition in soccer locally?

Coaches were asked to share their opinions about nutrition in soccer with specific reference to the local context. The team coach noted that “we” (Maltese stakeholders) are definitely lagging behind in this area, as the stakeholders lack the right information to pass on to the players. Different people tend to give various incoherent and inconsistent guidelines without the appropriate expertise in the field. This tends to result in confusion for the players, however the coach insisted the players also had a responsibility for their own nutritional practice and to cultivate the necessary willingness to adhere. He recognised and acknowledged some of the unique challenges existing in the local context, including the island's holiday lifestyle to which young players feel pressured to conform. Going to work, the beach, training, and finally “partying” or socialising with friends or family in the evening, cumulatively tend to afford few opportunities to engage in proper nutritional practices. Players who make it overseas tend to quickly change their lifestyles when confronted with their new environments, understanding the role of sacrifice in the pursuit of success, and gaining a newfound appreciation of some of the additional factors influencing performance, including nutrition. The coaches appeared to have little faith in players' ability to draw these conclusions, and make such lifestyle changes, while still playing locally, claiming “life is too good” for them in their home environment. The assistant coach referred to the data contained in the food diaries, confident it would be an accurate reflection of the “state” of nutrition locally. He

concluded by affirming the research findings, stating that many players do not have a nutritional plan or pattern, and hence consume foods that have adverse effects on performance in training and competitive matches.

Q5 Who is responsible for the nutrition care of a soccer player?

The coaches were asked who in their opinion should be responsible for ensuring and supporting optimum nutrition of players. The team coach quickly responded that responsibility should rest with individual players themselves to decide what to eat. The player would need to apply himself, and implement good nutritional habits as effectively as possible. He added that this process however needs to be supported by expert guidance from suitably specialised professionals, as well as from other members of the technical staff monitoring and encouraging adherence, as well as emphasising the benefits. He concluded by saying that psychological support was also necessary, and should be provided in conjunction with other supportive initiatives, maintaining players' focus on their aims and reinforcing positive behaviours.

The assistant coach agreed with the above points and although players were still somewhat “green” in the area of nutrition, much improvement had been noted over the years. He shared his observations that players today are more aware of their nutritional habits when compared to their peers in the past. He concluded by saying that holistic progress would only be possible by educating young players, making reference to research that suggests healthy young minds develop into healthy adults, who in turn share the same positive habits with their children, thus creating a positive cycle.

Q6 You have already been the coach of the U21 National team in the past edition in which time there was no member of the staff taking care of the players’ nutrition. Now that there is, what are your views about it?

The same technical staff had also been responsible for a previous U21 national team European qualification campaign during which a nutrition specialist was not involved. For the current campaign, the researcher was set to fill this role. The coaches were therefore asked about their views regarding this new inclusion. The coach said that having a person specialised in the area was essential, considering the modern competitive landscape. They cited the London-based club Tottenham Hotspurs as an example, where five nutrition specialists were employed with the team. He continued by stating that in Malta such a set-up was lacking for any of the national teams, let alone at club level. He added that there should be at least one nutrition specialist for each national team category, thus setting an example for the local clubs. If such a set-up ever became a reality, players would begin to understand that nutrition is an important part of their performance, and change their attitudes towards adopting effective nutritional practices. The assistant coach added that

the team should also have a chef as part of its technical staff for international competitions, to ensure optimal nutrition is actually implemented.

Q7 You are aware that so far the Malta Football Association has never employed a soccer nutrition specialist with the team. What are your views about this?

The coach replied that the experience of working with the researcher in the role of nutrition specialist had been overall a very positive one for technical staff and players alike, validating the prospect of such a role being permanently incorporated into the technical staff. He maintained that he had requested such a role be created even prior to the researcher's intervention, but was rejected due to lack of funds, an "excuse" the coach deemed unjustifiable. While acknowledging that excessive cost might be an issue for clubs, he rejected the validity of such an argument in the case of the national football association. He concluded by identifying mentality as the real problem, and a lack of belief that such a role would assist players or improve their performance, perhaps one of the causes influencing the continuing low-level performance of the Maltese national teams on the international stage. Unlike other small countries, Malta has failed to register significant improvements in performance over recent years. Iceland for instance, while having a population even smaller than that of Malta, had registered distinct improvements over recent years. The assistant coach also identified mentality as the main barrier, saying that in Malta things take time and intensive testing before they can initiate positive change, estimating that we do today what other associations did six to seven years ago.

Q8 The MFA recruits technical, physical and medical personnel as well as a part-time psychologist. Do you really think it is a finances issue (as MFA has vividly claimed) that is stopping the association from recruiting a soccer nutrition specialist to take care of the players' nutrition or are there any other barriers?

Expanding on previous questions, the interviewer referred to the technical staffing structure of the MFA, as well as the inclusion of a part-time psychologist across all age groups of the national team. The coaches were asked therefore to comment on any barriers they felt may be preventing the similar inclusion of a nutrition specialist in the professional set-up. The coach re-iterated mentality as the main issue, totally dismissing the MFA's claim that cost was the main restriction. The coach further expressed his frustration at the limitations this mentality imposes on the national team, which is expected to compete and obtain results against far superior opposition.

Q9 How would you define the role of soccer nutrition specialist with your team?

Next, insight was sought regarding the coaches' expectations of a soccer nutrition specialist as part of their technical staff. While re-affirming the importance of such a role, the team coach specified that the nutrition specialist should raise awareness, provide nutritional knowledge, and assist players to adopt better nutritional habits. In respect to the latter, he elaborated that there could never be certainty about the players' nutritional habits due to their semi-professional status and the reduced contact with technical staff resulting from a lack of residency. He referred to this situation as an incomplete jigsaw puzzle, making the full picture impossible to see when crucial pieces are missing. The assistant coach concurred, adding that maintaining in an optimal body composition was a constant struggle for the team, and that players must assume responsibility for this by using initiative in adopting appropriate nutritional practices. He concluded that knowledge and attitude were vital aspects of achieving such outcomes, incidentally both domains in which a nutrition specialist could prove extremely influential.

Q10 What is the players' reaction to this nutritional support that they are receiving?

The coaches were asked to comment on their perceptions of the players' feedback regarding the inclusion of a nutrition specialist with the team in this particular qualifying campaign. The coach showed conviction that the majority of players were taking it seriously, while acknowledging there would always be those who, "Do not care," and would try to, "Drag others who do care down with them so as not to feel in anyway inferior to them". Nevertheless, seeing a generally progressive improvement in attitude, however gradual it may be, was deemed extremely encouraging. The coach stressed the validity of having a full-time role within the staff to take care of this aspect of performance. The assistant coach added that in such cases we cannot expend excessive energy on those who do not want to learn, and that more can be achieved by focusing on those suitably showing interest.

Q 11 Any other comments you wish to add about this first time experience of having a soccer nutrition specialist as part of the staff with the U21 national team?

Finally the coaches were invited to comment on any aspect of nutrition in conclusion of the interview. The coach expressed an avid wish to see all stakeholders in Maltese soccer open their minds and see beyond only the technical and physical aspects of soccer. For as long as aspects such as nutrition are not taken seriously, Maltese soccer will remain stuck in its current stalemate. He continued by saying that, "We are down there ... rock bottom," and we have to recognise and admit that club level Maltese soccer is of an extremely low standard. He concluded by supporting and

encouraging the positive initiatives undertaken by the researcher in striving for increased awareness on nutrition in local soccer, expressing hope that it may one day lead to measurable improvements in standard. The players must also do their bit by being wholly dedicated to improving, making sacrifices, and meeting the challenges that lay ahead along the path to success. The assistant coach said that in the same manner the MFA recently agreed to employ a sports psychologist, so too should the field of sport nutrition receive such validation within the local soccer infrastructure. In conclusion, he stated that improvements at international level can only be made by tackling all modifiable factors methodically and in turn before they finally begin yielding the desired results. He hoped that such an approach be implemented sooner rather than later for the sake of younger age groups, so as to ensure the development of better U21 and senior national teams in the near future.

5.3.4 One-to-one semi-structured interview on perceived individual and team performance following no nutritional intervention with players in the starting of an international match

Q1 How did you prepare yourself nutritionally for the match?

Although the researcher had the planned menus related to the preparation for this match in hand, it was still deemed fit to ask the players how their nutritional preparation went, due to the fact that players were not instructed on which food items to select and what quantities from the buffet-style meal set-up. All eleven players in the starting formation consumed, “A bit of everything,” that was available on the set menu over the three-day period. One player took chocolates as a snack, while another opted for a banana.

Q2 Did the nutritional strategy in the build-up for this match meet your expectations?

Players were then asked whether they agreed with the menu choices available over the three days. Two of the players expressed a reluctance to judge due to their lack of knowledge in the area, five said they approved, while two disapproved of the set-up, stating it was, “Not properly structured.” In the latter instance, the two players explained that on match day they should have had lunch between 12:00 and 13:00 hours, and a pre-match meal between 16:00 and 17:00 hours, instead of the provided light snack at noon, and full lunch with two plates including pasta, chicken, potatoes, vegetables, and fruit just before the match.

Q3 Did you experience any fatigue at any point during the match? If yes, what minute was its onset?

Players were next asked about their perceptions of fatigue throughout the match, and specifically at what point they experienced its onset. All the players but one said that they felt extremely fatigued. Two players started experiencing fatigue as early as the 60th minute, six players experienced it between the 70th and 78th minute, while one player was fatigued towards the latter stages of the match, precisely in the 84th minute. They attributed the fatigue to the amount of running performed in response to the consistent pressure applied by their opponents. The goalkeeper recalled his legs feeling "dead" by the 70th minute, at which time another player also had to be substituted because he "Couldn't take it any more". Another player said that he felt as if he was, "Going to die with tiredness from the 75th minute onwards". Other players also confirmed they had difficulties in coping with the extreme fatigue. The only player who said he was not excessively fatigued commented that his tiredness was more mental than physical, as a result of his playing position as a central defender, requiring him to continuously run from side to side to defend.

Q4 If you felt fatigued during the match, in what phases/actions was this predominantly felt?

The players experiencing fatigue were then asked for more details about the nature and causes of their fatigue. The goal keeper quickly pointed out that it occurred mostly when giving goal kicks. Defenders mainly experienced tiredness when recovering from corners and clearing the ball, while the wingers were mostly fatigued when committing to lateral runs spanning significant portions of the length of the pitch. One of these players said that overall he did not perform to even 50% of his potential due to fatigue. Midfielders said they got tired chasing players with the ball, who executed quick movements to which, "Our legs were not reacting," as well as marking players without the ball, who executed a range of unpredictable movements and runs. The attacker of the team said that he ended up being more of a midfielder than an attacker, and became fatigued carrying out the duties associated with this role, to which he was not accustomed. This subsequently affected the strength he was able to exert when shooting during the rare instances he was able to capitalise on a loose ball or counter-attack, or to confront the opposing keeper one-on-one. He regretted to admit he lacked power to shoot the ball, as indeed was confirmed during the post-match video analysis which clearly indicated at least one shot on target that the opposing keeper was able to save without any difficulties. He concluded by saying that had this opportunity presented itself in the first half of the match, he had no doubt that he would have scored, or at least caused some trouble for the goalkeeper.

Q5 If you felt fatigued during the match, how did you deal with it?

Upon being asked how they dealt with such fatigue, all the players agreed there wasn't much else to do other than to preserve energy for the most important phases of the game, acknowledging that intensity and performance drastically decreased in the second half when compared to the first. One player said that he tried to control his breathing, while others said that they reduced the number of runs performed by trying to judge the severity and danger of the opponents' actions, prioritising decisions to act only when they might directly assist in averting conceding a goal.

Another player admitted he expected his teammates to cover him when he was not able to meet the physical demands of the game. Most of the players wanted to be substituted as a result of their fatigue, but the coach reserved the available substitutions for those appearing most fatigued of all. They continued to admit that the coach was unfortunately restricted to making substitution decisions based exclusively on extents of fatigue, and not on tactical requirements, which incidentally also became particularly necessary in the latter stages of the match.

Q6 If you felt fatigued during the match, did you manage to overcome it?

The three players who were substituted clearly did not manage to overcome their fatigue. The remaining players commented on the psychological aspects of the game, and specifically on the mental strength required to manage fatigue. Most of the players said that looking at the 0-0 result on the scoreboard was highly motivating due to the prospect of holding such a "big" team to a draw. They explained that towards the latter stages of the match this generated feelings of being engaged in a, "Race against time." This strategy however was only effective until they conceded a goal in the 85th minute. They then knew they lacked the energy to fight back and attack, leading in turn to conceding a second goal shortly thereafter.

Q7 If you felt fatigued during the match, was your performance affected?

When asked if they believed their individual performance overall was affected by fatigue, all the players replied in the affirmative. Some of the players continued to explain that their attention ended up becoming predominantly focused on the conservation of energy, rather than on aspects of the game itself. One of the most experienced midfielders commented that as a midfielder his role was to know where to pass the ball before it arrived at his feet, but excessive fatigue was preventing him from doing this. The resulting losses of possession naturally affected the entire team. Since overall strength also suffered, the remaining players confirmed that fatigue did indeed play a drastic role in their performance.

Q8 Did you experience any cramps or twitches or muscular strains during the match?

Players were specifically asked whether they experienced any cramps or twitches throughout the match. The goalkeeper confirmed experiencing cramp in both calves at the 70th minute, and upon every goal kick thereafter. One of the defenders also experienced cramp in both calves slightly later than the 80th min mark. The winger also reported experiencing cramp in one of his calves, while another player experienced cramp in one of his hamstrings. Only four players said that they did not experience any cramps.

Q9 How do you compare your fatigue between each of the halves?

When asked to compare fatigue across both halves of the match, all players recalled feeling fresh, tactically disciplined, and alert. In short, they possessed considerably more energy in the first half when compared to the second, which was in turn characterised by excessive overall tiredness and fatigue.

Q10 Do you think that the potential fatigue experienced as a team had an impact on the final result?

Players were asked to what extent they felt fatigue influenced the final outcome of the match. A majority of the players (80%) said that it did, particularly in the case of the first goal conceded. The central defender said that his defensive partner was “Totally fatigued” and therefore had to cover his area too, which was virtually impossible for him to do, citing this as the one of the main reasons for conceding the first goal. Players made the assessment that technically and tactically they were disciplined and able to compete at the same level as their opponents, while physically they admitted to being significantly inferior to their foreign counterparts. The resulting fatigue then became detrimental to the previously sound technical and tactical aspects, eventually resulting in a dramatic decrease in overall performance.

Q11 If you felt fatigued during the match, was this predominantly aerobic, anaerobic or both? Which one the most?

Asked whether the fatigue was predominantly more aerobic or anaerobic, most of the players said it was mostly anaerobic, since their legs felt very heavy and fatigued.

Q12 Why in your opinion did the team conceded two late goals? Was it a tactical, technical or a physical decrement? Or was it perhaps something else?

Players were then asked to elaborate further on why they felt they conceded two late goals, in terms of tactical, technical, or physical aspects of their game. The majority of the players attributed conceding the late goals predominantly to physical decrements in performance. They acknowledged however, that the tactical, technical and

physical domains were interrelated, and decrements in physical performance tended to in turn adversely affect tactical and technical performance also. Some of the players commented that they should have attacked more as a team, a tactical factor, however declining physical ability to develop attacking play meant that the physical domain still represented the primary performance limitation. They added that this was evidenced in the first half, since they were physically fit and therefore able to keep the game relatively balanced. Good opportunities to score were generated on both ends, and good tactical discipline exhibited by both teams. The game changed drastically however when fatigue set in, and all three performance domains consequently became adversely affected.

Q13 Did you experience any muscle soreness after this match? If yes, describe its nature.

Finally, the players were asked about the quality of their recovery after the match. More than half of the players said that they did not sleep much. While they were very tired overall, and experienced very "Heavy legs", there was no significant muscle soreness or cramping after the match.

5.4 Discussion

This study aimed to investigate nutrition and its effects on soccer performance. The researcher specifically explored the players' habits, attitudes, perception and barriers with respect to nutrition in soccer via one-to-one semi-structured interviews. The views of the team manager and assistant manager on nutrition were also explored, as well as individual perceptions of performance after an international match which were discussed with the participants who played the entire match.

In a study on the nutritional knowledge and food skills of talented adolescent athletes across different sports, soccer players faired the best in basic nutrition knowledge, answering 68% of the questions correctly (Burkhart and Coad 2010). They were however the least informed about knowledge specifically related to their particular sport, answering only 37.1% of the sport-specific questions correctly. When the same population were asked about the recommended guidelines for food and fluid intake before, during, and after exercise, the soccer players also struggled, with none knowing what to eat pre-competition, and only 7% knowing what to ingest during the competition itself. With regard to recovery they were better informed, with 64% able to match the recommended guidelines.

The sample group of Maltese U21 national team players exhibited knowledge of nutrition that was generally below expectations. They answered 60% of the twenty-seven questions posed in a nutrition knowledge test correctly, but only

tallied 30% when the results were expressed using negative marking, thus eliminating guess-work. This poor knowledge on nutrition among the study population indicates a need for nutrition education of soccer players. Similar studies among other athletes in the sport have also shown poor nutritional knowledge (Walsh et al. 2011; Hoogenboom et al. 2009; Zawila, Steib and Hogenboom 2003). Walsh et al. (2011) showed poor knowledge of the foods required for refuelling, sports drinks, and the role of protein in muscle formation among a sample of Irish rugby players aged fifteen to eighteen years. Research on female collegiate swimmers similarly showed a lack of knowledge on nutrition (Hoogenboom et al. 2009). Research on female collegiate cross-country runners suggested athletes lacked nutrition knowledge critical in preventing nutrition-related health problems (Zawila et al. 2003). The correlation between nutritional knowledge and actual dietary intake was not directly investigated in this study, however the data suggests the association to be weak. Nonetheless, a review of studies assessing the relationship between knowledge and dietary intake cited five out of nine studies as reporting a positive association of moderate magnitude between these parameters (Heaney et al. 2011). This was also confirmed more recently by Spronk et al. (2014). Similarly, Alaunyte et al. (2015) showed that players who scored higher in a nutritional knowledge test were more likely to consume more fruits, vegetables and CHO-rich foods. This study however showed that there is less variation in knowledge among soccer players.

Players' attitudes towards nutrition also varied considerably, reflecting diversity among individual players about whether nutrition is embraced as an important aspect of performance in soccer. Players were bound to form varied individual opinions on nutrition since nutritional support was not provided by the association. Most of the players were aware that their nutritional habits required improvement, and were looking forward to making the necessary changes ahead of the study period. A majority of the players claimed to know the "Rights and wrongs" of sound nutrition, however maintained that a great disparity existed between "Words and actions". They also commented on a distinctive lack of sufficient belief in the positive effects of nutrition on performance, rendering them reluctant to undergo any great deal of sacrifice associated with adopting healthier nutritional habits should these fail to yield guaranteed results.

The participants acknowledged they had a number of bad habits, but outlined various barriers preventing them from phasing these habits out. The addition of work or education commitments throughout the day also caused time restrictions on shopping for, planning, and ultimately preparing appropriate meals. Hectic schedules also caused some

players to lose their appetites after training, eat poorly, regularly miss meals, and hence lose weight easily, while others may have resorted to ravenous behaviours, consuming excessive amounts of take-away or fast foods. When describing the quality of their intake, players recognised a discrepancy between intake on weekdays and weekends as a result of "Letting go" after a match. They maintained that change is not easy, and cited the restriction of time for preparing meals due to work and college commitments as a major barrier. In terms of quantity, many of the participants believed they consumed a sufficient amount of food overall, however needed to reduce their intake specifically from fatty and sugary sources.

Dietary habits varied between the players, but a universal characteristic across the sample group appeared to be the omission of breakfast from the daily dietary regimen. This was also seen in a study by Ruiz et al (2005), whose research with adolescent soccer players also revealed skipping of the first meal of the day. Many of the players admitted to consuming "Unhealthy foods" every now and again, although a decided effort was made to limit this occurrence to once per week only. The consumption of unhealthy food was most prevalent after matches, regarded as a reward following a hard week of training. The pre-match nutritional routine was more or less uniform across the sample group, with the majority of players consuming a plate of pasta approximately three to four hours before kick-off. None of the players consumed brown pasta, though preferable to the white variety, still not a widely regarded practice. Accepted post-match nutrition guidelines were not observed by the players. Most believed that they could eat "anything" at this stage. Players reported they were able to keep themselves well hydrated throughout the day without much difficulty. Alcohol consumption was not an issue for most of the participants, while some stated they consumed alcohol socially, and only when it did not interfere with training or matches.

All participants in the research group were resident in Malta, a small island allowing for easy travel. More specifically, the participants were all resident in their respective family homes, supported by their parents or guardians. In-keeping with the cultural characteristics of the island, such a home environment typically involves a range of logistical comforts, including the provision of wholesome home-cooked meals, rendering personal culinary or food preparation skills redundant. On the rare occasions players were not presented with such a meal, they would typically experience difficulties in coping, and resort to haphazard snacking or heating-up of frozen food.

Some of the players' definitions of a “Nutritional plan” included, “Something that helps you eat better to perform better”. It was a common perception among the participants that adhering to such a plan requires, “A great deal of sacrifice”. For this reason, many of the players reported looking forward to the support of a soccer nutrition specialist throughout the study period. Some of their expectations of a nutrition specialist included the provision of individual and team dietary planning, ongoing support, and nutritional education designed to increase players' nutritional discipline. The majority of players claimed to have received hardly any nutritional support at any stage of their careers. They admitted their attitudes towards the importance of nutrition were still evolving, which was a positive development towards promoting adherence to a sound nutritional plan that did not represent any perceived upheaval. Players were generally satisfied with the way meals were provided ahead of international matches, commenting positively on the selection of foods, and the fact they could eat as much as they liked as a result of the buffet-style set-up. The majority of the players at this stage did not foresee that uncontrolled portion sizes might be an issue. The researcher found it challenging to compare the outcomes of this study to others, as research with regards to soccer players’ attitudes and perception towards nutrition in soccer was not encountered by the researcher, to date.

When players were presented with the detailed results of their seven-day food diaries, they duly noted the discrepancies between their own energy intake and the minimum recommended guidelines and, while exhibiting surprise and concern about the results, interpreted them as a call-to-action. They were most surprised about CHO intake specifically, which was well below the recommended level. They asked questions about how their dietary habits may be negatively affecting their performance, and expressed enthusiasm at the prospect of making the required remedial changes.

Overall both coaches expressed concerns about current nutritional practices in the team, re-iterating that support on the matter was not forthcoming from the association. The team coach clarified his position, stating that it was his prerogative to have the researcher on board providing full nutritional support throughout the study period, albeit on a voluntary basis. They stressed their appreciation for the importance of nutrition, and that a number of stakeholders were collectively responsible for sound nutritional practice, including the association, the clubs, and ultimately the players themselves.

The coaches were satisfied to see improvements in both the performance and nutritional attitudes of the players since the start of the study period. The players were visibly more careful about what they consumed and took their dietary

habits more seriously throughout the course of the study. While expecting the researcher to fully support the players as required, they stressed that the association should transmit the right message to the players by establishing more permanent measures for the effective management of this important modifiable factor influencing performance. To support any nutritional intervention, it is important for coaches to be well-educated in order to understand the necessity of such role (Heaney et al. 2008).

The players on the whole did not feel they were particularly nutritionally prepared prior to the study. They hypothesised that feeling "heavy" during periods of temporary residence with the team was possibly due to eating too much, or at least much more than their usual dietary intake at home. The timing and type of meals also differed from the norm. Some players admitted to consuming chocolates as snacks between meals, while claiming this was not necessarily wrong since chocolate "Gives [them] energy", and that nobody had ever told them to avoid this practice. They unanimously agreed that they felt fatigued during the match, particularly in the second half, sufficiently indeed to reduce their performance both physically and technically. Many also believed that such fatigue was precisely the main causal factor behind their loss, as both goals were conceded at the very end of the match. Fatigue began setting in during the 70th minute, after which players were either substituted or forced to play on at severely reduced intensities. Some but not all experienced muscle cramps. Others experienced difficulty sleeping after the match, or simply felt overly tried.

5.5 Conclusion

In this study, the players' nutritional knowledge, attitudes, beliefs, perceptions and barriers towards nutrition in soccer were explored. The views of the coaching staff on nutrition in soccer in the local context were also investigated, as well as perceptions of individual and team performances immediately following an international competitive match discussed with the players themselves. The findings showed that the players' attitudes, beliefs and perceptions towards nutrition were generally positive, and their enthusiasm was noted ahead of the planned implementation of prescribed dietary improvements. No prior nutritional support had been received by the players at any point in their careers either at club or national team level.

Players pointed out that their semi-professional status represented a hindrance towards pursuing sound daily nutritional strategies, but maintained confidence that with the relevant support from the soccer nutrition specialist, the main barriers preventing sound nutritional practice could be overcome. A majority of the players believed that their recent defeat to an

international side was due predominantly to fatigue, which had a detrimental effect to the physical, technical, and tactical performance domains. The coaching staff showed an understanding of the importance of nutrition in soccer, and were doing their utmost to improve this and other modifiable performance factors, despite several limitations arising from various local contextual phenomena.

With regard to the participants' knowledge on nutrition specifically related to soccer, performance on a validated knowledge test was satisfactory only in consideration of a total lack of prior nutritional guidance, thus highlighting a need for significant additional improvement before effective and autonomous nutritional decisions can be made by the players. Finally, the findings supported the general relevance of qualified nutritional specialists in soccer, and validated the need for an immediate and full nutrition intervention programme in support of the Maltese U21 national team to be intricately tackled in the upcoming final study described in the next chapter.

Chapter 6

Evaluation of a nine-month Nutrition in Soccer Education and Support Intervention Programme on an U21 male international soccer team

6.1 Introduction

Data generated from the previous studies revealed various limitations among the research population with regards to developing effective nutritional practices conducive with improved performance in soccer. The researcher thus formulated an in-depth nine-month nutrition support and education intervention programme, targeted initially at overcoming the identified barriers to optimal nutrition via a continuous nutritional education programme, supplemented with appropriate resources and ongoing support.

Individualised and tailor-made nutritional plans addressing players' personal requirements were selected as the primary intervention tool, particularly in light of the participants' semi-professional status. Such an intervention allowed the necessary adjustments to be made based on variable activity profiles outside of formal training and match-play, which according to Holway and Spriet (2011) and Rico-Sanz (1998) are not homogeneous. In health education, tailoring has been defined as;

> "*Any combination of information or change strategies intended to reach one specific person, based on characteristics that are unique to that person, related to the outcome of interest, and have been derived from individual assessment*." (Kreuter et al. 2000: Pg5;19)

Equipping all of the relevant stakeholders in soccer, in particular the technical staff, with the necessary information and tools to support optimal nutritional practice, constitutes a practical form of all-round support. The personalised soccer performance diet was based on the premise that the energy intake of soccer players must provide sufficient CHO to fuel training and match-play. Given the generally highly congested schedule of a soccer player, diets require daily adaptability of CHO intake to ensure requisite fuel availability for preparation and recovery between training sessions and matches. Moreover, personalised nutrition interventions should aim to match the individual needs of players, taking into account position, physical characteristics, recent training and competition demands, and especially individual food preferences (Williams and Serratosa 2006; Hoelscher et al. 2002), which have been found to significantly influence eating habits (Ono et al. 2012; Gedrich 2003; Hoelscher et al. 2002). The personalised dietary programmes were also intended to promote the restoration and even super-compensation of muscle glycogen levels, with a view to enhancing activity patterns during training and matches. Besides achieving a total intake of CHO compatible with fuel needs, the

diets were also designed to promote a strategic intake of CHO and protein before and after key training sessions, to optimise training adaptations and enhance recovery. For this reason, the tailor-made dietary plan provided to each player was based on individual dietary habits following in-depth and personalised assessments. Such an individualised approach has also been found to improve players' personal attitudes, and contribute towards positive modifications to their eating behaviours. Prescribing specific food portions that contain a hundred grams of CHO for instance, is predicated as more effective than simply and arbitrarily instructing players to eat more CHO-rich food (Burke 2001; Deakin 1994).

While the need for optimal nutritional practice is widely acknowledged, to date, education programmes specifically designed to encourage positive eating habits among soccer players are lacking (Garcia-Roves et al. 2014). In one of the few educational intervention programmes implemented on athletes (Martinelli 2013; Abood, Black and Birnbaum 2004), results were fairly inconclusive. Prior to the implementation of an educational programme on a sample of female college athletes, for instance, Abood, Black and Birnbaum (2004), reported a pre-intervention mean macronutrient intake ratio in the regions of 13% protein, 59% CHO, and 24% lipids. These values however represented only negligible deviation from the recommended guidelines, thus rendering a corrective educational intervention not entirely justifiable. Moreover, although increases in nutrition knowledge and self-efficacy were reported, the concurrent nutritional intervention itself did not produce any statistically significant improvements in eating habits. Other notable studies investigating the efficacy of educational interventions tested samples comprising participants who were either obese, or from the general population. In a study on obese adults, Anderson et al. (2011) provided counselling and guidance to participants undergoing a behavioural nutritional intervention for twenty-four weeks designed to promote weight-loss. The participants who had more direct contact with the researcher throughout the counselling and guidance process lost thirteen kilograms more than those in the control group, who were counselled only twice over the same study period. The results clearly show the efficacy of counselling as an adjunct to a successful intervention programme, suggesting that educational support modelled on similar operational parameters and characteristics may foster similarly augmented results. Indeed, a nutrition education programme may be planned, adapted, and delivered in a number of ways, so long as the information provider is a suitably qualified professional, adequately prepared, and available for the provision of continuing support. The nutrition specialist should also strive to foster an environment in which players feel empowered

to actively participate in their nutrition plan, rationalise their own goals, and effectively incorporate newly acquired nutritional competences into their own lifestyles (Austin and Seebohar 2011). The most common method of delivering the required knowledge-based content of a nutrition education programme is via talks and lectures (Ambre and Sengupta 2015; Molina-Lopez et al. 2013) however alternative methods may also be explored in order to maximise the learning outcomes achieved by developing soccer players.

A primary objective of the planned education programme was the development of evidence-based knowledge and positive attitudes towards nutrition. Considering the age of the participants, internet-based resources were considered as an effective low-cost method for the transference of knowledge. Online education also constitutes an accessible, flexible, and convenient delivery modality, customisable to the individual learning needs and abilities of the players. While some learners will readily adapt to such a modality, others may be slower to embrace it, requiring substantial incentives to participate. A mixed-methods approach combining online and traditional class-based settings with one-to-one nutritional counselling was therefore deemed preferable. Axelson and Brinberg (1992) argue that people "Think, feel and do", constituting a valid consideration in the development of interventions seeking to effectively address all three cognitive and behavioural domains and their respective interrelations, thus promoting maximal potential efficacy. Studies have shown that participants are often reluctant to alter their habitual diets despite their belief in the importance and effectiveness of adopting a healthy and balanced diet (Walsh et al. 2011; Jonnalagadda 2001). Williams (2012), shows that behavioural change with regards to nutrition is multi-factorial and complex, involving multiple changes in training, food choices, and responses to stimuli. Indeed, such change has been shown to affect many aspects of a player's daily life (Austin and Seebohar 2011). Situated at the heart of behavioural change theory (Proschaska and Di Clemente 1984) is the process of recording actions, and reflecting on consequences (Williams 2012). This can only achieved via a carefully planned and soundly structured nutrition education intervention programme.

A combination of team and personal nutritional strategies is important for players in adjusting to a lifestyle of optimal nutritional adherence. Team nutrition strategies are necessary at certain times including before and after training and matches. Professional clubs generally facilitate such strategies using dining room or cafeteria facilities for the provision of set meals or snacks to players after training. This not only provides players with immediate access to the nutrients required for recovery, but also serves an educational function, reinforcing the importance of nutrition in preparation for

and recovery from training and match-play. Pre- and post-match nutritional routines also serve as an ideal opportunity to boost morale, consolidate tactics, and evaluate performance. Buffet-style set-ups are often employed, allowing each team member to meet their individual needs and preferences (FIFA 2010; 2006), effective so long as players exercise due diligence and possess sound individual nutritional knowledge and praxis. Tailored dietary planning is regarded as the primary aim of target group segmentation, in a way that facilitates individualisation and personalisation of the individual based on socio-demographic, behavioural, motivational, psycho-social, as well as physical characteristics (Kreuter et al. 2000; De Vries and Brug 1999). None of the longitudinal interventions encountered by the researcher to date however employed such interventions based on personalised nutritional plans for each individual athlete. This may due to difficulties in accessing research populations and manipulating individual diets amidst highly congested fixtures.

Although nutrition intervention programmes are widely recommended in the literature, they are as yet largely untested extensively by researchers. In a rare study, Abood, Black and Birnbaum (2004) investigated the nutritional intake of a sample of female soccer players with a view to equipping them with tools to enhance their nutritional knowledge with relation to soccer including the known benefits, and improving their general habits and attitudes towards nutrition in soccer. Their intake however was found to be very close to the recommended values (protein, 13%; CHO 59%; and lipids, 24% of TDEI), rendering the subsequent intervention essentially unjustified.

The International Society of Sports Nutrition suggests that a fundamental nutritional consideration in maximising performance and training involves making sure athletes consume enough Calories to offset TDEE. Soccer training and competition result in an increased energy requirement that simply must be accompanied by an increase in energy intake in order to sustain performance capacity and prevent the onset and development of excessive fatigue (FIFA 2010; 2006; Clark 1994). This principle tends to assume greater complexity in the context of semi-professional soccer, where coaching staff are meant to exert less influence over players' activity levels outside of formal training sessions than they are able to in a professional setting. For these soccer players, the addition of work or education commitments throughout the day also cause time restrictions on shopping for, planning, and ultimately preparing appropriate meals. Hectic schedules also cause some players to lose their appetites after training, eat poorly, regularly miss meals, and hence lose weight easily, while others may resort to ravenous behaviours, consuming excessive amounts of take-away or fast foods. Since soccer players generally train at moderate to high intensity, the estimated mean daily energy

demand for senior male players has been estimated at between 3500 kcal and 4000 kcal on training days (Rico-Sanz et al. 1998; Reilly and Thomas 1979). Nutrition education intervention programmes based on time-management, meal preparation and cooking skills therefore appear to represent a potentially effective solution in offsetting the high incidence of poor nutritional practice in athletes (Heaney et al. 2008).

The aim of this study is therefore to address this gap in the literature by providing thorough nutritional support to a sample group of Maltese U21 soccer players, establishing and addressing their existing nutritional barriers, implementing a full nutrition and educational intervention, improving their dietary behaviour and practices, and ultimately maximising their performance in training and match-play. The study is based on the hypothesis that players will effectively improve their dietary practices, improve their knowledge related to soccer, improve their dietary practices as well as attitudes towards nutrition in response to a nine-month nutrition education and support intervention.

6.2 Materials and methods

6.2.1 Study participants

Twenty-five semi-professional players forming part of the U21 national soccer team of Malta were recruited in this study (age=20.7 ± 1.1 years; height= 178 ± 5.7 centimetres; BM = 76.1 ± 6.6 kilograms; %BF = 11.0 ± 1.3%). The study period spanned the majority of their qualifying campaign for the U21 2015 UEFA Championship, starting in January 2013 and ending in September of 2014. All participants were informed verbally and in writing about the nature and demands of the study, with clear explanations of the data collection procedures via a participant information sheet. Data collection began after participants returned the provided written informed consent to participate, in accordance with Edge Hill University ethical procedures.

6.2.2 Experimental design and procedure

The study included a longitudinal nine-month nutrition in soccer education and support intervention programme. The schematic representation below explains the stages of the intervention (Figure 6).

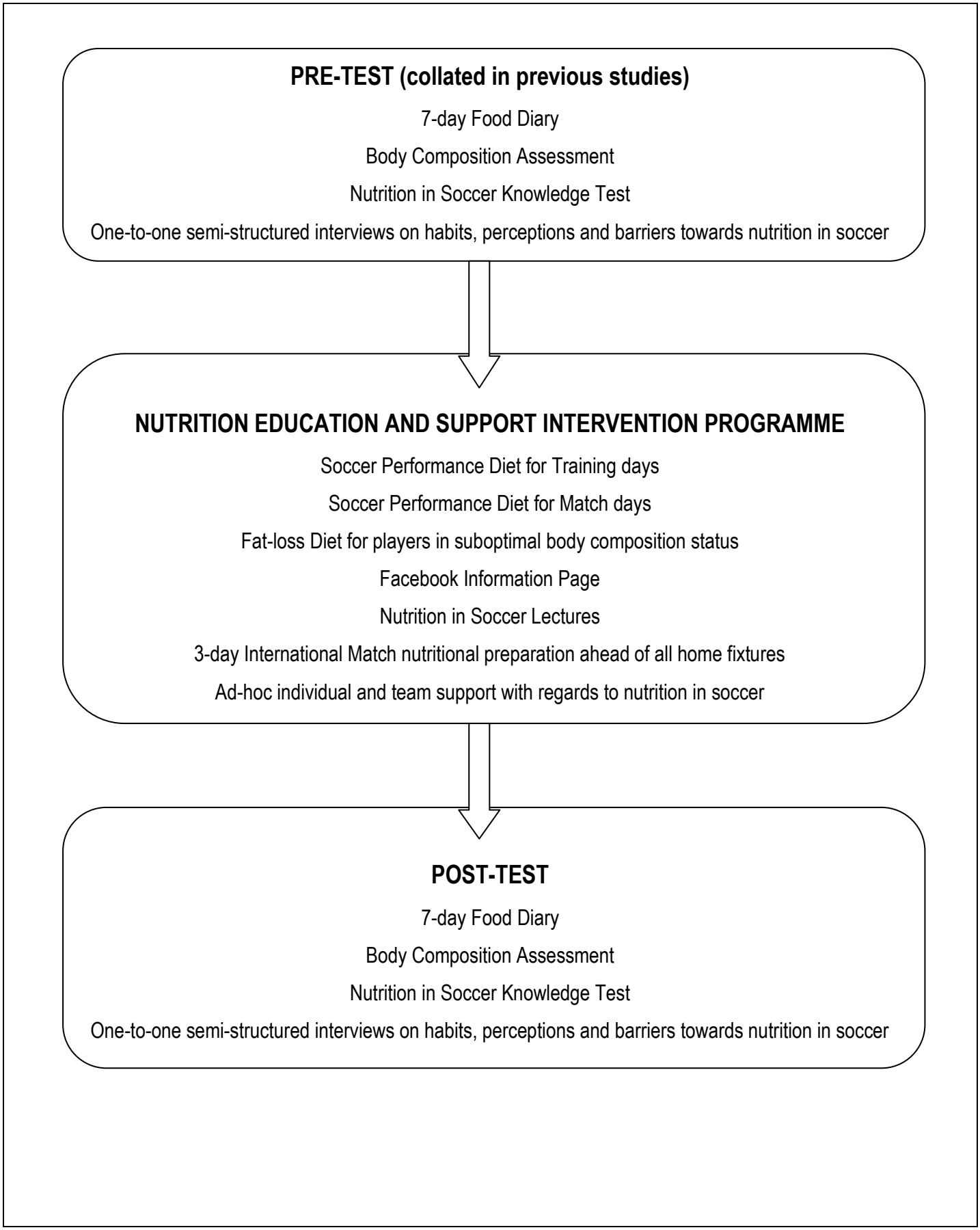

Figure 6: Schematic representation of the nine-month Nutrition Education and Support Intervention Programme

The theoretical and practical approaches informing the intervention were operationalised into four coordinated strategies, with the ultimate aim of affecting permanent improvements in players' dietary habits and nutritional knowledge in relation to soccer. Lasting behavioural change was sought throughout the longitudinal study period by guiding and supporting players through the five stages of change as proposed by Prochaska and Di Clemente (1984). The rationale behind this trans-theoretical model of behaviour change acknowledges that permanent lifestyle changes take place progressively across a number of steps, including the pre-contemplation, contemplation, preparation, action, and maintenance stages.

Recognising the burden such an intervention may represent to the participants, and to promote adherence, the researcher sought to formalise the longitudinal intervention. Participation and adherence was therefore discussed with the MFA president, technical director, and team managers. It was agreed that the researcher would fulfil the role of official team nutrition specialist, forming part of the technical staff alongside the team manager, assistant team manager, goalkeeper coach, physiotherapist, masseur, sports doctor, team secretary, and kit manager. A written agreement was drafted, stipulating that the researcher, in her capacity as the team nutrition specialist, was to be present with the team at all training sessions, retreats, and international home matches, among other formal and informal appointments. The researcher was provided with the official team attire and added to all documentation pertaining to the operational structure of the technical staff. The players also acknowledged the importance of this nutritional intervention and agreed to follow the recommendations made by the nutrition specialist, which would henceforth constitute an official part of the overall preparatory programme for the entire duration of the qualifying campaign. The national team training sessions were scheduled every Monday and Tuesday throughout the year. While this frequency of national team training is not customary for other foreign teams, the geography of the island permits easy access for all players regardless of their home localities, resulting in commutes rarely lasting any longer than thirty minutes. This set-up also ensured full access for the researcher in undertaking all phases and components of the nutrition education and support intervention programme, which included preparation of nutrition information lectures, personalised dietary plans, and a team menu ahead of international home matches (at which time players typically took up temporary residence in a local hotel), as well as maintenance of a Facebook group. The researcher was present and on hand at each scheduled training session, available for consultation with the players on any aspect of their nutritional development. Communication with

the players was maintained via all desired means including mobile phone, email, and social media. As a result of this ongoing contact, players requested various types of nutritional support, including advice on supplement use, timing of food intake, qualities of various specific foods, as well as queries about the effects of better nutrition such as the reduction of fatigue in local matches. In order to ultimately test the efficacy of the intervention, the players were asked to complete the 7-day food record (methods section 2.4) for the second time, as well as retake the nutrition knowledge in soccer test (methods section 2.7), allowing for a final analysis of comparative pre- and post-intervention data. A post-match interview exploring participants' views on individual and team performance was also conducted with participants who played the entire duration of the match (methods section 2.10).

Key participants in the education intervention programme were the team coaches. Studies have shown that for many athletes, the coach remains the primary source of nutrition education, despite the possibility of possessing incomplete knowledge in the field (Juzwiak and Ancona-Lopez 2004; Shifflett, Timm and Kahanov 2002; Corley, Demarest-Litchford and Bazzarre 1990). As the staff member with the most direct contact with all players, the coach often assumes the responsibility of advising players on matters of nutrition, or more specifically on the issuance of specific pre-match nutritional guidelines to be followed at home (Juzwiak and Ancona-Lopez 2004). Coaches often want their players to become as lean as possible. Unfortunately, however many coaches tend to become susceptible to widespread yet misinformed and inappropriate dietary strategies aimed at this goal. Low-energy and low-CHO diets tend to be commonly recommended interventions for fat loss, however in the context of soccer, training and competing in a negative energy balance inhibits players from re-synthesising muscle glycogen stores after training and matches (Bangsbo, Mohr and Krustrup 2006), thus decreasing exercise capacity. Well-informed coaches regarding basic nutrition principles are more able to effectively support specialist nutrition professionals. Including coaching staff in nutrition education programmes alongside players presents a practical means to achieving this outcome. The maintenance of current and in-depth knowledge on all facets of nutrition is certainly not the role of the coaching staff, however the identification and referral of players facing significant barriers or otherwise requiring additional specialised nutritional support, is a more practical operational function coaches are in a position to affect in support of positive performance outcomes related to nutrition.

Month 1

The researcher prepared a tailor-made soccer performance diet for each individual player to follow during training days (methods section 2.11.1) and match days (methods section 2.11.2). Following their experiences in undergoing the nutritional intervention for four weeks, the researcher then met the individual players for feedback with the former streamlining the diets as necessary. The aim of this exercise was to iron out any set-backs experienced, streamlining the diets for more seamless integration into players' normal daily routines and existing habitual lifestyle processes. Any barriers to adherence would also have to be identified and overcome using appropriate strategic interventions incorporated in the final updated soccer-performance diet. In order to track the implementation of the nutrition plan, players were asked to fill in a daily adherence diary and weekly feedback questionnaire. At the end of the four-week study period the players were further asked to complete a final questionnaire consisting of nine questions with an open-ended design. One of the most important analyses in the study was of overall adherence to the performance diet by the participants throughout the four-week study period. Such post-intervention tests are explained in methods section 2.11.7.

Month 1 to Month 9

The closed Facebook group providing ongoing nutrition information was maintained for seven consecutive months. The group was also used as a medium of communication between the researcher and the players. A number of posts were made each week which information is detailed in methods section 2.11.4. Constant contact was maintained with the players through this medium, itself widely regarded as a particularly effective means of communication given the age-group of the participants.

Players implemented their tailor-made soccer-performance diets over a period of four weeks throughout the month of September, during the initial phases of the new local league season. The nutritional plans were issued two weeks in advance, giving the players ample opportunity to check compatibility of the diet against their schedules, ensure conformity of prescribed foods and drinks against conditions flagged by the PAR-Q, and permit sufficient time to physically and psychologically prepare for the final implementation period, including logistical concerns such as purchasing the necessary food items. Five players from the team registered a high body fat percentage, thereby making fat-loss their main priority, as the performance diet prescribed to the remainder of the team may have actually resulted

in further weight gain in their specific cases should it be implemented. This was duly explained to each of the five players. They were all very receptive, and agreed to embark on a 4-week fat-loss diet with the aim of losing approximately 0.5 kilograms per week as described in section 2.11.3. The fat-loss diet was earmarked for implementation during the off-season in June, so as not to allow the low-energy levels associated with fat-loss programmes to affect performance during the competitive domestic league season. Player's BMR and TDEE were calculated at rest.

Month 3, 4 and 8

The team was resident together in a hotel over a consecutive three-day period prior to each of the international home international matches. The researcher prepared a complete menu plan for the team for the three-day period, and liaised with the hotel chef accordingly. Details of the menu plan are found in methods section 2.11.6. Alongside the match-preparation menu, a one-hour lecture ahead of each international home match tackling different areas of nutrition as detailed in methods section 2.11.5 was also delivered at the hotel premises.

Month 9

In the final stage of the study, the nutrition knowledge in soccer test, seven-day food diary, body composition test, one-to-one semi-structured interview, and post-match interview were all used to collect a fresh round of data, allowing for a comprehensive comparative pre- and post-intervention analysis (methods section 2.11.7). All data was collected under the same circumstances and conditions to ensure reliability and validity. The body composition test using skinfold analyses under the same conditions as in the pre-intervention stage detailed in methods section 2.4 to determine any changes in the body fat percentage.

6.3 Analyses and results

The analyses and results below evaluate the effectiveness of the nine-month nutrition in soccer education and support intervention programme.

6.3.1 Players' body composition

Players' mean BF percentage at post-intervention was recorded to be 11.1 ± 1.0 % with the highest reading recorded at 13.2% and the lowest at 9.2%. Table 22 below outlines the changes in body composition of the players following the

nutrition education and support programme. The mean BF percentage of the players was reduced by 0.5% while the player who recorded the highest body fat percentage reduced it by 1.4% following all the phases of the programme, including an initial fat-loss programme. Cohen's *d* was run in order to measure the magnitude of difference between the pre- and post- intervention %BF measurements and hence the effect size of the nutritional intervention. This (*d)* was achieved by having one mean subtracted from the other*,* divided by the pooled, or average, of the two groups' standard deviations. This statistical method revealed that the nine-month nutrition education and support intervention, had a positive effect on reducing the team's overall body fat (mean difference= 0.17; SE difference=0.2; p=0.46; 95%CI= -0.3 to 0.65; ES=0.17, small). A small effect was reported since the %BF of the players was already in line with the recommended guidelines (11.6%), as quoted in the literature review.

	Pre-intervention	**Post-intervention**	**DIFFERENCE**
Mean % BODY FAT	11.6%	11.1%	- 0.5%
SD	1.3%	1.0%	- 0.3%
Maximum	14.6%	13.2%	- 1.4%
Minimum	9.0%	9.2%	+ 0.2%

Table 22: Players' body composition changes at pre- and post- intervention

6.3.2 Players' dietary practices – quality of energy intake

Seven-day food diaries were used to analyse the players' TDEI with the respective amounts of CHO, PRO and fat forming part of this total. The team's mean energy intake at post-intervention was found to be 2665 ± 680 kcal per day when averaged over a seven-day period, with the highest and lowest values daily reported being 3898 kcal and 1438 kcal, respectively.

The macronutrient share as a % of TDEI, and the g·kg^{-1} BM for each macronutrient was the selected method of determining quality of the diets. The average daily protein and CHO intake of the players was 23% of TDEI or 1.9 g·kg^{-1} BM and 51% of TDEI or 4.5 g·kg^{-1} BM, respectively. The highest recorded daily CHO intake (7.3 g·kg^{-1} BM) reached the minimum recommendation for soccer players, while the lowest CHO intake was reported to be 2.1 g·kg^{-1} BM. The highest daily protein intake was reported at 3.3 g·kg^{-1} BM which exceeds the maximum recommendation. The lowest daily protein intake recorded was 0.5 g·kg^{-1} BM, which was well under minimum recommended guidelines. Fat intake

reached a mean of 26% of TDEI, while hydration intake was found to be 1605 ± 960 millilitres. Table 23 shows a comparison of the team's macronutrient, hydration, and TDEI intakes pre- and post-intervention. Cohen's *d* was ran in order to measure the effect size of the intervention in terms of TDEI, CHO and protein intake. TDEI statistics (mean difference= 520.4; SE difference= 156.8; p=0.005; 95%CI= 186.3 to 854.6; ES=0.83, large) showed that there was an average increase in the total intake consumed by the players over the seven-day testing period, more closely matching their total daily energy requirement in pursuit of the attainment of a state of energy balance. There was also a positive increase in the amount of CHO ingested, with a mean difference of= 0.76; SE difference=0.28; p=0.015; 95%CI= 0.175 to 1.375; ES=0.69, medium) even though this is still short of the recommended guidelines. Finally, in terms of protein intake, there was also a positive effect with a slight increase in intake shown (mean difference= 0.46; SE difference=0.11; p=<0.001; 95%CI= 0.22 to 0.70; ES=1.02, large), despite the habitual intake for this macronutrient already being at par with recommended guidelines.

	PRE-INTERVENTION	DIFFERENCE	POST-INTERVENTION
TDEI	2164 ± 498 kcal	+501 kcal	2665 ± 680 kcal
PRO (% of TDEI)	21% ± 4% of TDEI	+2% of TDEI	23% ± 6% of TDEI
PRO (g·kg^{-1} BM)	1.5 ± 0.4 g·kg-1 BM	+ 0.4 g·kg^{-1} BM	1.9 ± 0.5 g·kg-1 BM
CHO (% of TDEI)	48% ± 5%	+3% of TDEI	51% ± 8%
CHO (g·kg^{-1} BM)	3.7 ± 1.0 (g·kg^{-1} BM)	+ 0.8 g·kg^{-1} BM	4.5 ± 1.5 (g·kg^{-1} BM)
FAT (% of TDEI)	30% ± 5%	-4% of TDEI	26% ± 7%
HDYRATION	1648 ± 784 mL	-43 mL	1605 ± 960 mL

Table 23: Macronutrient, hydration and TDEI intake at pre- and post- intervention

6.3.3 Players' nutrition knowledge in soccer

Players were tested about their nutrition knowledge related to soccer at pre- and post-intervention stages, under the same conditions using the same knowledge test. Twenty-one players took the test at post-intervention stage, four less than at pre-intervention, as these players were dropped from the squad, and therefore also removed from the study as they were unable to complete the entire nine-month intervention. Out of twenty-seven questions the mean correct answers were eighteen, equating to 68 ± 9 % correct answers. The mean number of incorrect answers was eight. When expressed in terms of negative marking, the standard selected means of reporting results in this analysis, the average

team score in the soccer test was of 38 ± 19%. The highest mark obtained was 67% while the lowest mark was of 4%. The nutrition knowledge of the players was slightly improved as the team's correct answers increased by two, from sixteen to eighteen. The wrong answers did not change, while the "Do not know" answers decreased from three to one, which difference was translated in the number of correct answers (Figure 7). Correct answers percentage expressed in negative marking increased by 8%. This showed that even though not as significant, the players' knowledge improved over the nutritional support period. Cohen's *d* was ran in order to measure the size of difference between players' knowledge as regards to nutrition in soccer at pre- and post- intervention. Cohen's *d* measure for effect size revealed a positive effect in terms of better knowledge at post-intervention when the results were expressed both as normal and negative marking (Negative marking: mean difference= 9.17; SE difference=3.57; p=0.02; 95%CI= 1.7 to 16.6; ES=0.56, medium; Normal marking: mean difference= 7.58; SE difference=1.94; p=<0.001; 95%CI= 3.5 to 11.6; ES=1.94, very large).

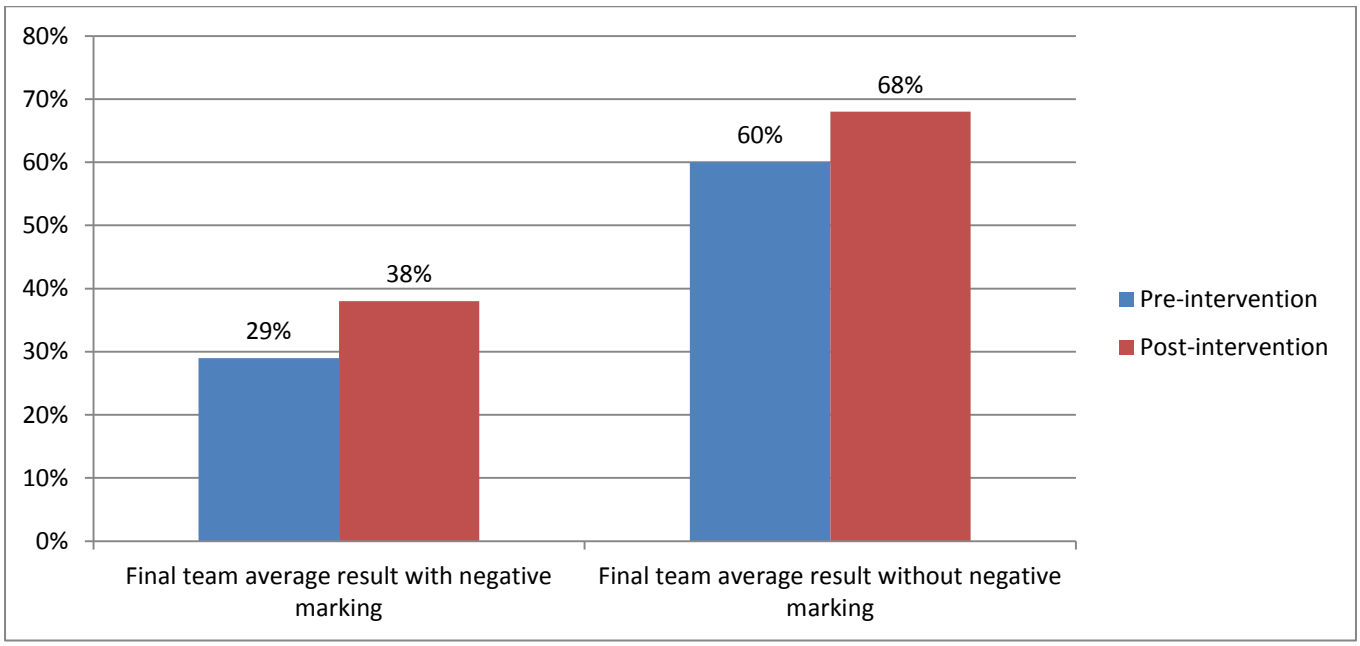

Figure 7: Comparison of the team's nutrition knowledge in soccer at pre- and post- nutrition education intervention

6.3.4 Players habits, perceptions, attitudes, barriers towards nutrition in soccer

The participants were again interviewed in the post-intervention phase for a more in-depth understanding of their habits, attitudes, perceptions, and beliefs towards a sound nutritional plan in soccer, given that they had now undergone the 9-

month nutrition in soccer education and support intervention programme. The replies given by the players served to indicate the extent to which the nutrition support and education intervention could be deemed a success, as well as the specific aspects of this success. The participants found the process of filling in the diary easier this time round, commenting that it was now “Second nature”. Upon analysing the data it was found that the participants had indeed demonstrated due competence throughout their data collection efforts. In a discussion based on the definitions of unhealthy food, participants described foods containing high sugar content such as sweets, and oils such as those found in junk food. The majority of the players stated that their consumption of such foods was now minimal. Some added that such foods increase fat levels in the body, contributing to altered body composition. One player said that such foods are “man-made” and unnatural, instead endorsing natural food options like fruit and vegetables. All participants reported they had now standardised their pre-match intake to a portion of multi-grain pasta with fresh tomato sauce, tossed in chicken, beef or turkey around three to four hours before kick-off. This was done in conjunction with drinking plenty of water the day before, and again on the day of the match. As regards to post-match intake, players were less rigid, but most commented that they now preferred more nutritious meals consisting of a source of meat with vegetables and potatoes, understanding this was key to the replacement of nutrients lost during the course of a match. Most of the players added that the habit of consuming junk food after a match was now completely eliminated from their routines, although some admitted to maintaining this practice, particularly when they felt they would not have given a good performance. Players also indicated heightened awareness about the benefits of keeping well-hydrated, making extra effort throughout the day to drink water. Alcohol consumption was reportedly eliminated by all the players, claiming they now took only “one-off” drinks during special occasions, and only when this did not interfere with training and/or matches. Actions on finding no food prepared at home unfortunately remained unchanged. Some players still opted for snacking in such a scenario, but claimed the snacks were now healthier, citing examples such as oat bars, fruits, and rice cakes. A majority of the players however now claimed that they were more willing and able to cook something fast and simple such as a plate of pasta, although reverting to heating up frozen foods to avert investment of time in food preparation persisted. When specifically asked if they would now be willing to prepare their own meals, nearly all the players replied affirmatively, however expressed their persistent concerns about lack of time resulting from their semi-professional status. Players offered some varied definitions of the prescribed nutritional plan, some focusing on the

healthy outcomes of balanced nutritional intake, while others verified the link to improved performance. They specified that a nutrition plan should reflect the right types and amounts of food at the right time in order to maximise performance. When asked if they agree with a “one diet fits all” system, all the participants said that this was not ideal, since each player has different body composition as well as different needs and requirements pertinent to their positional role within the team. One player noted that while it was good practice to have basic nutritional guidelines in place for the team, these would still need to be adjusted according to individual wants and needs. Participants re-iterated that they did not receive any additional nutrition information from their clubs or elsewhere, apart from the support given by the researcher during their time spent with the national team throughout the course of the study period. They confirmed that upon experiencing such nutritional support, they possessed a greater understanding of its importance, and were able to make their own nutritional choices more effectively, without influence from others except for their parents, who still prepared the main family meal in the evening. The participants described undergoing the development of a more comprehensive thought process before making nutritional choices. Such a process did not however always result in the best choice actually being affected, as they would still sometimes tend towards their appetite rather than the relevance of a particular food item. Despite being more aware of the foods being consumed, most of the players admitted to remaining largely unaware of their TDEI. The barriers towards optimal nutritional practice in the post-intervention interviews remained virtually unchanged. The most common barrier was still the allocation and availability of time for the preparation and ingestion of food. Work or college demands in the morning tend to leave little time to fit in much else. Other barriers such as not knowing how to cook, and not liking certain foods, especially vegetables, persisted. Following the actual implementation of the performance diet, one player identified a financial barrier, claiming that he spent approximately 200 Euro weekly to follow it. Finally, most of the players acknowledged that one must be willing to address and overcome such barriers in order to reap the benefits.

When players were asked to rate their own adherence out of 100% and provide reasons to support their answer, seven players said that they followed around 65% of the diet, while three others said they followed it to the letter, citing a 100% adherence rating. Three players did not follow it at all, while the rest said that they followed about half of its content. Of the three who reported a total lack of adherence, one cited work commitments, while the remaining two were both sidelined due to injury, and therefore could not consume the amounts prescribed. Some players commented that the

food quantity was sometimes too much, while others stated they did not have enough time to consume some of the prescribed meals. A considerable number of players said that they did not always find time to prepare the food, mainly due to being at work in the morning and not having sufficient time between finishing work and starting training.

When asked about the barriers they experienced or recognised throughout the intervention which could have prevented them from following the prescribed plan, participants were consistent in nominating a lack of time as a significant barrier. This did not only affect food preparation, but even the actual act of eating. Work or college commitments were cited as the main causes of this lack of time for preparing foods in advance. During the dietary planning process the researcher made every attempt to ensure prescribed foods were simple to prepare in advance, however the players would still need to find at least some time to affect these preparations. Some players however, admitted that they were simply too lazy to prepare all the food prescribed. Other barriers included the evening lifestyle where players socialised with friends or dined out, making it virtually impossible to consume the foods as prescribed.

When asked if they would repeat the prescribed dietary plan, all the players said they would. They again re-iterated some of the difficulties posed by work and/or college commitments, but they stated that they would refer to the diet whenever possible. Indeed, some players affirmed the importance of doing so in order to become better soccer players.

Players were hesitant to suggest significant changes to the performance diet. While acknowledging that the dietary plan was effective and addressed the main barriers, they insisted the barriers were still present, and short of becoming professional players in order to follow a diet more diligently, little could be done to improve their eating habits further.

Some players suggested that variety be limited, and more of the same meals repeated. This would reduce the amount of ingredients requiring purchasing. The rest of the players said that the performance diet was “good”, in terms of food selection and the balanced timing of meals. Other suggestions included the removal of vegetables and addition of chocolate as a snack or treat, the inclusion of a daily sweet dessert in the evening, and some even requested a daily alcohol allowance in terms of units of wine or beer.

In terms of the most challenging aspects of following the diet, the participants again highlighted time restrictions, as well as not being able to keep up with the preparation and ingestion of the prescribed food. They suggested the possibility of preparing all food for the week in advance; however they quickly voiced concerns that this was a routine they were unlikely to maintain for any more than a few weeks. Some of the players also highlighted that the biggest struggle was

to have breakfast in the morning, since they were simply not used to it. Again this raised some time issues, since the players had to wake up earlier before work to consume it, and as one participant said, “With such a busy lifestyle, you would want to spend each possible minute resting in bed”.

When asked if they were willing to continue following such a dietary plan and receive ongoing nutritional advice, players said they would like to keep on following the diet “When it is possible”. Many concurred that the diet had helped them to perform better, and one player said that he actually recommended the plan to fellow soccer players. Indeed, some of the players later reported they were still following the performance diet some months later. Less committed players said they would “try to” maintain it.

Players were then asked to elaborate on any specific improvements they could attribute to following the performance diet. One player explained that before training he used to feel consistently bloated. He hypothesised that this could have been due to his pre-match meal being too close to the start of training or match-play. As a result of following the performance diet he now reported feeling in much better condition, with less bloating. Other players said they had more energy, and did not feel lethargic as they sometimes did in the past before training or match-play.

Some of the more positive feedback included an overall better perceived performance in training and matches, and experiencing far less fatigue than they did in the pre-intervention stage. Some participants also felt they were experiencing better recovery from training, while others were more cautious in their responses, citing no drastic changes as a result of the performance diet, believing that improvement would occur gradually over time and not after just four weeks of implementation.

The participants all agreed that such support is an essential part of becoming a better player. The majority felt that the intervention had improved their nutritional knowledge with relation to soccer and were more able to apply this knowledge into practice. What's more, the players felt more responsible for their nutritional intake following the intervention. They were unable to approach nutrition in this way before due to a general lack of guidance or education. As a result of their participation in the study some players felt what they now needed the most was determination and most of all, the time to implement it. One player declared that he was never a fan of nutrition and did not believe much in its potential, but following the intervention he now felt he had seen enough proof of its worth, and would continue to follow such a diet to continue maximizing his performance.

In the last question, players were reminded that no nutrition specialists were employed by the MFA with any of the national teams, and had it not been for the researcher conducting this study, no nutritional support would have ever been provided. Most of the players suggested that a soccer nutrition specialist in the team set-up was a must. They added that having full nutrition support with the youngsters is even more important in order to instil early positive nutritional habits that are hopefully maintained well into adulthood. This type of support would need to be more educational in nature in order to cultivate knowledge and positive attitudes towards nutrition. Support for adult players should, according to the players themselves, involve dietary prescription and guidance based on individual traits and positional play. The participants concluded by saying that, as players, they felt it was important to have someone to refer to and guide them through the "Ups and downs" of following a thorough nutritional plan, providing reassurance and motivation.

Upon being asked how they prepared nutritionally for the match, the players replied that they followed the nutritional plan prepared by the researcher. They did not feel the need to eat more or do anything different than what which was prescribed. They agreed with the menu provided over the three days of residency with the team and commented that it suited them well. Only three players from the entire squad remarked that they experienced some fatigue, although this was reported to occur later than in the pre-intervention phase. Fatigue was mostly felt during the numerous runs they had to perform, moments when they were defending but suddenly attempted to counter-attack, as well as when chasing back the opponents. The non-fatigued players recounted that they managed to maintain the same pace throughout the match. When asked how the fatigued players dealt with such occurrence, strategies included staying in the same position in order to recover, pacing intensity throughout the remaining minutes of the match, reducing the amount of runs to save energy, and using self-talk to push harder through the fatigue. Ultimately, they all reported successfully managing to overcome the fatigue, and finishing the match without the need to be substituted. The fatigued players said that their performance was slightly reduced towards the end of the match, however they maintained their fatigue was managed and kept under control. Players were specifically asked whether they experienced any cramps or twitches throughout the match. Only one player reported feeling a twitch in the 60th minute, as he accelerated in an overlap and immediately after had to run back to cover his position. The participants specified that fatigue was felt more in the second half, particularly during the last fifteen minutes of the match. Affected players agreed that their fatigue was

predominantly aerobic. Players were further asked whether fatigue was experienced collectively as a team, and whether this affected the final result of the match. Only one player said that this could have been the case. Players were asked why in their opinion they conceded five goals, or more specifically whether it was mostly a physical, technical, or a tactical issue. Players gave varied responses. Some of their suggestions included lack of concentration and tactical discipline, and an inability to keep up with the tempo of the match. One player mentioned not playing regularly enough with his local club, and hence lacking the experience and readiness for matches of such calibre. Overall, the participants all agreed that it was a multitude of factors combined, although the majority of blame was placed on tactical discipline. Regarding the quality of their recovery following the match, all participants reported feeling some soreness. They agreed that it was the same degree of soreness usually experienced after an international match. In addition to the pre-intervention questions, the participants were asked to voice their opinions as to why they thought the loss was heftier this time round, given that this was the second leg against the same opponents as their previous encounter. The responses were again varied, and included suspension or injury of key players thus reducing the effectiveness of the team, better tactical preparation from the side of the opposing team given that they now had a better understanding of their opponents' weaknesses and did not want to spend the majority of the match held to a draw as in the previous encounter, concession of an early goal in this encounter, and a general lack of motivation and determination following a string of five consecutive defeats. The players also commented that their opponents appeared much more mentally prepared, determined and aggressive than in the previous encounter. The team captain commented that his team had changed psychologically, stating that, “The talent on our side is still there, but the belief has left us.”

6.4 Discussion

Following the entire longitudinal research period with the U21 national team, including the nine-month nutrition in soccer education and support intervention, players exhibited improvements in their nutritional knowledge and practice on a number of levels. The main aim of this study was to measure the effect of a nine-month nutrition education and support intervention strategy on soccer players. Pre-intervention tests of body composition, nutrition knowledge in soccer, quality of energy intake, as well as the players’ attitudes, beliefs, habits, and barriers were repeated post-intervention under the exact same conditions via skinfold calliper analysis, nutrition knowledge in soccer test, seven-day Food diary and one-to-one attitudes, beliefs, habits and barriers interview respectively at post-intervention.

A pre- and post- intervention comparative analysis revealed positive changes in body composition (less 0.5%) as also seen in a similar study on college soccer players by Goderwis (2015). Such positive change as an effect of the intervention is regarded as an important consideration in analysing the physical activity level of the players, since fat surplus has been found to substantially decrease performance (Reilly and Doran 2000).

In terms of menu preparation ahead of international matches, players felt that the nutritional plan provided by the researcher throughout the course of the intervention helped their physical preparation and averted debilitating fatigue, facilitating the maintenance of sound technical ability throughout the entire match. These perceptions serve to further support evidence that soccer players should consume a high-CHO diet to sustain training and performance in soccer. In what may be considered among the most influential of positive changes, the players' quality of dietary intake changed to accommodate the consumption of less fat, and more CHO to support their training and match-play. Even though still below the recommended values, CHO intake increased by 0.8 $g \cdot kg^{-1}$ BM to a total of 4.5 $g \cdot kg^{-1}$ BM. Due to their semi-professional status, the players found it difficult to consume all the prescribed foods, suggesting more support may have been required. Protein intake increased by 0.2 grams to a total average intake of 1.9 $g \cdot kg^{-1}$ BM, hence slightly exceeding the maximum daily recommendations. Fat percentage was reduced to 26% from 31% of TDEI. Other studies have supported the positive effects of educational interventions on nutritional knowledge; however do not show marked improvements on actual dietary intake, as exhibited by the research participants from the Maltese U21 national soccer team. Wise et al. (2014), reported no significant differences in the dietary intake of soccer players and coaches following an educational intervention. Similarly, Martinelli (2013) indicated that nutrition education was effective at increasing participants' nutrition knowledge, but not at improving their dietary intake. These conflicting results imply that there may be a controversial relationship between nutrition knowledge and actual dietary intake, suggesting a need for further research that also investigates the effects of tailor-made dietary interventions in conjunction with educational programmes.

Some of the reported changes made in players' nutritional habits included drastic reduction or total elimination of junk and fatty foods, replacement of refined CHO sources with multi-grain alternatives, increased consumption of fruits and vegetables, decreased portion sizes offset by increased meal frequency, inclusion of an oats or muesli based breakfast, and the formation of a consistent pre-match routine consisting of appropriately timed ingestion of multi-grain pasta with

tomato sauce and chicken or a similar meat source. Post-match habits also improved, as the participants shifted from eating anything they liked, to a more nutritious option comprising CHO, protein, and unsaturated fat sources. The participants felt more able to make healthier snack choices in the form of oat bars, rice cakes and fruit, as opposed to fattening and sugar-loaded snacks such as sweets, chocolates, or biscuits, claiming a greater sense of general responsibility over their nutritional choices. They also started making use of snacks one hour before and fifteen minutes after training in a bid to top-up and replenish glycogen stores. Pre- and post-match nutrition, the importance of CHO as the main source of fuel, the importance of adequate hydration, the difference between saturated and unsaturated fats, optimal macronutrient intake ratios for soccer, reading food labels accurately, and choosing healthy food items were nominated as among the most valuable lessons learned. A majority of the participants reported generally positive changes to their eating patterns. They would typically start the day with a good breakfast where no breakfast was consumed in the past, include healthy snacks between meals, consume a pre-training meal based on complex CHO, and finish off the day with a wholesome dinner. They clarified that such changes did not involve significant sacrifice in order to affect, and that nutritious food can also “taste good”.

They also summarised the success of the intervention as a process of change, as an application of knowledge and expertise in terms of food sources, in conjunction with a willingness, determination and motivation to improve nutritional practices. Certain beliefs such as protein constituting the most important energy source for soccer were dismissed, and general attitudes towards nutrition were improved across the sample group as a result of participants' first hand experiences of the perceived differences during match-play performance following both optimal and sub-optimal nutritional habits. While not all barriers were overcome, several were effectively addressed, indeed individual players worked hard to personally address them. Participants generally showed a willingness to adhere to the nutritional plan prescribed for them, even after the completion of the study period and termination of direct researcher support, maintaining that they perceived no reason to stop given the improvements they had already witnessed in their own performance. They acknowledged that without support, there was a higher probability of slacking. They nevertheless vowed to do their best in maintaining the diet, since many aspects of the intervention had already become routinised. The participants commented that the extent of the support provided throughout the nine-month intervention surpassed their expectations, and were appreciative of the work done by the researcher and technical staff. They recalled that the

most challenging aspect of it all was the individual guided portion allowance at each of the buffet-style meals provided during their residency at the hotel ahead of each home international match. They had been accustomed to consuming whatever and however much they wanted during these meals. Indeed, this was a routine they would look forward to due to the abundance of food to which they were not accustomed in their usual semi-professional routines. While some of the players immediately understood the reasons for portion control, others who very well may have also understood, were irate about being deprived of their desired food preferences. They nonetheless concluded by the end of the intervention that their updated nutritional practices represented a "Turning point for the better" in their careers. Most of the participants felt that the programme had empowered and motivated them with first-hand knowledge and experience as regards the efficacy of optimal nutrition, rather than simply dictating what should and should not be eaten. One player commented that the programme was comparable to his experiences playing at a professional level with Norwich City F.C. in the UK. Players found the tools used during the intervention effective, with the Facebook group constituting the preferred source of information. Especially among younger generations, computer-tailored nutrition education has been found to be an innovative and promising tool to motivate people in making necessary dietary changes. Brug, Oenema and Campbell (2003) suggest such a strategy is more effective than general nutrition information transmitted via traditional means. The daily posts uploaded each day, were "Just a click away" on any device be it smart phone, laptop, or tablet. They recalled that captioned photos with summarised messages worked particularly well, as the information they contained was easier to remember. They commented that every day, without even being consciously aware of it, they were enriching their knowledge of nutrition. Indeed, interesting discussions via comments on the page sometimes ensued, encouraging healthy debate among players and staff alike. Comments about the tailor-made nutrition preparation at the hotel ahead of the international match were varied. Some players disliked the portion control, but claimed they were eventually able to understand and appreciate the underlying reasoning, and thus accepted it. Other players said it was an excellent strategy, since most tended to over-consume at a time when moderation and careful preparation was key. Some players also commented that the exercise was a valid experience of professional conditions, in contrast to the usual routines resulting from their semi-professional status. One player recounted, albeit unsure of the influence of pure coincidence, that the only matches in which he did not experience cramp, were those during which the researcher was present to provide the menu and control portions for the team. The tailor-made nutrition plan was most

appreciated by the players when they understood the meticulous calculations behind it. The plan was nevertheless deemed easy to understand, based on a simple format indicating the amounts and grams of each ingredient of each meal. Each plan was also adjusted and updated throughout the course of the intervention, to accommodate any changing needs or circumstances of the participants as and when required. The nutrition lectures delivered at the hotel during the residency periods surrounding home international matches provided more elaborate nutritional information and opened the floor for any questions or issues regarding any aspect of nutrition, and receive immediate feedback from the researcher, staff, and peers. Most players found these sessions beneficial, however expressed preference towards the other support measures provided throughout the intervention, declaring them more convenient and more effective. Some of the participants felt there were too many players in attendance for adequate concentration to be fostered, thus preventing the aims of the sessions from being met. Smaller groups may have helped increased confidence among the players, and decrease distractions and disruptions. Apart from the planned information measures outlined above, the researcher provided constant nutritional one-to-one support via a number of additional means including face-to-face meetings, Facebook, email and phone calls. Players found these measures beneficial since they targeted the individual queries and problems. A majority of the participants expressed interest in ongoing support beyond the scope of the research-based nutrition intervention itself, now viewing nutrition as a vital component of optimal performance in soccer. After having experienced it first hand, they gained a newfound appreciation of its importance, and could not understand why such support was not provided by the MFA. Some players raised the interesting view that such nutritional guidance, particularly educational support, was even more crucial in the context of semi-professional soccer. Unlike professional players, they had to keep up with a more varied and unpredictable range of activities throughout the day, and take responsibility for their own nutritional choices in the absence of food that is readily available and prescribed for them by experts. Some of the participants suggested the team coach speak to the technical director of the MFA in order to address the need for more formal nutritional support for the national team, also commenting that the association should encourage local clubs to also provide nutritional support to all local club players. Such nutritional support should ideally start with the younger age groups (Purcell et al. 2013; Jeukendrup and Cronin 2011), thereby increasing the likelihood of retaining sound nutritional habits well into adulthood. When asked if they noticed any improvements in performance, the participants highlighted numerous benefits resulting from the implementation of the nutrition strategies. Answers like

'definitely' and 'of course' were seen across the sample group, with more specific answers including improved overall strength, increased stamina, less perceived fatigue, and the ability to start and finish a match with consistently higher energy levels and without muscle cramps. Other perceived benefits included better quickness and agility, feeling leaner, and the tendency to recover faster between training sessions and after matches. Apart from the purely physical benefits, players also reported an improvement in skill, claiming that due to less fatigue, their legs "Responded better" to the technical demands of complex movements such as dribbling. One participant reported that he was able "Stand out" above other players in domestic league and cup matches as a result of lower fatigue, particularly in the latter stages of play. Aside from the physical and technical benefits, players also recognised psychological advantages. Instead of having to think about preserving energy throughout the course of a match, participants were able to maintain better concentration, to make better decisions faster, and be more confident overall. The participants felt they had been equipped with knowledge and skills that could assist them in their progression throughout the remainder of their careers, particularly in the local scene due to the absence of optimal nutrition practices among other local soccer players. While many of the participants were sceptical about the benefits of nutrition in the early stages of the intervention, attitudes and perceptions changed considerably across the sample group after experiencing some of the benefits first hand. One player claimed he was going to feel "lost" without the researcher's guidance, fearful that he would not be able to retain the nutritional habits alone. The sound nutritional habits had helped him dearly throughout the season, and support was crucial in overcoming an upbringing characterised predominantly by terribly unhealthy eating habits. When assessed at post-intervention stage on nutritional knowledge, players exhibited this newfound knowledge in a range of depths and contexts. Nearly all the players mentioned the importance of maintaining a balanced diet, distributing foods according to their sources, eating small portions frequently, and starting off the day with a wholesome breakfast. One player mentioned that in order to lose weight, he would need to implement a weight-loss diet during the off-season and not in-season, while another participant mentioned that CHO is stored as glycogen in muscles and liver. Other players highlighted the difference between simple and complex CHO, and specified the times when these should be consumed during the day. The difference between macro- and micro-nutrients was also specified, affirming that only the former provides energy. One player was able to describe the role of vitamins and minerals in the body, and another questioned some of the claimed benefits of supplements. Two players were happy to report they were now able to read and

understand nutrition labels, while around half the players stated the importance of shifting from white to whole grain pasta, rice, and bread. Another player mentioned that protein is not only found in meat, but also in vegetables along with CHO and other vitamins and minerals. All the players concurred that the nutrition support helped them in their career, and would strive to maintain their newly acquired habits, as one participant stated, “I will not unlearn what I have learned”. The participants voiced a number of take-home thoughts, including the notion that adherence to a sound nutritional plan can “Only do good”, and certainly will not result in adverse effects. Also, nutrition was deemed as important an aspect as any other in soccer performance, which was much like a jigsaw puzzle; if a piece is missing, the performance “picture” remains incomplete. One player went as far as to say that the intervention had affected him positively both as a person and as a player.

6.5 Conclusion

Following the intensive intervention implemented as part of the research study, participants expressed a desire for continued nutritional support, acknowledging a newfound understanding of the importance of having a nutrition specialist in the technical staff of the team. This study has provided a detailed picture of the practical and logistical considerations associated with implementing nutritional support in semi-professional soccer, and highlighted the current lack of any organised or formal nutrition-based initiatives specifically in the local Maltese context. It has in part reduced the paucity of nutrition research in soccer, and showed that a nutrition education and support intervention programme was an effective means of improving both the participants’ nutrition knowledge and actual dietary practices, even though such differences were subtle. These findings imply a controversial relationship exists between nutrition knowledge and eating patterns, highlighting the need for further research in the area, possibly centred more rigorously around the psycho-social aspects of nutritional habits.

Chapter 7

General Discussion and Conclusion

7.1 Introduction

This chapter constitutes a synthesis of the main findings from each of the four studies comprising this thesis. Their relationship with existing literature is discussed, in context of the original contributions to knowledge they provide. Limitations of the research are also considered throughout the discussion, and recommendations for future research are made.

7.2 Realisation and thesis aims

Previous research has established that proper nutrition is considered a significant determinant of athletic performance. Aside from heredity and training, it has been suggested that no single factor plays a greater role in performance than diet.

The general aims of this thesis were to investigate the physiological, psychological and sociological aspects of nutrition and soccer, and posit a comprehensive nutritional framework that actively engages soccer players in adopting a diet that is supportive of optimal performance in soccer training and match-play. In the initial study the researcher needed to actively demonstrate whether proper nutrition actually marks an effect on physical performance in soccer. Since no prior studies to this effect had been conducted to date, a 90 h dietary intervention tested via a 90-minute soccer–specific field protocol was adopted as a point of departure for this longitudinal research. Following collection of 90 h food diaries, the 90-minute BEAST90$_{mod}$ protocol was carried out. A 90 h dietary intervention was implemented, followed by a repeat of the 90-minute soccer-specific protocol within a single week. was concluded, based on the players' results, that nutrition played a vital role in increasing total distance covered via the simulated 90-minute soccer-specific protocol. In light of these findings, the remaining studies explored the implementation of necessary dietary approaches and their effects on performance in both training and match-play throughout the subsequent two-year longitudinal support period.

The researcher teamed up with the Maltese U21 national soccer team for a total period of twenty-four months. The players' habitual dietary intake, energy expenditure, and energy balance were initially examined via a seven-day Food and Exercise diary during a week of competitive training. Next, an understanding of the reasons behind the players' poor customary dietary habits, as indicated by the Food and Exercise diary data, was sought. Information about the players' knowledge, attitudes, habits, perceptions, and barriers towards a diet conducive with optimal performance in

soccer was also collected using various methods. A soccer-related nutrition knowledge test was created for the players to complete individually, permitting an assessment of their current nutritional knowledge with specific relation to soccer. One-to-one semi-structured interviews exploring the players' habits, perceptions, beliefs, and attitudes were conducted individually to gain a deeper understanding of the influences and implications surrounding their dietary choices. Players in the starting formation who had played at least eighty minutes of a chosen international match were interviewed about their post-match evaluations following no specific pre-match nutritional strategy. The coach and assistant coach were also interviewed in order to provide more insight about the team's nutritional preparations.

The researcher also planned a 9-month nutrition education and support intervention programme which players were bound to undertake as part of their preparations for the UEFA U21 European Championship qualifying campaign. The intervention included the provision of daily information via a closed Facebook group, a personalised dietary plan, nutrition information lectures, as well as menu preparation and dietary intervention ahead of international games, supported by ongoing individual and team feedback. In order to measure the effects of the intensive nine-month intervention, the researcher tested the players in the same manner as in the pre-intervention stage for their knowledge via the same soccer-related nutrition knowledge test, their dietary practices via the seven-day Food Diary, their attitudes, beliefs, perceptions and habits via the one-to-one semi-structured interview, and their match performance via the post-international match interview. The players showed significant improvement in each of the tested parameters, and expressed a definitive preference towards the continued provision of such support beyond the scope of the research study intervention, at both club and international levels. The principal aim of the four interlinked studies was to present findings that provide players and stakeholders in soccer with a clear indication of the benefits of specialised nutrition in soccer, thus empowering them with a range of appropriate tools and strategies to adopt informed individual and team approaches to nutritional decisions, and ultimately facilitating improved physical performance in soccer training and match-play.

7.3 Main discussion

Soccer is a contact sport requiring strength, power, and a capacity for sustained high-intensity activity (Bangsbo 2014; Tumilty 1993). In the modern competitive landscape, every player and every team must strive to achieve the edge needed to win. While hard work in training and sound tactics are vital, a well-developed nutritional plan that meets

overall energy expenditure, optimises energy stores, reduces fatigue, adequately hydrates, promotes rapid recovery, as well as achieves and maintains optimal body weight and physical condition, can constitute a much needed edge over the competition (FIFA 2010; Burke, Loucks and Broad 2006; Manore and Thompson 2006; Murphy and Jeanes 2006). Typically, the energy demands of training and competition require the soccer player to consume a well-balanced diet in terms of macro- and micro-nutrient ratios, with special emphasis on ensuring sufficient CHO intake (Rollo 2014; Korkmaz 2004), and meeting overall energy expenditure (Collins and Rollo 2014; MacLaren 2003). Fat intake should be carefully controlled, protein consumed in sufficient but not excessive quantities, and fluids ingested to maintain constant hydration (Williams 2012). The overall plan should additionally be characterised by an appropriately timed intake of the required nutrients, to facilitate adequate recovery between matches and promote desirable training adaptations (Ono et al. 2012; Austin and Seebohar 2011; Hawley, Tipton and Millard-Stafford 2006; Williams and Serratosa 2006). A combination of the above factors, subject to effective nutritional management, helps contribute to the development of peak performance in soccer (Alghannam, 2013; Williams 2012).

The most significant finding of the first study was that a 90-hour soccer-performance diet marked a positive effect on the physical performance of participating soccer players. A dietary intervention involving 10 $g \cdot kg^{-1}$ BM of CHO, 1.7 $g \cdot kg^{-1}$ BM of protein, and less than 30% fat per day was administered. Following the dietary intervention, players covered an additional 887 ± 233 metres or 8.1% during the 90-minute soccer-simulated protocol. An effect size of 2.4 was revealed, constituting a significant difference, and thus representing an overall successful nutrition intervention. Recent data shows that among professional French first division players, the total distance covered in a soccer match was between 10, 426 and 12, 030 metres (Dellal et al. 2010). This range corroborates the total distance covered by the participants during the 90-minute soccer-specific protocol. An improvement in total distance covered (1, 300 metres) was also found by Sougilis et al. (2013), where players who followed an 84-hour diet consisting of a high CHO intake (8 $g \cdot kg^{-1}$ BM) versus players who followed a low CHO (3 $g \cdot kg^{-1}$ BM) diet for three days prior to an eleven-a-side soccer match**.** No other research to date has manipulated the diet of soccer players and tested performance directly in a field-based environment over a 90-minute protocol closely replicating the demands of a soccer match. Balsom et al. (1999b) reports that during a 90-minute four-a-side indoor soccer match, players on high CHO diets (65% of TDEI) performed at higher (33%) intensity during the match than those on low CHO diets (30% of TDEI). In addition to these findings, Bangsbo et

al. (1992) demonstrated an increase of 0.9 kilometres in the distance covered during intermittent running to fatigue on a treadmill by the high CHO group (8 g·kg^{-1} BM of CHO) at the end of the protocol when compared to the group following a normal diet (4.5 g·kg^{-1} BM of CHO). As fatigue sets in, research shows that the total distance covered at high intensity is reduced (Mohr, Krustrup and Bangsbo 2005), especially in the second half of a match when compared to the first in both elite and sub-elite soccer (Carling and Dupont 2011; Coelho et al. 2011; Bradley et al. 2009; Di Salvo et al. 2009). This was similarly the case in the pre-intervention soccer-simulated protocol, but not at post-intervention stage, where players ran, on average, more in the second half than they did in the first. The total distance covered was thus increased between the two trials. A delay in the onset of fatigue was shown between trials, and hence a positive effect of optimal nutrition on physical performance in soccer revealed. RPE values gathered at each half during each of the two trials were significantly lower in the second when compared to the first trial where no set nutritional intervention was in place. Moreover, RPE values at the end of the second half in the post dietary intervention trial were not higher than those at the end of the first half in the first trial, indicating that fatigue had not set in as is usually the case in the second half when compared with the first. Future research may examine the design of a variety of optimal meal plans as opposed to one, that accommodate the variable daily routines typical of semi-professional players. Future research could also explore the technical and tactical implications over a 90-minute simulated soccer protocol following a dietary intervention. Other studies may investigate the notion of adapted nutritional strategies according to playing position and/or individual activity performed during the match.

Energy balance was investigated next, as well as the quality of energy intake of the U21 national team soccer players. The mean energy intake (2164 ± 498 kcal) was slightly below that reported in one of the recent recent studies conducted on Spanish players of the same age. namely 2796 kcal as reported by Iglesias-Guitierrez et al. (2012). The customary dietary intake of the Maltese players was in line with that found in semi-professional players by Renan and Collado (2013), also using the food diary as a means of data collection. Mean energy expenditure was 2799 ± 382 kcal, resulting in a mean energy balance daily deficit of 705 ± 648 kcal during a week of competitive training. Few studies have analysed energy balance in soccer, and those that have show highly variable results, possibly due to the use of diverse methodologies and experimental designs, and to differences in the ages, competitive levels, and training loads of the participants (Garcia-Roves et al. 2014). Energy expenditure in training has been found to be in the region of 1080

to 1350 kcal among English professional players, in a study dating back to 1979, thus rendering the reliability of the values questionable. No recent studies estimating energy expenditure in soccer training have been encountered to date. To adjust for this lack of data, the researcher used the MET formula to estimate energy expended during training sessions, out of which the total two-hour duration was segmented into fifteen minutes of low intensity at the beginning and end of the session in the warm up and cool down, respectively. From the remaining hour, fifteen minutes were considered as moderate intensity, and forty-five minutes as high intensity. The researcher averaged these intensities over a two-hour session following a number of observations of team training sessions. Energy expended throughout the course of a match was found to be in the region of 1540 kcal in a more recent study by Coelho et al. (2010). The rest of the Calories expended during the day, including expenditure associated with other daily activities and the BMR averaged out at a TDEE of around 3000 kcal. The value of the players' estimated average energy requirement was significantly less than their current mean customary intake. The data shows that the players' energy requirement was significantly higher than their current customary intake, and while magnitudes of deficits differ, evidence of a negative energy balance reflects observations from similar populations in other studies ranging from 3100 to 4050 kcal per day for the lightest and heaviest players respectively (Reilly and Thomas 1979; Rico-Sanz et al. 1998; Ebine et al. 2002). Caution must be exercised however when attempting to apply direct comparisons between populations due to methodological differences between study designs. Typically, this study revealed nutritional malpractice among soccer players of this national side and highlighted the need for optimal nutrition strategies among the population. The most significant finding was that players did not meet the minimum daily guidelines for CHO intake (48% of TDEI – 3.7 $g \cdot kg^{-1}$ BM) which was also lower than the intake reported by other studies in the literature among soccer players of a corresponding age, as noted by Reeves and Collins (2003), Ruiz et al. (2005) and Iglesias-Guitierrez et al. (2012), with CHO intakes of 5.9 $g \cdot kg^{-1}$ BM, 4.7 $g \cdot kg^{-1}$ BM and 4.7 $g \cdot kg^{-1}$ BM, respectively. When considering the minimum recommended guidelines (7 $g \cdot kg^{-1}$ BM) the findings were worrying, given that CHO is the main substrate for soccer (Williams and Rollo 2015; Clark 1994)**.** Unlike CHO intake, which did not meet the minimum recommendations for soccer players, protein intake of the sample group in this study met and nearly exceeded the minimum (1.4 $g \cdot kg^{-1}$ BM) and maximum (1.7 $g \cdot kg^{-1}$ BM) recommended guidelines for soccer players engaged in moderate to intensive training, respectively (Boisseau et al. 2007; Clark 1994). The findings (1.5 $g \cdot kg^{-1}$ BM) were within the recommended range of 1.4

- 1.7 g·kg^{-1} BM for soccer players (FIFA 2010; 2006; Boisseau et al. 2002; Lemon 1994; Clark 1994) in order to optimise training, accelerate recovery following muscle damaging exercise (Nedelic and LeGall 2013; Tipton et al. 2007) as well as support gains in lean mass (Tipton and Wolfe 2004). This finding was not surprising, since other research (Briggs et al. 2015a) also demonstrates adequate protein intakes, despite being in a state of negative energy balance. Similar values were also reported by Ruiz et al. (2005) and Iglesias-Guitierrez et al. (2012), with an average intake of 1.8 g·kg^{-1} BM and 1.6 g·kg^{-1} BM among similar aged soccer players, respectively. In terms of fat, given the high-intensity nature of soccer, recommendations are based on facilitating CHO intake, as opposed to directly contributing to energy metabolism (Burke 2004). Soccer-specific research suggests a fat intake of <30% (FIFA 2010; 2006; Clark 1994). The participants were in conformity with maximum recommendations for fat, as mean fat content (30 ± 5% of TDEI) was indeed equal to maximal recommendations according to soccer-specific research. When compared to studies of similar-aged players however, the Maltese national side consumed less fat overall than their European counterparts as evidenced by Ruiz et al. (2005) and Iglesias-Guitierrez et al. (2012) at 38% of TDEI and 37% of TDEI, respectively. Similar fat-intake percentages (31%) were found among Turkish National team players (Korkmaz 2004). A limitation of this part of the dietary analysis was a lack of differentiation between the main types of fats, which were instead analysed homogeneously. In this study, the main aim was to have players fully super-compensated ahead of training and match-play, something achievable via carbohydrate manipulation (Rollo 2014). Knowing the total percentage of fat with respect to the % of TDEI therefore was enough for the researcher to estimate relevant dietary habits. Collecting accurate and reliable nutritional data from adolescent populations is known to involve a number of challenges, including under-reporting and lack of detailed information of food consumption (Magkos and Yannakoulia 2003; Livingstone et al. 1992). Busy schedules, lack of interest, and negligence are common factors affecting the use of dietary recalls and food diaries as reliable data collection methods (Burke and Deakin 1994). While it is accepted that the data collection period may only provide a limited insight into a player's customary intake, a seven-day energy intake collection period is considered optimal to increase reliability and validity while minimising the burden of lengthy longitudinal collection periods (Bingham 1987). In reality however there is no gold-standard, as all methods of measuring dietary intake have inherent limitations and may be affected by errors of precision and validity. Moreover, the current study also represents high ecological validity through the use of a free-living experimental design. Previous studies assessing energy intake and expenditure

within formalized training centres (LeBlanc, LeGall and Grandjean 2002), may increase internal validity via the exertion of greater control, but exclude influences of habitual family and school environments. Hypothetically, a combined method of dietary data collection in the form of self-reported, weighed food diaries and twenty-four hour recall interviews may cumulatively increase the accuracy of self-reported energy intake measurements.

The third study showed that player's nutritional knowledge with relation to soccer was generally poor. While their beliefs and attitudes were positive overall, it was pointed out that many players were essentially lazy, relying on their parents to have their meals prepared and shopping done. Many felt the snack options were solely the players' own responsibility, and main meals instead dependent on their family environment. Lack of time was a recurrent issue due to work or college commitments in the morning, leaving little time for food preparation. Prior to the start of the intervention, a majority of the participants stated they did not entirely believe that nutrition marked a positive effect on performance. They would think twice therefore before making any great deal of sacrifice in adopting healthy nutritional strategies without guarantees of success. Players admitted they consumed unhealthy foods every now and again, but tried to limit this occurrence to just once a week. In the majority of cases such foods were taken immediately after a match, as players tended to relax and feel they needed a treat for being "so good" all week. The pre-match nutritional routine is considered as one of the most important components of soccer-related nutrition, as verified by the interview data. Post-match nutrition on the other hand was almost completely disregarded and deemed unnecessary. Players in the research group live on an island where travel is convenient and home life provides certain comforts, including the preparation of wholesome home-cooked meals by parents. Players were not used to the unavailability of cooked food at home and hence found it difficult to cope in such a situation, having to resort to haphazard snacking or heating-up frozen food, with very few possessing the basic culinary skills to prepare their own meals. Players generally believed that a *nutritional plan* is something that helps you "eat better to perform better", requiring a great deal of sacrifice to undertake. Players therefore looked forward to the upcoming ongoing support of the soccer nutrition specialist. In a similar study, 91% of the interviewed soccer players were willing to meet a nutrition specialist for support (Brown, Imthurn and Ramsay 2015). Players believed that the soccer nutrition specialist should guide them every step of the way, providing a multitude of support mechanisms ranging from both individual and team dietary planning, to changing attitudes in order to help the players become nutritionally disciplined. Similar beliefs were exhibited by first division soccer team players in a study

conducted by Brown, Imthurn and Ramsay (2015). Just like the U21 national team players of Malta who believed that proper nutrition could improve their performance and were willing to work on it, 91% of the football players in the study by Brown Imthurn and Ramsay (2015) believed that proper nutrition would enhance their performance. The perspectives of the coach and assistant coach provided valuable insights about the lack of nutritional awareness of the players, and lack of support from the national association in the field of nutrition. The poor nutrition knowledge among the research population indicated a need for nutrition education of the players. They continued by saying that a number of stakeholders were responsible for the players' diet, including the association, the club, and ultimately players themselves, stating that at the end of the day, one cannot manually force the players to consume good food.

In the final study of the nine-month nutrition education and support intervention programme, players improved the quality of their daily intake tested via the seven-day Food Diary, improved their knowledge in soccer-related nutrition tested via the nutrition in soccer knowledge test, improved their habits, affirmed their beliefs and attitudes towards nutrition assessed via the one-to-one semi-structured interviews, and finally felt physically stronger and more energetic both in training and international match-play following the personal nutrition intervention as assessed by the post-match interviews. Before the intervention, nutrition education was not a consistent part of the semi-professional soccer player's regimen. Only the highest level clubs employ a sports nutritionist/dietician on a part-time basis. Following the intervention however, players reported to have changed nutritional habits over time, all of them highlighting that the quality of their intake had improved in a number of ways. This finding was also presented in a similar study among professional soccer players conducted by Wise, Capurro and Fogt (2014). The improvement was affirmed via analysis of the 7-day Food Diary data which showed that players had an average intake of 4.5 $g \cdot kg^{-1}$ BM of CHO, 1.9 $g \cdot kg^{-1}$ BM of protein, and consumed 26% of TDEI per day of fat. In terms of CHO, an effect size of 0.69 was reported, revealing a large effect. Even though the minimum recommendation of 7 to 12 $g \cdot kg^{-1}$ BM for CHO for soccer players engaged in moderate to intensive training was not reached (FIFA 2010), the players made a considerable improvement in their CHO intake with an overall increase of 0.8 $g \cdot kg^{-1}$ BM when compared to the pre-intervention stage. The increase in CHO was coupled with a decrease in fat consumption per day, which decreased from 30% to 26% following the nutrition intervention and support programme. Pre-intervention CHO intake was almost identical to values published by Iglesias-Guitierrez et al. (2012) following a study of Spanish first division players of the same age (4.7 $g \cdot kg^{-1}$ BM), greater than

that of Greek fourth division players according to Chryssanthopolous et al. (2009) who consumed 4.2 g·kg^{-1} BM, but less than male players in the English Premier League whose consumption was reported at 5.6 g·kg^{-1} BM, itself somewhat worrying considering not even elite professional soccer players could reach the minimum recommendations for daily CHO intake (Briggs et al. 2015a). The average daily pre-intervention protein intake (1.5 g·kg^{-1} BM) was already within the recommended range, and hence the aim of the intervention became to maintain it. By the post-intervention stage, the participants had slightly increased the value to 1.9 g·kg^{-1} BM, remaining within the recommended range for soccer players undertaking intensive training (Clark 1994). Protein change after the intervention was shown to have an effect size of 1.02, which is considered optimal. The 26% of TDEI of fat intake was among the lowest recorded in the literature to date. Caccialanza et al. (2007), Chryssanthopolous et al. (2009), Russell and Pennock (2011), Ruiz et al. (2005) all report fat intake of over 30% of TDEI, except for Briggs et al. (2015a) who reports an intake of 29% which is still more than that of the Maltese U21 national team players.

In terms of nutritional knowledge, the players achieved 68% in the post-intervention nutrition in soccer knowledge test as opposed to the 60% they achieved before the educational intervention. A shift was made from the 'Do not answers' to correct answers, as the total mean number of wrong answers remained the same at eight out of the twenty-seven questions asked. In terms of inferential statistics reported using Cohen's *d,* an effect size of 0.56 and 1.94, considered as 'large' and 'perfect' were seen for the improvement in nutrition knowledge at post-intervention stage when results were expressed in negative and normal marking, respectively. While the improvement in knowledge was less significant, when coupled with the better quality of intake as evidenced by the Food Diary data, it shows a marked improvement in terms of knowledge and dietary intake as a correlated value. The positive but weak association between nutrition knowledge and dietary intake was also verified in a review by Spronk et al. (2014) among both community and athletic populations, as well as by Pirouznia (2001), who suggested that if individuals are educated about healthy eating, they are more likely to apply this knowledge in practice than those who are not. Conversely, some studies have proposed that although nutrition education may increase an individual's knowledge of nutrition, an improvement in nutrition behaviour does not necessarily follow (Chapman et al. 1997), and that nutrition knowledge is not necessarily linked to healthy eating behaviours (Shepherd and Towler 1992). This study was based on the hypothesis that the provision of a person knowledgeable in current dietary recommendations and aware of optimum nutrition practices and science in the

field of soccer, can help maximise performance in soccer players. Further research might investigate whether elite athletes have higher levels of nutritional knowledge and dietary practices when compared to non-elite athletes or sedentary individuals. Among the sample group, certain beliefs such as protein being the most important energy source for soccer were deconstructed, and general attitudes towards nutrition globally improved as a result of players experiencing the benefits of eating well on performance in soccer first hand. Finally, while not all barriers were overcome, several were indeed addressed as a result of the dedication shown by some of the players. Work restrictions and time however still remained consistent and significant barriers, difficult to address given the semi-professional status of the players. Players showed a willingness to maintain their adherence to the nutritional plan prescribed for them even upon cessation of support from the researcher, stating they saw no reason for stopping since the plan had helped them dearly in their performance. The same desire for obtaining competency in applying nutrition-related practices was also shown by the participants in a study by Hansen (2010). While some of the participants claimed that without proper supervision and guidance it would have been easy to slack and drop out, the majority said that they will do their best and feel determined to keep going. They added that upon having adjusted to the new routine, it had become the norm. While in young athletes it is largely considered to be the responsibility of the club to ensure they are following diets consisting of the correct amounts of macro and micro nutrients, as well as water and Calories to replace what has been lost in training. As for adult semi-professional players, the onus of responsibility to seek nutrition education with a view to enhancing performance ultimately rests with individual players who are responsible for their own health. Burke et al. (2001) notes that athletes who received nutrition education achieved higher knowledge and attitude scores, and as their knowledge increased so too did the quality of their dietary intake. Since attitude towards nutrition is a prevalent theme in improving praxis, future research might identify the factors of team settings best suited for improving attitudes of the athletes concerning the role of nutrition in improving athletic performance.

7.4 Conclusion

This study reduces the paucity of nutrition research among soccer players, and reveals that future research is needed to develop and progress management of this modifiable factor influencing performance in soccer. Despite the popularity of soccer and the burgeoning field of soccer-related scientific research, the nutritional aspects of the game have surprisingly garnered little attention.

The main conclusions of this thesis relate to a number of significant implications of the nutritional aspects of soccer. We know that nutrition is very important not only for the provision of the required nutrients for sustaining everyday tasks, but also for optimal performance in the sporting context. The findings of this research show that poor dietary practices and nutritional knowledge with relation to soccer existed among the research population of Maltese U21 national team soccer players. Most importantly, they show that proper nutrition improves the physical capacity of soccer players during matches, and a well-designed nutrition education and support programme greatly benefit the nutrition knowledge, dietary habits, personal attitudes as well as the overall performance in soccer training and match-play of players.

Overall, the study was limited by reliance on self-reported data. It has nonetheless provided the researcher and soccer community in general with a valuable pool of data on the current situation with specific regard to nutritional practices in an established soccer club and the U21 national team. While the findings presented in this study is far from conclusive, the results of all four systematic studies have ultimately provided data upon which stakeholders in the game can make informed decisions, with a view to implementing effective nutritional strategies, thus ultimately maximising performance in soccer training and match-play. More research is needed regarding the specific effects of nutrition interventions on knowledge, attitudes, dietary behaviours, and performance in soccer.

7.5 Practical applications

This study has shown that the creation of a positive nutrition experience is multi-factorial, and deeply rooted in development of self-efficacy in the athlete. The need for nutrition education as part of players' general training and preparation was established, given that participants had not previously received such education at national team or club level.

Players were motivated in their belief that healthy eating habits optimise performance and provide additional benefits throughout their career and beyond. It is postulated therefore that while such educational and support interventions should theoretically target younger players to promote sound nutritional practices throughout the life span, the various stakeholders in soccer at all levels should play their part in developing sound nutritional practice.

It has also been argued that the association should provide "360 degree" support to players and other support staff, including, in the absence of a dedicated nutrition department, the enrolment of a suitably qualified professional with

appropriate expertise in the field. If players possess nutritional knowledge including what to eat and when, then they are more likely to implement this knowledge in practice throughout their daily routines, and achieve the reported benefits of healthy eating. Ancillary support staff should also be included in such educational and support programmes to promote adequate nutritional knowledge across the board, thereby cultivating generally positive attitudes towards nutrition, and a healthy eating culture within the team.

By combining the efforts of all stakeholders, this study postulates that improved dietary practices for soccer players should be based on;

The creation of a general environment that is conducive with optimal nutrition practices.

Improvement of nutrition-related knowledge, and attitudes toward the efficacy and role of good nutrition in optimising performance in players and coaching staff.

Further understanding of the psycho-social aspects of nutrition in soccer, aimed at supporting nutrition services, resources, and guidelines, since these areas are common antecedents in supporting positive nutrition-related outcomes.

Cultivation of attitudes among coaches and players reflective of the importance of properly adopted nutrition practices, pre-loading strategies, inter-match supplementation, and involvement in the recovery process using proper nutritional practices as a recovery aide.

A holistic approach combining physical, technical, and tactical aspects of training, with a desire to optimise nutritional habits, with a view to reaching maximal performance potential.

Chapter 8

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Chapter 9

Appendices

10.1 Participant Information Sheet for study 1

Before you decide to take part in this study it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. This Participant Information Sheet and Consent Form explain all the tests and research involved in this study. Such information will help you decide whether you would like to take part in this research. The researcher can be contacted if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

STUDY TITLE

The effect of optimal nutrition on physical performance in soccer

INTRODUCTION

You are incited to take part in this study conducted by Ms. Dorianne Bonnici (367486M), as part fulfilment of the PhD research followed at Edge Hill University, Lancashire, UK. This researcher has been awarded a Scholarship grant by the Maltese government to conduct this Research Project. All the studies that form part of this PhD Research Project shall be submitted by January, 2019. The whole study shall tackle the effects, knowledge, habits, perceptions, barriers and strategies towards nutrition in football. Your participation in this study will enable the researcher to examine the effect of optimal nutrition on physical performance in football match-play. You will be required to fill in a 3-day Food and Exercise Diary, take on a 3-day Diet Plan and perform the Modified $BEAST_{90}$ protocol twice in two weeks.

PURPOSE OF INVESTIGATION

The Masters Dissertation study conducted by the same researcher among the U21 Maltese National Team players revealed that players are in a negative energy balance and that the food is generally consumed from the wrong sources. Such results fuelled the researcher to study this area even further and provide evidence of whether proper nutrition is worth taking on as a strategy to maximise your physical performance in football. A study that tests the proposed has not been encountered by the researcher in literature to date. For this reason, the aim of this investigation is to examine whether optimal nutrition has an effect on the performance of football players in a game situation, as replicated in the Modified $BEAST_{90}$ protocol.

YOUR PARTICIPATION

To be able to bring out the best of such an investigation, disciplined and dedicated semi-professional players who the researcher can trust were required. Being a player who plays for a team in the top Maltese division whose challenging to win the most prestigious titles of the season makes you the ideal participant for this study.

If you agree to participate in this study, you will be requested to;

- complete and return the Health and Lifestyle Questionnaire
- fill in a 3-day Diary
- participate in the first trial of the Modified $BEAST_{90}$ protocol
- consume the meals prescribed in the 3-day Diet Plan
- consume the pre-match nutritional strategy
- participate in the second trial of the Modified $BEAST_{90}$ protocol

You are reminded that you have every right to withdraw from the study at any time and for any reason, and will not be required to state your reasons for withdrawing. Your decision not to participate will not prejudice your progress in the team in any way.
The researcher cannot guarantee or promise that you will receive any benefits from this research; however possible benefits may include the adjustment of your own diet that may positively affect your performance in football training and match-play.

PROCEDURE

The researcher will meet you as a team for an introductory meeting to explain the aims and objectives, as well as your roles and responsibilities in this research. At this meeting, the researcher shall disseminate the Participant Information Sheet and Consent Form as well as the Health and Lifestyle Questionnaire. You will be requested to fill in these forms and return them to the researcher within a week, should you accept to participate in this study.

You will first meet the researcher individually who will re-explain all the stages of the study in detail, ensure that the details in the Health and Lifestyle Questionnaire are well understood and to explain the procedure on how to fill in the 3-day Food Diary.

For three consecutive days of the first week, you will be required to fill in the 3-day Food Diary provided. On the fourth day, you would need to participate in the first trial of the Modified $BEAST_{90}$ protocol. Three days of rest will follow. During this period, the researcher shall meet you individually at your convenience to meticulously explain the Diet Plan which the researcher would have prescribed for you to follow in the next three consecutive days at the end of this rest period.

Beginning of the second week, you would need to take on and consume all the meals prescribed in the 3-day Diet Plan. Ahead of your participation in the second trial of the Modified $BEAST_{90}$ protocol, you are further required to follow the pre-match nutritional strategy prescribed for you by the researcher. To ensure adherence, you will be asked to take a photo of all the meals and snacks prepared. You are requested to send the photos to the researcher as attachment on email by the end of the same week. On the fourth day of this week, you will be required to participate in the second trial of the $BEAST90_{mod}$ protocol for the last time.

POTENTIAL RISKS ENCOUNTERED

All studies involving human participants have some degree of risk; however, the possibility of harm in this investigation is minimal. Your participation is voluntary. If at any time during the study you feel uncomfortable you may choose to withdraw from the study without fear of repercussions.

In this study you will be exposed to a Diet Plan that you may not have necessarily followed. For this reason, the researcher shall prescribe foods that are easily bought and meals that are easily prepared to reduce such possible. The Modified $BEAST_{90}$ protocol includes the active involvement of different activity patterns, typical of football match-play confined in two circuits of 45mins separated by a 15 minute interval, replicating the half-time in a football match. The researcher understand the risks associated with a protocol that is entirely new to you, nonetheless the protocol assures that the physiological load is equivalent to that undergone in a standard 90minute football match.

STUDY RESULTS

Results of this study will be published in journals, written up in the PhD Research Project Dissertation and may be presented at conferences. All the results will only be interpreted by the researcher and will be kept in a secure location for future personal research in the area. In order to keep records confidential, the researcher will store all information as numbered codes in computer files that will only be available to me and my supervisor and/or research coordinator.

All the data will be analysed and published as a team, and thus your name of individual identity will not be revealed at any time. Feedback will be given to the technical staff as per team performance. Individual feedback may be given at your discretion.

THE RESEARCHER

Should you wish to ask any questions please do not hesitate to contact me on dorianne.bonnici@mcast.edu.mt or by phone/text on +356 77056570. If you are satisfied, and would like to participate in this project, you are kindly asked to read and sign the consent form, as proof of your approval and consequent participation.

SUPERVISORS

The Research Coordinator of this study is Professor Lars McNaughton from Edge Hill University, Lancashire. The main supervisor of this study is Mr. Ibrahim Akubat from Newman University College, Birmingham.

This study was granted ethical approval by Edge Hill university ethics committee.

If you have any questions and/or concerns, during or after the investigation, or wish to contact an independent person to whom any questions maybe directed or further information may be sought from, please contact Dr. Lars McNaughton at the University of Edge Hill, Lancashire, UK

Appendix 1: Participant Information Sheet for study 1

10.2 Consent form for study 1

DEPARTMENT

Department of Sport and Physical Activity

STUDY TITLE

The effect of optimal nutrition on physical performance in Football

- I confirm that I have read and understood the information sheet for the above study and the researcher has answered any queries to my satisfaction.
- I understand that my participation is voluntary and that I am free to withdraw from the project at any time, without having to give a reason and without any consequences.
- I understand that I can withdraw my data from the study at any time.
- I understand that any information recorded in the investigation will remain confidential and no information that identifies me will be made publicly available.
- I consent to being a participant in the project
- I consent to being video recorded as part of the project

I have read *Ethical Guidelines* and *Ethical Approval for Research*. I am satisfied that all ethical issues have been identified and that satisfactory procedures are in place to deal with those issues in this research.

Participant's name and surname: _____
Participant's signature: _____
Date: _____

Researcher's name and surname: _____
Researcher's signature: _____
Date: _____

Appendix 2: Consent form for study 1

10.3 Health and Lifestyle Questionnaire

The information provided in this questionnaire will be kept entirely confidential. It is essential you answer the questions fully and truthfully

Name: _____ Surname: _____ Age: _____

In case of emergency, whom may the researcher contact?

Name: _____ Relationship: _____ Contact number: _____

Height	_____cm	Weight	_____kg
Resting blood pressure (mmHg)	_____ /_____	RHR	_____bpm

CONFIDENTIAL HEALTH QUESTIONNAIRE

1. Have you or do you suffer from any of the following.
   (Please tick & give details where applicable)

Asthma	☐	Angina	☐	Chest pains	☐
High Blood Pressure	☐	Frequent Colds	☐	High Cholesterol	☐
Low Blood Pressure	☐	Dizziness/Fainting	☐	Epilepsy	☐
Bronchitis	☐	Diabetes	☐	Arthritis	☐

If yes, please provide details to each of the above:

_____

_____

2. Have you previously suffered from serious illness or accident? Yes No

If yes, please provide details to each of the above:

_____

_____

3. In the previous six months have you consulted a doctor? Yes No

If yes, please provide details to each of the above:

_____

_____

4. Are you currently taking any medication? Yes No

If yes, please provide details to each of the above:

_____

_____

5. Is there a history of heart disease in your family? Yes No

If yes, please provide details to each of the above:

_____

_____

6. Are you suffering from a disease that inhibits the sweating process? Yes No

If yes, please provide details to each of the above:

_____

_____

7. Is there anything to your knowledge that may prevent you from participating in the protocols that you have been outlined to you? Yes No

If yes, please provide details to each of the above: _____

CONFIDENTIAL LIFESTYLE QUESTIONNAIRE

1. Occupation

Kindly explain the type and time of physical exertion involved:

_____

_____

2. Dislikes for foods and drinks

Please list down foods and drinks that you do not like and that you would not consume for whatever reason:

_____

_____

3. Treats

Please list down foods and drinks that you consider as a treat and would still like to have in your diet:

_____

_____

4. Allergies for foods and drinks

Please list down foods and drinks that you might or have an allergy for:

_____

_____

5. Time for food preparation

Please outline the available time that you or the person who cares for you have to prepare meals and snacks prescribed:

_____

_____

6. Daily schedule

Please outline your typical daily schedule by filling the table below:

TIME OF THE DAY	ACTIVITY UNDERTAKEN	INTENSITY OF ACTIVITY	DURATION OF ACTIVITY
06.00 – 07.00			
07.00 – 08.00			
08.00 - 09.00			
09.00 – 10.00			
10.00 – 11.00			
11.00 – 12.00			
12.00 – 13.00			
13.00 – 14.00			
14.00 - 15.00			
15.00 – 16.00			
16.00 – 17.00			
17.00 – 18.00			
18.00 – 19.00			
19.00 - 20.00			
20.00 – 21.00			
21.00 – 22.00			
22.00 – 23.00			
23.00 – 00.00			
00.00 – 06.00			

Please outline any changes to the above schedule on certain days of the week, except for the weekend:

_____

_____

All information on this form is correct to the best of my knowledge and I have sought, and followed, any necessary medical advice.

I will not be permitted to take part in any testing if I:

- Have a known history of medical disorders (i.e hypertension, heart or lung disease)
- Have a fever; suffer from fainting or dizzy spells
- Are currently unable to train due to injury or illness
- Have had a thermoregulatory disorder
- Have a gastrointestinal disorder

By signing this form I, _____ (your name) agree that I assume all risk of injury or adverse effects to health, and agree to release and discharge Ms. Dorianne Bonnici and associated agents from any and all claims or causes of action, known or unknown, arising out of my participation in this study.

Participant's name: _____ Participant's signature: _____ Date: _____

Appendix 3: Health and Lifestyle Questionnaire

10.4 Food Diary

TIME	Describe FOOD/DRINK	BRANDAME	PORTION/MEASURE
06:00-07:00			
07:00-08:00			
08:00-09:00			
09:00-10:00			
10:00-11:00			
11:00-12:00			
12:00-13:00			
13:00-14:00			
14:00-15:00			

15:00-16:00			
16:00-17:00			
17:00-18:00			
18:00-19:00			
19:00-20:00			
20:00-21:00			
21:00-22:00			
22:00-23:00			
23:00-00:00			
00:00-06:00			

Appendix 4: Food Diary

10.5 Food and Exercise Diary

ENERGY INTAKE				ENERGY EXPENDITURE	
TIME	**Describe FOOD/DRINK**	**BRANDNAME**	**PORTION/AMOUNT (household measures or grams/millilitres)**	**ACTIVITY**	**TIME**
06:00-07:00					
07:00-08:00					
08:00-09:00					
09:00-10:00					
10:00-11:00					
11:00-12:00					
12:00-13:00					
13:00-14:00					
14:00-15:00					

15:00-16:00					
16:00-17:00					
17:00-18:00					
18:00-19:00					
19:00-20:00					
20:00-21:00					
21:00-22:00					
22:00-23:00					
23:00-00:00					
00:00-06:00					

Appendix 5: Food and Exercise Diary

10.6 Food and Exercise Diary sample

ENERGY INTAKE				ENERGY EXPENDITURE	
TIME	**Describe FOOD/DRINK**	**BRANDNAME**	**PORTION/AMOUNT (household measures or grams/millilitres)**	**ACTIVITY**	**TIME**
06:00-07:00	Cereal with whole milk Coffee with skimmed milk with sugar Biscuits	Coco Pops Benna light blue Nescafe Frisian flag Go ahead	Full bowl 1 cup 1 teaspoon 4 biscuits	Shower Eating 	15 min 20 min
07:00-08:00	Yoghurt strawberry light	Benna	1	Driving	30 min
08:00-09:00	Maltese bread with butter with cheese with ham with tomato	 Flora Cheddar Pork	6 slices 2 spreads 2 slices 2 slices 1 tomato	At school	50 min
09:00-10:00	Banana Water		1 2 glasses	Up the stairs	2 min
10:00-11:00	Cereal bar Orange juice	Special K Safari	1 bar 1 small packet (150ml)	Working (delivery man)	4 h
11:00-12:00	Hot chocolate with sugar	Aero	1 mug 1 teaspoon	Cooking	30 min
12:00-13:00	Spaghetti with onions with tomato sauce with chicken Breast with green peppers	Barilla Mayor	Medium plate	Walking Watching tv Internet	15 min 90 min 30 min
13:00-14:00	Mixed nuts sated	Rokky	1 fist	Playstation	30 min
14:00-15:00	Twistees Chocolate chip cookies	 Devon	1 packet 10 cookies	Training	90 min
15:00-16:00	Noodles Coca Cola	Indomie	1 packet 500ml	Training	
16:00-17:00	Steak with baked potatoes with lettuce with tomatoes with spinach with fresh cream	Cuberoll	100g 3 1 leaf 2 1 fist with sauce	Studying Eating 	30 min 45 min
17:00-18:00	Apple Tea with skimmed milk with sugar	 Tetley	1 1	Cleaning	10 min
18:00-19:00	TRAINING : Gatorade		500ml	Training	50 min
19:00-20:00	TRAINING: Gatorade		500ml	Training	
20:00-21:00	Tortellini with bacon with fresh Cream with onions with grated cheese	Barilla Hopla	100g		
21:00-22:00					

22:00-23:00	Vodka with Coca Cola with Red bull	Smirnoff	1 shot 1 glass 3 glasses	Socialising	30 min
23:00-00:00				Sleep	1 h
00:00-06:00				Sleep	7 h

Appendix 6: Food and Exercise Diary sample

10.7 Participant Information Sheet for studies 2, 3 and 4

Before you decide to take part in this study it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. This Participant Information Sheet and Consent Form explain all the tests and research involved in this study. Such information will help you decide whether you would like to take part in this research. The researcher can be contacted if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

STUDY TITLE

A comprehensive nutrition education and support investigation and intervention for Maltese U21 Male National Football Team of Malta.

INTRODUCTION

You are incited to take part in this study conducted by Ms. Dorianne Bonnici (367486M), as part fulfilment of the PhD research followed at Edge Hill University, Lancashire, UK. This researcher has been awarded a Scholarship grant by the Maltese government to conduct this Research Project. All the studies that form part of this PhD Research Project shall be submitted by January, 2019. The whole study shall tackle the effects, knowledge, habits, perceptions, barriers and strategies towards nutrition in football. Your participation in this study will enable the researcher to assess your knowledge, attitude, perception, habits and barriers at the beginning and at the end of this 15-month long nutritional strategy. You will be required to take on a football-related nutritional knowledge test, two semi-structured interviews at the beginning and at the end of the programme. Along the course, you will be exposed to an array of information on football nutrition and adjust your diet according to the researcher's recommendations.

PURPOSE OF INVESTIGATION

The Masters Dissertation study conducted by the same researcher in 2011 among the U21 Maltese National Football Team players revealed that players are in a negative energy balance and that the food is generally consumed from the wrong sources. Such results fuelled the researcher to study this area even further and provide evidence of whether proper nutrition is worth taking on as a strategy to maximise your physical performance in football. In a study conducted in 2013, the researcher proved that players covered an increase of approximately 900m in a 90-minute fitness protocol replicating the typical activity patterns of a football match. Leaving no doubt that proper nutrition does mark a positive effect on the players' physical performance, the Malta Football Association has agreed to embark on a 15-month nutritional programme led by the researcher to maximise the physical performance of the players ahead of the 2014 World Cup u21 qualifiers.

YOUR PARTICIPATION

Your participation in this study is part of the team's preparation for the World Cup Qualifiers. This will be the first time in your career, whereby you will be given guidance and undertake nutritional interventions and strategies to improve your nutrition to help maximise your performance.

If you agree to participate in this study, you will be requested to;

- complete and return a Health Questionnaire
- be measured for Height, Weight and Body Fat
- fill in 7-day Food and Exercise Diaries
- undertake sports nutrition knowledge questionnaires
- undertake semi-structured interviews on nutrition attitudes, habits and perception
- freely participate in a 7-day team diet
- take part in a 15-month nutrition support programme which may include dietary training interventions, nutritional strategies, information sessions, one-to-one sessions and other related but non-invasive methods

You are reminded that you have every right to withdraw from the study at any time and for any reason, and will not be required to state your reasons for withdrawing. Your decision not to participate will not prejudice your progress in the team in any way.

The researcher cannot guarantee or promise that you will receive any benefits from this research; however possible benefits may include the adjustment of your own diet that may positively affect your performance in football training and match-play.

PROCEDURE

The researcher will meet you as a team for an introductory meeting to explain the aims and objectives, as well as your roles and responsibilities in this research. At this meeting, the researcher shall disseminate the Participant Information Sheet and Consent Form as well as the Health Questionnaire. You will be requested to fill in these forms and return them to the researcher within a week, should you accept to participate in this study.

You will first be measured for height, weight and body fat. Within a week you will be requested to undertake the football-related nutrition knowledge questionnaire. After that is completed, you will be asked to note down all your energy intake and expenditure over 7 days on the provided 'Food and Exercise Diary'. You will be supported on how to fill in this document through verbal and written instructions. The researcher will then contact you individually for an available slot in order to participate in the semi-structured interview that will look into identifying your attitudes, habits and perceptions towards nutrition. At the end of the interview you will be presented with a general diet to follow for a week. Within a week of the voluntary participation in this diet you will be asked a number of questions on the barriers to the adherence of such a diet through another semi-structure interview.

After this initial baseline testing, you will participate with your team in nutrition support programme which will include an array of strategies and interventions such as the manipulation of training diet according to your training needs, nutrition strategies, nutrition awareness and understanding, knowledge and information amongst others. The researcher shall be part of the technical staff that will collaboratively prepare you for the World Cup qualifiers.

At the end of the 15-month programme you will again undertake the test conducted in the first month of the programme to mark its effectiveness on the player's knowledge, attitude, perception, habits and practice of a nutrition support programme.

POTENTIAL RISKS ENCOUNTERED

All studies involving human participants have some degree of risk; however, the possibility of harm in this investigation is minimal. Your participation is voluntary. If at any time during the study you feel uncomfortable you may choose to withdraw from the study without fear of repercussions.

In this study you will be exposed to non-invasive body composition assessments and widely-available foods that are easily bought and prepared. Food allergies are best eliminated since the researcher will meticulously evaluate all the information given in the collected Health Questionnaire.

STUDY RESULTS

Results of this study will be published in journals, written up in the PhD Research Project Dissertation and may be presented at conferences. All the results will only be interpreted by the researcher and will be kept in a secure location for future personal research in the area. In order to keep records confidential, the researcher will store all information as numbered codes in computer files that will only be available to me and my supervisor and/or research coordinator.

All the data will be analysed and published as a team, and thus your name of individual identity will not be revealed at any time. Feedback will be given to the technical staff as per team performance. Individual feedback may be given at your discretion.

THE RESEARCHER

Should you wish to ask any questions please do not hesitate to contact me on dorianne.bonnici@mcast.edu.mt or by phone/text on +356 77056570. If you are satisfied, and would like to participate in this project, you are kindly asked to read and sign the consent form, as proof of your approval and consequent participation.

SUPERVISORS

The Research Coordinator of this study is Professor Lars McNaughton from Edge Hill University, Lancashire. The main supervisor of this study is Mr. Ibrahim Akubat from Newman University College, Birmingham.

This study was granted ethical approval by Edge Hill university ethics committee.

Appendix 7: Participant Information Sheet for studies 2, 3 and 4

10.8 Consent form for studies 2, 3 and 4

DEPARTMENT
Department of Sport and Physical Activity

STUDY TITLE
A comprehensive nutritional support programme for the U21 Maltese National Football Team

- I confirm that I have read and understood the information sheet for the above study and the researcher has answered any queries to my satisfaction.
- I understand that my participation is voluntary and that I am free to withdraw from the project at any time, without having to give a reason and without any consequences.
- I understand that I can withdraw my data from the study at any time.
- I understand that any information recorded in the investigation will remain confidential and no information that identifies me will be made publicly available.
- I consent to being a participant in the project
- I consent to being video recorded as part of the project

I have read *Ethical Guidelines* and *Ethical Approval for Research*. I am satisfied that all ethical issues have been identified and that satisfactory procedures are in place to deal with those issues in this research.

Participant's name and surname: _____
Participant's signature: _____
Date: _____

Researcher's name and surname: _____
Researcher's signature: _____
Date: _____

Appendix 8: Consent form for studies 2, 3 and 4

10.9 Nutrition knowledge in soccer test questions before and after the validation trial

	Knowledge questions before the Validation trial	Knowledge questions after the Validation trial
	Part 1: Energy	
1	Where does the most valuable source of energy in soccer generally come from?	Where does the most valuable source of energy in soccer come from?
2	Which of the following release the same amount of energy in terms of kcal?	Which of the following macronutrients release the same amount of energy per gram?
3	How should the daily distribution of energy from macronutrients be?	What is the optimum daily distribution of energy from the macronutrients for a soccer player in terms of percentage (%)?
4	What is the best way to reduce your energy intake?	What is the best strategy to reduce your total daily energy intake?
	Part 2: Nutrients	
1	If a soccer players wants to reduce the amount of fat in his diet, which would be the best food to omit/exclude from the diet?	If a soccer player wants to reduce the amount of fat in his/her diet, which food should he/she not take?
2	Which of these foods have the highest carbohydrate content?	Which of the foods below have the highest carbohydrate content?
3	Which of these foods have the highest protein content?	Which of the foods below have the highest protein content?
4	Which would be the best choice for a low fat, low sugar, high carbohydrate snack?	Which of the foods below would be the best choice for a low-fat, low-sugar, high-carbohydrate snack?
5	If a footballer would like something sweet, but is trying to cut down on sugar, which would be the best choice?	If a soccer player would like something sweet but wants to cut down on sugar, what food should he/she consume from the choice below?
6	Vitamins from foods are best used as a?	What is the function of the vitamins we absorb from foods?
7	What would be the best breakfast for a semi-professional football player?	What would be the best breakfast that a soccer player can take from the choice below?
8	What would be the best mid-morning snack for a semi-professional football player?	What would be the best mid-morning snack that a soccer player can take from the choice below?
9	What should the semi-professional football player's midday lunch be based on?	What should the mid-day lunch of a soccer player be based on?
10	Which are the best fats that a footballer could consume?	What would be the best source of fat that a soccer player can take from the choice below?
11	Which of these foods are the highest in protein?	Which of these foods below have the highest protein content per gram?
12	For what is protein the most important?	What is the most important function of protein for a soccer

		player?
	Part 3: Hydration	
1	How much litres of water should a footballer drink on average?	What is the minimum amount of water that a soccer player training in moderate temperate weather conditions should drink on average per day?
2	How will dehydration affect performance?	How is dehydration likely to affect the performance of a soccer player in training and match-play?
3	What is the most important ingredient in a sports drink?	What is the most important ingredient in a sports drink consumed by a soccer player?
	Part 4: Supplements	
1	What is the importance of supplements?	How important are supplements for a soccer player?
2	What is the best form of protein?	What is the best source of protein that a soccer player can take?
3	In which sources is creatine normally found?	From which sources is creatine normally obtained?
	Part 5: Match-day nutrition	
1	What is the best food source that a footballer can immediately take (within 15 min) after a game or a training session?	Which of the foods below should a soccer player take within 15 min of finishing match?
2	What would be the best pre-match meal?	Which of the foods below should a soccer player take as a pre-match meal?
3	How many hours before a game should the pre-match meal be consumed?	How many hours before a match should a soccer player consume the pre-match meal?
4	What would be the best post-match meal?	Which of the foods below should a soccer player take as a post-match meal?
5	What is the average amount of water that should be consumed up to 60 min before a game?	What is the average amount of water that a soccer player consume 60 min before a match?

Appendix 9: Nutrition knowledge in soccer test questions before and after the validation trial

10.10 Nutrition knowledge in soccer test answers before and after the validation trial

Answers before the Validation trial		Answers after the Validation trial	
		Part 2: Nutrients	
6	a. Source of energy	a.	As a source of energy
12	a. For energy for training	a.	Provides energy for training
	b. For recovery from training	b.	Promotes recovery from training
	c. For muscle mass	c.	Builds muscle mass

Appendix 10: Nutrition knowledge in soccer test answers before and after the validation trial

10.11 Nutrition knowledge in soccer test with choice of answers (English version)

Part 1: ENERGY

1. Where does the most valuable source of energy in soccer come from?
   a. Carbohydrate
   b. Protein
   c. Fat
   d. Do not know

2. Which of the following macronutrients release the same amount of energy per gram?
   a. Protein and Fats
   b. Fats and Carbohydrates
   c. Carbohydrates and Protein
   d. Do not know

3. How should the optimum daily distribution of energy from the macronutrients for a soccer player in terms of % be?
   a. Carbohydrates 50% - Protein 20% - Fat 30%
   b. Carbohydrates 60% - Protein 20% - Fat 20%
   c. Carbohydrates 60 % - Protein 30% - Fat 10%
   d. Do not know

4. What is the best strategy to reduce your total daily energy intake?
   a. Skip meals
   b. Eat frequently in small portions
   c. Eat three big portions per day
   d. Do not know

Part 2: NUTRIENTS

1. If a soccer player wants to reduce the amount of fat in his diet, which food should he not take?
   a. Steak
   b. Sausages
   c. Turkey
   d. Do not know

2. Which of the foods below have the highest carbohydrate content?
   a. Meat, Vegetables, Fruit
   b. Pasta, Bread, Vegetables
   c. Pasta, Bread, Sweets
   d. Do not know

3. Which of the foods below have the highest protein content?
   a. Dairy products, meat and nuts
   b. Vegetables, fruits and meat
   c. Nuts, meat and potatoes
   d. Do not know

4. Which of the foods below would be the best choice for a low fat - low sugar - high carbohydrate snack?
   a. Diet strawberry yoghurt
   b. Muesli bar
   c. Wholemeal crackers and cheddar cheese
   d. Do not know

5. If a soccer player would like something sweet but wants to cut down on sugar, what food should he consume from the choice

below?
   a. Honey on toast
   b. Cereal snack bar
   c. Banana with plain yoghurt
   d. Do not know

6. What is the function of the vitamins we take in from foods?
   a. As a source of energy
   b. To increase muscle strength
   c. To help in the process of energy transfer
   d. Do not know

7. What would be the best breakfast that a soccer player can take from the choice below?
   a. Cornflakes with full-fat milk
   b. Muesli/Oats with skimmed milk, dried fruits and honey
   c. Sandwich toast with butter, ham and cheese
   d. Do not know

8. What would be the best mid-morning snack that a soccer player can take from the choice below?
   a. Fruit
   b. Biscuits
   c. Cereal bar
   d. Do not know

9. What should the midday lunch of a soccer player be based on?
   a. Breads, grains and cereals
   b. Fruit and vegetables
   c. Meat and poultry
   d. Do not know

10. What would be the best source of fat that a soccer player can take from the choice below?
   a. Butter, cheese and milk
   b. Avocado, olive oil and salmon
   c. Milk, olive oil and fries
   d. Do not know

11. Which of these foods below have the highest in protein content per gram?
   a. Fish, broccoli, eggs
   b. Beef, potatoes, muffins
   c. Chicken, rice cakes, apples
   d. Do not know

12. What is the most important function of protein for a soccer player?
   a. Provides energy for training
   b. Promotes recovery from training
   c. Builds muscle mass
   d. Do not know

Part 3: HYDRATION

1. What is the minimum amount of water that a soccer player training in moderate temperate weather conditions drink on average per day?
   a. 1-2 litres
   b. 3-4 litres
   c. 2-3 litres
   d. Do not know

2. How is dehydration likely to affect the performance of a soccer player in training and match-play?
   a. Limits performance
   b. Does not affect performance
   c. Increases performance
   d. Do not know

3. What is the most important ingredient in a sports drink consumed by a soccer player?
   a. Sugar
   b. Sodium
   c. Creatine
   d. Do not know

Part 4: SUPPLEMENTS

1. How important are supplements for a soccer player?
   a. Very important and should be taken daily
   b. Very important and should be taken three times a week
   c. Not necessary if following a balanced diet or have a deficiency
   d. Do not know

2. What is the best source of protein that a soccer player can take?
   a. Natural protein-rich foods
   b. Protein shakes
   c. Amino acid pills
   d. Do not know

3. In which sources is creatine normally found?
   a. Meat and fish
   b. Meat and beans
   c. Supplements only
   d. Do not know

Part 5: MATCH-DAY NUTRITION

1. Which of the foods below should a soccer player take within 15 minutes after a match?
   a. Banana
   b. Cranberry Juice
   c. Chocolate
   d. Do not know

2. Which of the foods below should a soccer player take as a pre-match meal?
   a. Meat, potatoes, vegetables
   b. Pasta with low fat sauce
   c. Pizza
   d. Do not know

3. How many hours before a match should a soccer player consume the pre-match meal?
   a. 1-2 hours before a match
   b. 2-3 hours before a match
   c. 3-4 hours before a match
   d. Do not know

4. Which of the foods below should a soccer player take as a post-match meal?
   a. Meat, potatoes, vegetables
   b. Bread, cheeses and dairy products

c. Anything could be eaten at this time
d. Do not know

5. What should the average amount of water that a soccer player consumes 60 minutes before a match be?
   a. 1 litre
   b. 2 litres
   c. 500ml
   d. Do not know

Appendix 11: Nutrition knowledge in soccer test with choice of answers (English version)

10.12 Nutrition knowledge in soccer test with choice of answers (Maltese version)

L-ewwel parti: Energija

1. Minn fejn fej gej l-iktar sors ta' energija important ghall-futbol?
a. Karbojdrati
b. Protejina
c. Xaham
d. Ma nafx

2. Liem minn dawn in-nutrijent magguri jaghtu l-istess ammont ta' energija ghal kull gramma?
a. Protejina u Xaham
b. Xaham u karbojdrati
c. Karbjdrati u protejina
d. Ma nafx

3. Kif suppost ghandha tkun imqassma il-gurnata bhala distrubuzzjoni ta' ikel min-nutrijenti magguri f'persentagg?
a. Karbojdrati 50% - Protejina 20% - Xaham 30%
b. Karbojdrati 60% - Protejina 20% - Xaham 20%
c. Karbojdrati 60 % - Protejina 30% - Xaham 10%
d. Ma nafx

4. X'inhu l-ahjar mod biex tnaqqas l-ammont ta kaloriji li tikkonsma f'gurnata?
a. Taqbez xi ikliet
b. Tiekol ftit ta' spiss
c. Tiekol tlett porzjiniet kbar kuljum
d. Ma nafx

It-tieni parti: In-nutrijenti

1. Jekk plejer irid inaqqas l-ammont ta' xaham mid-dieta tieghu, liem ikel ikun ahjar li kieku ma jiekolx?
a. Laham
b. Zalzett
c. Dundjan
d. Ma nafx

2. Liem mill- ikel imnizzel hawn taht ghandu l-iktar koncentrazzjoni ta' karbojdrati?
a. Laham, haxix u frott
b. Ghagin, hobz u haxix
c. Ghagin, hobz u helu
d. Ma nafx

3. Liem mill- ikel imnizzel hawn taht ghandu l-iktar koncentrazzjoni ta' protejina?
a. Prodotti maghmula mill-halib, laham u 'nuts'
b. Haxix, frott u laham
c. 'Nuts', laham u patata
d. Ma nafx

4. Liem mill- ikel imnizzel hawn taht huwa l-ahjar ghazla ghal 'snack' li jkun fih ftit xaham, ftit zokkor imam hafna karbojdrati?
a. Jowgart light tal-frawli
b. Bar tal- meusli
c. Krekers somor bil-gobon cheddar
d. Ma nafx

e. Jekk plejer ghandu aptit xi haga helwa imam fl-istess hin irid inaqqas iz-zokkor, liema ikel huwa l-ahjar li tiehu mill-ghazla

ta' hawn taht?
f. Hobz bl-ghasel
g. Bar tac-cerejali
h. Banana b'jowgart plejn
i. Ma nafx

j. X'inhi l-importanza tal-vitamini li niehdu mill-ikel?
k. Sors ta' energija
l. Biex inzid is-sahha
m. Biex tghin titrasferixxi l-energija
n. Ma nafx

o. X'inhu l-ahjar kolazzjon li tista tiehdu bhala plejer mill- ghazla ta' hawn taht?
p. Cornflakes bil-halib
q. Meusli/Oats bil halib xkumat, frott niexef u ghasel
r. Hobz bil-butir, perzut u gobon
s. Ma nafx

5. X'inhi l-ahjar snack li plejer jista jiehu fl-ewwel nofs tal-gurnata mill-ghazla ta' hawn taht?
a. Frott
b. Gallettini
c. Bar tac-cerejali
d. Ma nafx

6. Kif l-ahjar li ghandha tkun l-ikla ta' nofs in-nhar ghall-plejer tal-futbol?
a. Hobz, grejns u cerejali
b. Frott u haxix
c. Laham u tjur
d. Ma nafx

7. Liem tahseb li hu l-ahjar sors ta' xaham li plejer tal-futbol ghandu jiehu mill-ghazla ta' hawn taht?
a. Butir, gobon u halib
b. Avokado, zejt taz-zebbuga u salamun
c. Halib, zejt taz-zebbuga u cips
d. Ma nafx

8. Liem mill- ikel ta' hawn taht ghandu l-iktar ammont ta' protejina ghal kull gramma?
a. Hut, brokkoli u bajd
b. Laham, patata u maffins
c. Tigieg, rajs kejks u tuffieh
d. Ma nafx

9. X'inhi l-iktar rwol important tal-protejina ghall-plejer tal-futbol?
a. Ittik l-energija
b. Tghinek tirkupra ahjar
c. Tibni iktar muskoli
d. Ma nafx

It-tielet parti: Idrazzjoni

4. X'inhu l-ammont minimu ta' ilma li plejer tal-futbol fil-gurnata f'temperatura medji?
a. 1-2 litru
b. 3-4 litru
c. 2-3 litru
d. Ma nafx

5. Kif taffetwalek il-performance jekk ikollok nuqqas ta' ilma fis-sistema waqt trejning jew logba tal-futbol?

a. Tnaqqaslek il-performance
b. Ma taffettwax il-performance
c. Timpruvjalek il-performance
d. Ma nafx

6. X'inhu l-iktar ingredjent important fi drink sportiv li jiehu plejer tal-futbol?
a. Zokkor
b. Melh
c. Krejatina
d. Ma nafx

Ir-raba parti: Supplimenti

4. Kemm huma important is-supplimenti ghall- plejer tal-futbol?
a. Importanti hafna u ghandek tikkonsmahom kuljum
b. Importanti hafna u ghandek tikkonsmahom tliett darbiet fil-gimgha
c. Mhux important jekk ghadek dieta bilancjata jew xi bzonnijiet partikolari
d. Ma nafx

5. X'inhu l-ahjar sors ta' protejina li plejer tal-futbol jista jiehu?
a. Prodotti naturali li fihom il-protejina fihom
b. Trab tal-protejina
c. Pilloli ta' l-amino acid
d. Ma nafx

6. F'liema sors ta' l-ikel insibu l-protejina normalment?
a. Laham u hut
b. Laham u fazola
c. Supplimenti biss
d. Ma nafx

Il-hames parti: Nutrizzjoni fil-gurnata tal-loghba

6. Liem mill-ikel ta' hawn taht plejer tal-futbol ghadu jikkonsuma sa hmistax il-minuta wara li tispicca il-loghba?
a. Banana
b. Juice tal-krenberi
c. Cikkulata
d. Ma nafx

7. Liem mill-ikel ta' hawn taht il-plejer tal-futbol ghandu jiehu bhala l-ikel principali ta' qabel il-loghba?
a. Laham, patata u haxix
b. Ghagin b'zalza minghajr xaham
c. Pizza
d. Ma nafx

8. Kemm suppost qabel il-loghba plejer tal-futbol ghandu jiehu l-ahhar ikla principali?
a. 1-2 sighat qabel loghba
b. 2-3 sighat qabel loghba
c. 3-4 sighat qabel loghba
d. Ma nafx

9. Liem mill-ikel ta' hawn taht plejer tal-futbol ghandu jiehu bhala l-ikla principali ta' wara il-loghba?
a. Laham, patata u haxix
b. Hobz, gobnijiet u prodotti tal-halib
c. Tista tiekol li jkun dan il-hin
d. Ma nafx

10. Kemm hu l-ammont ta' ilma li plejer tal-futbol ghandu jjixrob sittin minuta qabel loghba bejn wiehed u iehor?
    a. Litru
    b. 2 litri
    c. 500ml
    d. Ma nafx

Appendix 12: Nutrition knowledge in soccer test with choice of answers (Maltese version)

10.13 Interview questions before and after the validation trial

	Interview questions before the Validation trial	Interview questions after the Validation trial
	Part 1: Personal judgement of current nutritional habits	
1	How did you find filling in the Food and Exercise diary?	How would you describe the experience of filling in a daily Food and Exercise diary?
2	Did you come to terms with any nutritional habits as you were penning down your daily nutritional intake?	Did you come to terms with any nutritional habits as you were penning down your daily nutritional intake?
3	How do you rate the quality of your daily nutritional intake before to as when you are filling in the Food and Exercise diary?	How do you rate the quality of your daily nutritional intake before you started filling in the Food and Exercise diary?
4	Is there anything in your daily nutritional intake that you would change in terms of both quality and quantity?	Is there anything in your daily nutritional intake that you would change in terms of both quality and quantity?
5	How willing are you to improve your daily nutritional intake, provided the support to be given to you by the researcher as your Football Nutrition specialist?	How willing are you to improve your daily nutritional intake, provided that the support will be given to you by the researcher as your Soccer Nutrition specialist?
	Part 2: Current dietary habits and patterns	
1	Tell me about your customary eating pattern	Describe your daily customary eating pattern
2	What do you mean by unhealthy food? How often do you take unhealthy food?	How do you describe unhealthy food? How often do you take it in a week?
3	How do you prepare yourself for the game nutritionally?	Describe your pre-match nutritional routine
4	How do you prepare yourself after the game nutritionally?	Describe your post-match nutritional routine.
5	How much do you usually drink? And at what times?	Describe your hydration pattern. Is there a particular time that you need to hydrate yourself more apart from during training and/or matches?
6	Do you consume alcohol? How much? Does this depend on training and game schedule?	Describe your alcohol consumption. How often do you drink alcohol in a week and how many units? Does this interfere with your training and match schedule?
7	What do you normally do when you are extremely hungry but find no prepared meals at home?	What do you normally do when you are extremely hungry but find no ready prepared meals at home?

	Part 3: Attitude towards nutrition	
1	What does a 'diet' mean to you?	What does a 'nutritional plan' mean to you?
2	What are you expecting from the Football Nutrition Specialist?	What are you expecting from the Soccer Nutrition Specialist?
3	Common on the statement 'One diet fits all the team', do you agree? Why?	Comment on the statement 'One diet fits all the team'. Do you agree? Why?
4	Have you ever had some information relayed to you in nutrition? Nutrition in sport? Nutrition in football? Do you feel that this is important? Why?	Have you ever had some information relayed to you in nutrition? Do you feel that this is important? Why?
5	What type of support do you get from the national team and club?	What type of nutritional support do you get from the national team and club?
6	Do you feel it is necessary to have someone telling you what to eat? Or would you find this unnecessary and a hassle? Why?	Do you feel that it is necessary to have someone telling you what to eat? Or would you find this unnecessary and a hassle? Why?
7	Do you have any food or drink, or meal preferences, traditions or superstitions in relationship to training and/or games?	Do you have any food or drink, or meal preferences, traditions or superstitions in relationship to training and/or matches?
8	How do people around you influence your food choices? Why?	Do the people around you influence your food choices? How? Why?
9	Do you find yourself thinking about some aspect of nutritional content before taking that food? Why?	Do you find yourself thinking about the nutritional content of the food or drink being taken? Why?
10	Would you dedicate some time to prepare meals? Give reasons for your answer.	Would you dedicate some time to prepare meals? How? Which conditions?
	Part 4: Perception towards nutrition	
1	Do you think that proper nutrition can help you perform better? To what extent?	Do you think that proper nutrition can help you perform better? To what extent?
2	If you were given a diet, would you follow it? Under what conditions?	If you were given a nutritional plan would you follow it? Under what conditions?
3	Are you aware of how many calories you need to consume every day to have enough energy for training?	Are you aware of how many calories you need to consume per day to have enough energy for training?
4	What sort of self-talk/decision making choices do you engage in when you are choosing foods/snacks through a typical day?	What sort of self-talk/decision making choices do you engage yourself in when choosing foods/snacks through a typical day?
5	How is your diet at training camps/competitions	How is your nutritional plan at training camps/competitions

	usually? What sort of snacks do you consume at this time?	usually? What sort of snacks do you consume at this time?
6	If you had to prescribe a diet for your own self, what would this include?	If you had to prescribe a nutritional plan for your own consumption, what would this include?
7	Do you believe that a Football Performance Diet marks a positive effect on performance in football? Outline a comparative scenario to explain this, if any	Do you believe that a Soccer Performance Diet marks a positive effect on performance in football? Outline a comparative scenario to explain this, if any
	Part 5: Experienced and perceived barriers towards optimal nutrition	
1	What do you consider as barriers to following a sound nutritional plan? Which is the one that affects you most?	What do you consider as barriers to following a prescribed nutritional plan?
2	How can you counteract for these barriers?	How can you counteract these barriers?
3	If the planned diet had to go around and address all the barriers identified, would you be willing to follow such a diet?	If the planned nutritional plan addressed all the barriers identified, would you be willing to implement it?
4	Would you make this diet become a norm? How?	How would you make this nutritional plan become a norm?
	Part 6: Reaction to current dietary intake analysis	
1	Is the result of this analysis what you expected your diet to be?	Is the result of the 7-day Food and Exercise Diary analysis what you expected it to be?
2	How concerned are you with this result?	What are your reactions to this result?
3	What are you going to do now? Why?	Are you planning to make any changes on the basis of these results? Why?
4	Is there a difference in your attitude and perception to nutrition in football following this one-to-one interview? Why?	Has your interest in nutrition before and after giving you the result of the 7-day Food and Exercise Diary analysis changed? How?

Appendix 13: Interview questions before and after the validation trial

10.14 Team coach and assistant coach semi-structured interview questions

1. What are your views towards nutrition in soccer?
2. Do you believe that practised optimal nutrition marks a positive effect on the performance of the soccer player?
3. If you believe in the benefits on nutrition in performance in soccer, in what aspects of performance do you think the player and the team benefits?
4. What is your opinion about nutrition in soccer locally?
5. Who is responsible for the nutrition care of a soccer player?
6. You have already been the Coach of the u21 National team in the past edition in which time there was no member of the staff taking care of the players' nutrition. Now that there is, what are your views about it?
7. You are aware that so far the Malta Football Association has never employed a soccer nutrition specialist with the team. What are your views about this?
8. The MFA recruits technical, physical and medical personnel as well as a part-time psychologist. Do you really think it is a finances issue (as MFA has vividly claimed) the is stopping the association from recruiting a soccer nutrition specialist to take care of the players' nutrition?
9. How would you define the role of soccer nutrition specialist with your team?
10. What is the players' reaction to this nutritional support that they are receiving?
11. Any other comments you wish to add about this first time experience of having a soccer nutrition specialist as part of the staff with the u21 national team?

Appendix 14: Team coach and assistant coach semi-structured interview questions

10.15 Players' post-match interview questions

1.	How did you prepare yourself nutritionally for the match?
2.	Did the nutritional strategy in build up for this match meet your expectations?
3.	Did you experience any fatigue at any point during the match? If yes, what minute was its onset?
4.	If you felt fatigued during the match, in what phases/actions was this predominantly felt?
5.	If you felt fatigued during the match, how did you deal with it?
6.	If you felt fatigued during the match, did you manage to overcome it?
7.	If you felt fatigued during the match, was your performance affected?
8.	Did you experience any cramps or twitches or muscular strains during the match?
9.	How do you compare your fatigue between each of the halves?
10.	Do you think that the potential fatigue experienced as a team had an impact on the final result?
11.	If you felt fatigued during the match, was this predominantly aerobic, anaerobic or both? Which one the most
12.	Why in your opinion did the team conceded two late goals? Was it a tactical, technical or a physical decrement? Or was it perhaps something else?
13.	Did you experience any muscle soreness after this match? If yes, describe its nature.

Appendix 15: Players' post-match interview questions

10.16 Pre-match team menu at pre-intervention stage

Day	Time	Meal	Content
2 days pre-match	21:45	Dinner	• Spaghetti with fresh tomato sauce & parmesan cheese • Grilled fillet of beef with roast potatoes, tomatoes & variety of vegetables • Chocolate dessert
1 day pre-match	09:00	Breakfast	• Variety of cereal with fresh cold milk • White & brown bread (& toast) with ham, cheese slices and tomatoes • Hard boiled & scrambled eggs • Fruit yoghurt • Fruit juice • Pastry (croissant etc) • Tea/coffee
	13:00	Lunch	• Vegetable soup • Warm vegetable risotto • Grilled chicken legs with roast potatoes, tomatoes & vegetables • Variety of fresh fruit
			Training at 19:00
	21:00	Dinner	• Fresh creamy mushroom soup • Penne with fresh tomato sauce • Grilled veal with roast potatoes, tomatoes, vegetables • Choice of ice-creams
Match-day	09:00	Breakfast	• Variety of cereal with fresh cold milk • White & brown bread (& toast) with ham, cheese slices and tomatoes • Hard boiled & scrambled eggs • Fruit yoghurt • Fruit juice • Pastry (croissant etc) • Tea/coffee
Training at 10:00			
	12:00	Light snack	• No information provided
	16:00	Late lunch	• Fusilli with fresh tomato sauce • Grilled chicken breast with boiled potatoes, tomatoes & vegetables • Variety of fresh fruit
Match at 20:45			
	23:15	Dinner	• Minestrone • Spaghetti with bolognese sauce • Veal escalope (grilled) with roast potatoes, tomatoes & vegetables • Chocolate cake

Appendix 16: Pre-match team menu at pre-intervention stage

10.17 Soccer performance training day dietary plan for a 70kg player

Time	Meal	Food	Brand	Packaging - Preparation	Portion	Weight
07:45 – 08:15	**Breakfast**	Cornflakes	Kelloggs	Carton box	4 cups	100g
		with skimmed milk	Benna	Light blue	1 cup	240ml
		with honey		Canned	2 teaspoons	34g
		with raisins		Fresh/Packaged unsalted	2 tablespoons	60g
		with apricots		Fresh/Packaged unsalted	6	48g
		Orange juice		Fresh	2 oranges	
10:30 – 11:00	**Snack**	Apple		Fresh	1 medium	100g
13:00 – 14:00	**Lunch**	Brown bread		Packaged	4 slices	128g
		with butter		Packaged	4 thin spreads	
		with tomatoes		Fresh	2 medium	170g
		with turkey meat		Packaged/counter	2 slices	46g
		with rucola leaves		Fresh	10 leaves	5g
		Apple juice		Unsweetened	1 glass	240ml
15:30 – 16:00	**Pre-training meal**	Brown rice	Misura/Tilda Brown	Packaged		200g
		with chicken breast		Skinless - fresh		50g
		with onion		Fresh	1/2 onion	30g
		with garlic		Fresh	3 cloves	5g
		with cherry tomatoes		Fresh	6 medium	90g
18:30 – 20:00	**Training**	Sports drink	Gatorade	Packaged	1 small	500ml
20:00 – 20:15	**Post-training snack**	Nutrigrain	Kellogg's	Packaged	1 bar	37g
		Cranberry Juice	Safari/Pfanner/Rauch	Unsweetened		240ml
20:45 – 21:00	**Dinner**	Beef strips/steak		Fresh		75g
		with garlic		Fresh	3 cloves	5g
		with onion		Fresh	1/2 onion	30g
		with yellow pepper		Fresh	1 sliced	160g
		with tomatoes		.	4 medium	340g
		with mushrooms		Fresh	6	56g
		with carrots		Fresh	1 carrot	60g
		with potatoes		Fresh	3 medium	525g
Hydration	*All day*	*Water*				*3 -4 L*

Appendix 17: Soccer performance training day dietary plan for a 70kg player

10.18 Soccer performance match day dietary plan for a 70kg player

Meal	Time		Menu
Breakfast	08:30	Cereal: Dairy: Grains: Drink:	Cornflakes/Muesli/Oats *with* skimmed milk – honey - dried fruit Fruit yoghurt - Boiled eggs Brown bread – fresh turkey breast - cottage cheese - low fat butter spread - avocado Fresh squashed oranges – water
Lunch	12:30	Soup: First plate: Main dish:	Mushroom – Carrot – Lentil & bean - Minestrone Brown pasta – Risotto *with* mince beef – chicken – turkey – pork *with* fresh tomato sauce Chicken breast – lean beef – turkey – chicken – beef – salmon – pork - rabbit – fish - veal Selection of vegetables Sweet potatoes
Pre-training snack	60' before training	Snack:	Banana – apple – rice cakes – oat bar
Post-training snack	Within 15' from end of training session	Snack:	Unsweetened cranberry juice – milk – fruit smoothie
Dinner	Within 120' from end of training session	Soup: First plate: Main dish:	Mushroom – Carrot – Lentil & bean - Minestrone Brown pasta – Risotto *with* mince beef – chicken – turkey – pork *with* fresh tomato sauce Chicken breast – lean beef – turkey – chicken – beef – salmon – pork - rabbit – fish - veal Selection of vegetables Sweet potatoes

Appendix 18: Soccer performance match day dietary plan for a 70kg player

10.19 Players' weekly soccer performance diet implementation questionnaire

1. I am finding it difficult to consume the type of food given in this diet
2. I am finding it difficult to implement this diet overall
3. I feel like snacking on other foods
4. I would eat more if I had the opportunity
5. I feel the crave of taking something sweet and sugary
6. I feel hungry
7. I feel that this diet fulfils my current training needs
8. I feel lighter and able to do sharper movements
9. I look forward to continue this diet until I reach my desired body fat level

Appendix 19: Players' weekly soccer performance diet implementation questionnaire

10.20 Prescribed team menu at post-intervention stage

Meal	Time		Menu
Breakfast	08:30	Cereal:	Cornflakes/Muesli/Oats *with* skimmed milk – honey - dried fruit
		Dairy:	Fruit yoghurt - Boiled eggs
		Grains:	Brown bread – fresh turkey breast - cottage cheese - low fat butter spread - avocado
		Drink:	Fresh squashed oranges – water
Lunch	12:30	Soup:	Mushroom – Carrot – Lentil & bean - Minestrone
		First plate:	Brown pasta – Risotto *with* mince beef – chicken – turkey – pork *with* fresh tomato sauce
		Main dish:	Chicken breast – lean beef – turkey – chicken – beef – salmon – pork - rabbit – fish - veal Selection of vegetables Sweet potatoes
Pre-training snack	60' before training	Snack:	Banana – apple – rice cakes – oat bar
Post-training snack	Within 15' from end of training session	Snack:	Unsweetened cranberry juice – milk – fruit smoothie
Dinner	Within 120' from end of training session	Soup:	Mushroom – Carrot – Lentil & bean - Minestrone
		First plate:	Brown pasta – Risotto *with* mince beef – chicken – turkey – pork *with* fresh tomato sauce
		Main dish:	Chicken breast – lean beef – turkey – chicken – beef – salmon – pork - rabbit – fish - veal Selection of vegetables Sweet potatoes

Appendix 20: Prescribed team menu at post-intervention stage

10.21 List of Facebook posts as part of the Nutrition Education and Support Intervention Programme

Post number	Topic covered	Title of the post	Post information	Resources attached
1	Hydration	Sugars in drinks	- Tablespoons of sugars found in a number of common drinks	Picture: Different hydration sources in cans and bottles attached to a panel, with the equivalent amount of sugar in a plastic bag attached to panel underneath the respective bottle or can
2	Energy	Calorie intake	- Energy values of macronutrients - Adding up the daily calories	Video: This is what 2000 calories look like
3	Energy	Energy expenditure	- Time required to burn 200 calories via different types of exercise	Video: Ways of burning 200 calories
4	Protein	Protein function, sources and recommended % for a soccer player	- Different functions of protein in the body - Recommended protein % of TDEI and g · kg^{-1} ·BM - Protein sources from food	Picture: Animal and plant sources of protein
5	Fats	Fat function, sources and recommended % for a soccer player	- Different functions of fat in the body - Recommended fat % of TDEI and g · kg^{-1} ·BM - Fat sources from food	Picture: Unsaturated sources of fat
6	Vitamins	Vitamin function, sources and recommended daily allowance	- Different functions of vitamins in the body - Fat soluble and water soluble vitamins - Vitamins sources from food	Picture: Fat soluble and water soluble vitamins
7	Supplements	Replacement of natural food sources instead of supplements	- PRO % of TDEI and g · kg^{-1} ·BM - requirement for a soccer player - Types of supplements - Pros and cons of using supplements	Picture: Natural lean protein vs man-made protein shake
8	Hydration	Pre-match hydration	- Importance of hydration on match day - Hydration amounts and timing before a match	Picture: Famous soccer player effectively drinking water before a match
9	Nutritional habits	Daily nutritional plan	- Ideas of food sources as breakfast, mid-morning snack, lunch, pre-training meal,	Picture: Famous soccer player eating a variety of

			pre-training snack, post-training snack, post-training meal - Reasons for such food choices depending on the time of the day	nutritious meals
10	Nutritional strategies	Post-training nutrition	- Benefits and aim of post-training nutrition, especially within the 15 min time window after a session ends - Ideas for post-training snack	Picture: Examples of post-training snacks
11	Protein	Protein sources	- Nutritional content and comparison of a chicken and a turkey breast	Picture: Nutritional information label of chicken breast and turkey breast
12	Energy intake	Portion sizes	- Small frequent meals rather than less frequent huge meals - Bigger meals take longer to digest – stress on pancreas to release enough insulin	Picture: Three different – sized plates with the same food sources but different portion sizes
13	Energy intake	Food plate	- Approximate % of TDEI coming from carbohydrate, protein and fat for soccer players	Picture: Plate labelled with different nutrition portions according to soccer % of TDEI recommended for a soccer player
14	Energy sources	Energy value of foods	- Energy value of each macronutrient - Example using 100g of pasta; its nutrient source in grams multiplied by each respective energy value and the total amount of calories	Picture: Macronutrient energy values table
15	Nutritional habits	Attitude	- Being determined to make positive food choices - Eating well will help the player be more prepared for training and match-play	Picture: Famous soccer player having a nutritious breakfast
16	Nutritional benefits	Delays fatigue	- Effects of fatigue on the performance of a soccer player including cramps, loss of strength, less distance covered	Picture: Soccer player sidelined with cramps during a match
17	Energy intake	Practical daily strategies	- Choosing whole-grain over white foods - Keeping well hydrated - Choose fruit and vegetables as snacks - Choosing healthy food sources over supplements	Picture: Different options for healthy snacks

			-	Replacing juices with water	
18	Energy intake	Being too skinny	-	Strategy of putting on muscle and not fat weight - Taking fat sources to add on weight is not a good strategy - Slightly increasing the portions of the good foods is one of the options	Picture: Different main meals fit for a soccer player
19	Hydration	Daily water intake	-	Around 3 litres per day depending on weather conditions and amount of training - Other hydration ideas include sports drinks during training, freshly squeezed fruits and vegetables	Picture: Fruit smoothie and water
20	Hydration	Sugars in drinks	-	Tablespoons of sugars found in a number of common drinks	
21	Sugars	Sugars in Coca Cola	-	Number of teaspoons of sugars in different sized coca cola bottles	Article: How much sugars are present in soft-drinks with particular reference to Coca Cola
22	Fat loss strategies	Replacing fat weight with muscle weight	-	Long-term strategy that includes proper diet planning and target training - Importance of body composition in a soccer player	Picture: Famous soccer player weight fluctuations
23	Energy balance	Balanced diet	-	Energy intake vs energy expenditure - Energy intake > Energy expenditure = Fat gain - Energy intake < Energy expenditure = Fat loss	Picture: Scales balance with energy intake on one side and energy expenditure on the other side
24	Energy intake	Sample nutritional plan of a soccer player	-	Ideas for breakfast, mid-morning snack, lunch, pre-training meal, pre-training snack, post-training snack, and dinner	Picture: Each of the proposed meals
25	Fat loss strategies	Nutritional tips on losing fat while continuing training as a soccer player	-	Not eliminating carbohydrates since player still needs them as an energy source - Not skipping meals - Cutting down on condiments and sugary snacks - To consume smaller and more frequent	Picture: Choice of healthy vs fattening meals

				portions	
26	Macronutrients	Food sources for each macronutrient	-	Grain and plant sources of carbohydrate	Picture: Food sources of each macronutrient
			-	Animal and plant sources of protein	
			-	Good sources of fat	
27	Hydration	Sports drinks	-	Use and examples of isotonic sports drinks	Video: Making your own sports drink
			-	Ingredients to make own sports drink	
28	Energy expenditure	Energy expenditure in a soccer match	-	Approximate energy cost in a match according to the level of the match and positional role of the individual player with the team	Picture: Energy expended by positional play in soccer
29	Macronutrient	Carbohydrate guidelines for a soccer player	-	7 to 12 g · kg^{-1} ·BM	Picture: Calculation example of carbohydrate recommended intake for a 70 kg soccer player
			-	Scenario example with a soccer player weighing 70 kg	
30	Energy storage	Carbohydrate storage – glycogen	-	Carbohydrate as the primary source of energy in soccer	Picture: Table of reducing muscle glycogen levels before a match, at half-time and after a match
			-	Muscle glycogen stored in muscles and liver	
			-	Effects on performance if players has low glycogen levels	
31	Supplements	Type of supplements	-	Types: Powders, boosters, capsules, gels	Picture: Forms of supplements in shakes, gels, capsules, boosters
			-	Natural food alternatives	
32	Supplements	Energy boosters	-	Nutritional information of similar energy boosters	Picture: Energy boosters examples
			-	Effect on performance	
			-	Effect on the body	
33	Energy value	Calories	-	Definition of calories	Video: This is what 200 calories look like
			-	Nutrients that contribute to calories	
			-	Total Daily Calorie Intake	
34	Energy intake	TDEI	-	Definition	Picture: TDEI on training days versus TDEI on off days
			-	Adjusting the TDEI according to the weekly training schedule	
35	Energy balance	Estimating your energy expenditure	-	BMR	Picture: Energy expenditure in common physical activities
			-	Energy expenditure in common daily activities	
			-	Estimating energy balance	

36	Macronutrients	Sources of carbohydrate as a snack	- Nutritional information of dried fruits - Fibre as a nutrient	Picture: Carbohydrate content of an array of dried fruits
37	Macronutrients	Sources of unsaturated fat as a snack	- Nutritional information of unsalted nuts - Controlled portions of unsalted nuts	Picture: Fat content of an array of unsalted nuts
38	Energy expenditure	Physical demands and energy expenditure in a soccer match	- Total distance covered - Distance covered in fast run - Distance covered in sprint - Time spent walking/standing - Time spent jogging - Time spent sprinting - Work to rest ratio - Total calories burnt	Picture: Bar graph on time spent on each category mentioned in description
39	Energy intake	Recovery nutrition	- Aims of recovery nutrition - Focus on carbohydrate replenishment and protein intake - Foods to eat at the recovery stage	Picture: Sample dishes that can be used take following training
40	Energy intake	Junk food	- Nutritional facts of junk food - Examples of junk food	Picture: Junk food sources
41	Energy intake	Dietary Plan	- Meal frequency - Breakfast ideas - Lunch ideas - Dinner ideas - Dinner ideas - Snack ideas	Article: Famous soccer player nutritional plan
42	Hydration	Use of sports drinks	- When to use sports drinks - Benefits of sports drinks	Picture: Sports drinks available on the market
43	Hydration	Isotonic sports drinks	- Timing of isotonic sports drinks - Content of isotonic sports drinks	Picture: Nutrition label of an isotonic sports drink
44	Nutritional strategies	Pre-match nutrition	- Nutrition in the evening before a match - Carbohydrate needs for glycogen storage	Picture: Carbohydrate-loaded meal
45	Nutritional strategies	Match-day nutrition plan	- Preparation for a late afternoon match - Preparation for a morning match - Breakfast, snacks, pre-match meal and pre-match snack ideas	Picture: Table of match-day nutritional plan for a morning match and a late afternoon match
46	Nutritional strategies	Halt-time strategy	- High-carbohydrate source - Fluid-based sources	Picture: Sources of carbohydrate rich sources

					to be used at half-time
47	Supplements	Use of supplements	-	Use of supplement in case of a particular deficiency	Picture: Multi-vitamin supplements
			-	Vitamin and mineral supplements	
48	Energy intake	Breakfast idea	-	Importance of breakfast	Picture: Muesli with honey and dried fruits as breakfast meal
			-	Ideas for breakfast sources	
49	Macronutrients	Protein use	-	Protein importance in recovery	Picture: Table with protein content in various meats
			-	Protein content in various meats	
50	Energy intake	Snacks	-	Timing of snacks	Picture: Different examples of snack ideas
			-	Targeted nutrient content of consumed snacks	
51	Hydration	Energy drinks	-	Definition of energy drinks	Picture: Energy drinks comparison to sports drinks
			-	Energy drinks examples	
			-	Difference between sports drinks and energy drinks	
52	Nutritional strategy	Food guidelines	-	Eatwell plate as a general portion and nutrient intake rule	Picture: UK Eatwell plate
			-	Adaptation to the diet of a soccer player	
53	Energy	Energy use	-	How our body stores and uses energy for performance	Picture: Fuelling a car vs food being ingested in your body as fuel
			-	Comparison to fuelling your car to fuelling your body	
54	Nutritional strategies	Controlling your body composition	-	Eating small portions frequently	Picture: Nutritious small plates of food examples
			-	Keeping your metabolism going	
55	Energy intake	Vitamins and Minerals	-	Function of vitamins and minerals	Picture: Fruit and vegetables as sources of vitamins and minerals
			-	Vitamin and mineral sources	
56	Energy intake	Fruits	-	Nutritional content of a variety of fruits	Picture: Nutrition label for a number of different fruits
57	Energy intake	Energy values of foods	-	Energy values of common foods and their energy content in terms of common activities	Picture: Energy value of meals and what activities can be done with an equivalent amount of energy
58	Energy intake	Vegetables	-	Good sources of protein and carbohydrate intake	Picture: Soups of different vegetables
			-	Ways of taking in vegetables if do not	

				fancy them much such as soups and mashed in other foods	
59	Macronutrients	Protein	-	Protein content of common foods	Picture: Nutritional table with protein content of different vegetables
			-	Protein content of vegetable sources	
60	Nutritional strategies	Pre-match meal	-	Aim of a pre-match meal	Picture: Pre-match meal example
			-	Timing depending on kick-off	
			-	Daily strategy	
			-	Pre-match meal examples	
61	Nutritional strategies	Dietary intake vs Training in Fat Loss	-	Importance of the right source and amount of food in a fat loss strategy	Picture: Food and training contribution to fat loss regime chart
62	Nutritional strategies	Pre-match snacks	-	Importance of pre-match snacks	Picture: Fruits as snacks
			-	Carbohydrate sources	
			-	Fruit as snacks	
63	Energy intake	Fast food	-	Fast food facts	Picture: Calorie content in different junk food sources
			-	Calorie dense foods	
			-	High fat content	
64	Nutritional strategies	Halt-time nutrition	-	Use of fluids	Picture: Cranberry juice nutrition facts
			-	Sources such as cranberry juice	
65	Nutritional strategies	Hydration before a game	-	Important of hydration ahead of a match	Picture: Amount of water before a match
			-	Amount of water before a match	
66	Macronutrients	Carbohydrates	-	Complex carbohydrates vs simple carbohydrates	Picture: Complex carbohydrates versus simple carbohydrates sources
			-	Timing of the use of each of them	
			-	CHO % of TDEI and $g \cdot kg^{-1} \cdot BM$	
67	Energy intake	Sports Nutrition Pyramid	-	Guidelines for nutrient intake	Picture: Sports Nutrition Pyramid
			-	Carbohydrate base with less important food sources on top	
68	Energy intake	Nutrition labelling	-	Understanding the nutrition label	Picture: Explanation of a nutrition label
			-	Portion sizes quoted	
69	Energy intake	Alcohol	-	Energy value	Wine: Calorie chart for various alcoholic drinks
			-	Energy value of various alcoholic drinks	
			-	Effect on performance	

Appendix 21: List of Facebook posts as part of the Nutrition Education and Support Intervention Programme

10.22 Nutrition in soccer lectures as part of the Nutrition Education and Support Intervention Programme

Talk	Topic/Area	Information delivered
1	Energy balance, Energy intake, Energy expenditure, Nutrients and hydration	- Food as the body fuel - Comparison to fuelling a car and fuelling the soccer player's body - Contribution to energy intake - Contribution to energy expenditure - Basal Metabolic rate (BMR) - Total Daily Energy Expenditure (TDEE) - Energy balance - Energy values of macronutrients - Function of each macronutrient - Sources of each macronutrient - Function of micronutrients - Sources of micronutrients - Glycaemic index - Aim of hydration - Sources of hydration - Hydration Plan - Closure and other questions *Resources:* Video – Importance of hydration Video – Understanding energy balance
2	Digestion, supplementation and match-day strategies	- Process of digestion - Role of pancreas - Factors affecting metabolism - Timing and choice of intake - Types of supplements - Pros and cons of supplement use - Supplements vs natural food sources - Breakfast on match-day - Pre-match meal sources and timing - Pre-match snack sources and timing - Inter-match nutrition - Post-match snack

		- Post-match meal - Closure and other questions *Resources:* Video – Nutrition on match-day Video – Supplements in sport
3	Other soccer-related information including fat accumulation, carbohydrate use, dietary plans	- Disposition of fat in the body - Storage of glycogen (maximum amount, places of storage) - Breakfast aim and examples of food - Mid-morning snack aim and examples of food - Lunch aim and examples of food - Pre-training meal aim and examples of food - Pre-training snack aim and examples of food - Post-training snack aim and examples of food - Post-training meal aim and examples of food - Adopting a balanced diet supportive to soccer - Optimum body composition for performance - Nutrition attitudes, beliefs and myths - Nutritional barriers - Closure and other questions

Appendix 22: Nutrition in soccer lectures as part of the Nutrition Education and Support Intervention Programme

10.23 Soccer-performance diet intervention final questionnaire

1. How much out of 100% did you follow this 4-week performance diet? If you did not follow or fully follow it, kindly provide reasons why.
2. If any, outline the main barriers and their associated limitations to following such performance diet.
3. If you were asked to follow this performance diet once again, would you do so? Kindly give reasons for your answer
4. What would you change and/or add to this performance diet? Kindly provide tangible examples of food and/or drinks that you would add/change and or remove, times of meals etc...
5. What aspect of this performance did you find most difficult? Kindly provide examples.
6. Are you willing to keep on following such performance diet and continue receiving nutritional advice to assist you in your soccer career? Kindly provide reasons for your answer
7. Following the implementation of this performance diet, have you experienced any improvement in: soccer performance in training, soccer performance in match-play, during the recovery phase?
8. Now that you have experienced nutritional guidance, do you feel that it is important to have such support, or it would not make much difference? Kindly provide reasons for your answer
9. The MFA does not employ a nutrition specialist. The support being given from the researcher is voluntary as part of my research, acknowledging the fact that should this research was not done, none of such support would have been given throughout these months. What are your suggestions to the MFA?

Appendix 23: Performance diet intervention final questionnaire

10.24 Soccer-specific performance diet (72 h) for intervention in study 1

24h						
TIME	**MEAL**	**Food**	**Brand**	**Packaging**	**Portion**	**Weight**
07.00 - 08.00	Breakfast CEREAL	Cornflakes	Kelloggs	Carton box	4 cups	100g
		with skimmed milk	Benna	Carton flask (green)	1 cup	240ml
		with honey		Canned	2 heaped teaspoons	34g
		with dried apricots		by weight/packaged	6	48g
		Apple		Fresh	1 medium	100g
		Fruit cocktail		Canned in syrup	1/2 can	210g
		Orange juice		Fresh	2 medium	
09.00 - 09.30	Snack	Rice cakes	Snack-a-jack Caramel	Packaged	5 rice cakes	65g
		Pear		Fresh	1 medium	150g
11.30 - 12.00	Lunch SANDWICH	Bread	Wholemeal	Packaged	4 thick slices	176g
		with butter		Packaged	4 thin spreads	
		with tomatoes		Fresh	2 medium	170g
		with turkey meat		Packaged/counter	2 slices	46g
		Apple juice		Packaged	1 glass	240ml
14.00 - 14.30	Snack	Flavoured Yoghurt	Benna	Packaged	1 cup	150g
		Peach slices		Canned in syrup	1 can	210g
TIME	**MEAL**	**Food**	**Brand**	**Packaging**	**Portion**	**Weight**
16.00 - 16.30	Pre-training meal RICE CHICKEN	Rice	Misura/Tilda Brown	Packaged		100g
		with Chicken Breast		Skinless - fresh		75g
		with orange pepper		Fresh	1 whole	160g
		with onion		Fresh	1/2 onion	
		with garlic		Fresh	3 cloves	
		with cherry tomatoes		Fresh	6 medium	90g
18.00	Pre-training snack	Banana		Fresh and ripe	1 medium	100g
		Water				600ml
18.45 - 20.15	Training					
20.15 - 20.30	Post-training snack	Nutrigrain	Kellogs	Packaged	1 small	20g
		Cranberry Juice		Packaged		240ml

21.00	Dinner BEEF STEW	Beef strips/steak		Fresh		75g
		with garlic		Fresh	3 cloves	
		with onion		Fresh	1/2 onion	
		with yellow pepper		Fresh	1 sliced	160g
		with tomatoes	Polpa di Pomodoro	Canned	1 can	400g
		with mushrooms		Fresh	6	50g
		with peas		Frozen	3 tablespoons	90g
		with carrots		Fresh	1 medium	60g
		with potatoes		Fresh	3 medium	525g
		Maltese Bread		Fresh	2 thick slices	100g
Hydration	*All day*	*Water*				*2-3 litres*

48 h						
TIME	**MEAL**	**Food**	**Brand**	**Packaging**	**Portion**	**Weight**
07.00 - 08.00	Breakfast CEREAL	Meusli	CountryStore/Cruesli	Carton box	4 cups	100g
		with raisins		by weight/packaged	1 tablespoon	30g
		with dried apricots		by weight/packaged	6	48g
		with skimmed milk	Benna	Carton flask (green)	1 cup	240ml
		with honey		Canned	2 heaped teaspoons	17g
		Fruit cocktail		Canned in syrup	1/2 can	210g
		Orange juice		Fresh	2 medium	
09.00 - 09.30	Snack	Rice cakes	Snack-a-jack Caramel	Packaged	5 rice cakes	65g
		Apple		Fresh	1 medium	100g
11.30 - 12.00	Lunch SANDWICH	Bread	Wholemeal	Packaged	4 thick slices	176g
		with butter		packaged	4 thin spreads	
		with tomatoes		Fresh	2 medium	170g
		with tuna		Canned in brine	1 can	80g
		Kiwi		Fresh	2 medium	80g
		Apple juice		Packaged	1 glass	240ml
14.00 - 14.30	Snack	Flavoured Yoghurt	Benna	Packaged	1 cup	150g
		Pineapple slices		Canned in juice	1 can	210g
16.00 - 16.30	Pre-training meal COLD PASTA	Farfalle	Misura/Barilla Integrale	Packaged		150g
		with kidney beans		Canned	3 tablespoons	105g

		with cherry tomatoes		Fresh	6 medium	90g
TIME	**MEAL**	**Food**	**Brand**	**Packaging**	**Portion**	**Weight**
18.00	Pre-training snack	Banana		Fresh and ripe	1 medium	100g
		Water				600ml
18.45 - 20.15	Training					
20.15 - 20.30	Post-training snack	Cereal Bar	Kellogs	Packaged	1 small	20g
		Cranberry juice		Packaged		240ml
21.00	Dinner PORK CASSEROLE	Pork steak		Fresh		75g
		with garlic		Fresh	3 cloves	
		with onion		Fresh	1/2 onion	
		with green olives		Fresh	4	10g
		with chopped basil		Fresh	1 fist	10g
		with balsamic vinegar		Packaged	1 tablespoon	15g
		with mustard		Packaged	1 tablespoon	15g
		with potatoes		Fresh	3 medium	540g
		Maltese Bread		Fresh	2 thick slices	100g
Hydration	*All day*	*Water*				*2-3 litres*

72h

TIME	MEAL	Food	Brand	Packaging	Portion	Weight
07.00 - 08.00	Breakfast CEREAL	Cornflakes	Kelloggs	Carton box	4 cups	100g
		with skimmed milk	Benna	Carton flask (green)	1 cup	240ml
		with honey		Canned	2 heaped teaspoons	34g
		with dried apricots		by weight/packaged	6	48g
		with raisins		by weight/packaged	2 tablespoons	60g
		Apple		Fresh	1 medium	48g
		Fruit cocktail		Canned in syrup	1/2 can	210g
		Orange juice		Fresh	1 glass	65g
09.00 - 09.30	Snack	Rice cakes	Snack-a-jack Caramel	Packaged	5 ricecakes	150g
		Pear		Fresh		150g
11.30 - 12.00	Lunch SANDWICH	Pitta		Packaged	2 pitta	190g
		with butter		Packaged	4 thin spreads	
		with tomatoes		Fresh	2 medium	170g
		with tuna		Canned in brine	1 small can	80g
		Grapes		Fresh	1 bunch	100g
		Apple juice		Packaged	1 glass	240ml

14.00 - 14.30	Snack	Flavoured Yoghurt	Benna	Packaged	1 cup	150g
		Peach slices		Canned in syrup	1/2 can	210g
16.00 - 16.30	Pre-training meal RAVIOLI	Ravioli (ricotta)		Frozen		150g
		with tomatoe sauce		Canned		400g
		with mince beef		Fresh		100g
		with garlic		Fresh	3 cloves	
		with onion		Fresh	1/2 onion	
TIME	**MEAL**	**Food**	**Brand**	**Packaging**	**Portion**	**Weight**
18.00	Pre-training snack	Banana		Fresh and ripe	1 medium	100g
		Water				600ml
18.45 - 20.15	Training					
20.15 - 20.30	Post-training snack	Cereal Bar	Kellogs	Packaged	1 small	20g
		Cranberry Juice		Packaged		240ml
21.00	Dinner CHICKEN CASSEROLE	Chicken legs		Fresh	2 legs	125g
		with garlic		Fresh	3 cloves	
		with onion		Fresh	1/2 onion	
		with carrots		Fresh	1/2 carrot	60g
		with sweet potatoes		Fresh	4 sweet potatoes	250g
		with thyme		Dried, ground	2 teaspoons	
		with lemon juice		Fresh	1 lemon	55g
		Maltese Bread		Fresh	3 thick slices	150g
Hydration	*All day*	*Water*				*2-3 litres*

Soccer-performance test day

TIME	MEAL	Food	Brand	Packaging	Portion	Weight
07.00 - 08.00	Breakfast CEREAL	Meusli	CountryStore/Cruesli	Carton box	4 cups	100g
		with apricots		by weight/packaged	6	48g
		with raisins		by weight/packaged	1 tablespoon	30g
		with skimmed milk	Benna	Carton flask (green)	1 cup	240ml
		with honey		Canned	2 heaped teaspoons	17g
		Fruit cocktail		Canned in syrup	1/2 can	210g
		Orange juice		Fresh	2 medium	
09.00 - 09.30	Snack	Apple		Fresh	1 medium	100g
11.30 - 12.00	Lunch PASTA SALAD	Couscous		Packaged		150g
		with kidney beans		Canned	3 tablespoons	105g
		with chick peas		Canned	3 tablespoons	105g

		with cherry tomatoes		Fresh	8 medium	120g
		with tuna		Canned in brine	1 can	80g
		with lemon juice		Fresh	1 lemon	55g
		Kiwi		Fresh	2 medium	80g
		Apple juice		Packaged	1 glass	240ml
14.00 - 14.30	Snack	Flavoured Yoghurt	Benna	Packaged	1 cup	150g
		Pineapple slices		Canned in juice	1 can	210g
TIME	**MEAL**	**Food**	**Brand**	**Packaging**	**Portion**	**Weight**
16.00 - 16.30	Pre-training meal SPAGHETTI BOLOGNESE	Spaghetti	Misura/Barilla Integrale	Packaged		150g
		with garlic		Fresh	3 cloves	
		with onion		Fresh	1/2 onion	
		with carrots		Fresh	1/2 carrot	60g
		with mince beef		Fresh		100g
		with marrowfat peas		Canned	1 small	125g
17.30	Pre-training snack	Toast	French sliced	Fresh	2 slices	40g
		with jam	Fruit seeds	Canned	4 spreads	60g
		Banana		Fresh and ripe	1 medium	100g
		Water				600ml
18.30 - 20.15	TEST					
	Halftime	Sports drink	Gatorade	Packaged	1 small	500ml
Hydration	*All day*	*Water*				*1-2 litres*

Appendix 24: Soccer-specific performance diet for intervention in Study 1