3.1 Energy Balance in Football

INTRODUCTION

In football, league competition does not require players to "peak" for an individual match. Instead, players are required to sustain a high level of performance over periods of weeks, if not months. Thus, an objective of the professional football player is to maintain a body mass throughout the competitive season that is "realistic" from both a health and performance perspective. The energy intake and macronutrient content of the diet should be adjusted depending on the demands of training or match day performance as well as the specific goals of the player. Therefore, there is no "one size fits all" approach; rather the dietary requirements are specific to the individual player and should be modified depending on the work required (Jeukendrup 2014, Impey, Hammond et al. 2016). To achieve dietary adjustments the nutritionist may modify the training and match environment to impact the "nutrition" behaviour of the player (Module 4) (Betts and Gonzalez (2016)). Nevertheless, ultimatley, educating the player on how to modify energy intake appropriately is the overall objective to achieve long term success. In this unit, we will cover how to apply the basic concepts of energy balance in football**.** The aim of Unit 2 is to understand best practice with regard to body composition assessment as well as the benefits and limtatations of common assessment techniques.

ENERGY FOR FOOTBALL

Energy can be defined as the ability to do work. It is common to use the term "calories" to express the energy content of food. More accurately, energy is measured in Kilocalories (kcal) which are units of heat or Kilojoules (KJ) which are units of work. The energy content of the main macronutrients recommended in a player's diet are listed in Table 1. Different foods will contain more or less energy (kcals). Rarely are the foods or meals a player eats made up of a single macronutrient. To this end, it is important for nutritionists and players to understand the energy available from different dietary sources.

Table 1: Energy content of the main dietary macronutrients

Macronutrient	Energy (Kcal)	Energy (KJ)
1 g carbohydrate	4	16
1 g fat	9	37
1 g protein	4	17

Source: Prepared by the author.

The packaged foods available for players to purchase will carry the nutritional value information. The nutrition information will be listed on the

food label and should contain; the weight of the food, all ingredients (listed in quantity order), the breakdown of macronutrients, storage conditions and finally if the food contains any ingredient which may cause allergic reactions. The energy content of the food should be displayed and the quantity of macronutrients (carbohydrate, proteins and fat) listed on the label. Different counties will have varying legislation with regard to the information required on food packaging. Therefore, it is encouraged for those completing this course to become familiar and understand the food labels of your region.

DID YOU KNOW?

A calorie is a unit of energy. A calorie is the amount of heat required to raise the temperature of 1 gram of water by 1 degree Celsius.

1 calorie = 4.2 Joules
1000 calories = 1 Kcal = 4.2 KJ

PRINCIPLES OF ENERGY BALANCE

Energy balance in football is a dynamic process (Galgani and Ravussin 2008). Energy is provided to the player via all foods and beverages (non-water) in their diet. This energy is used by the player in several fundamental processes including cellular maintenance, thermoregulation, growth, reproduction, immunity and locomotion (Loucks, Kiens et al. 2011). When players train or compete, energy expenditure is increased significantly, which increases the need for additional energy to be ingested through the diet. Numerous factors operate in concert on each side of the energy balance equation, which will ultimately determine the body mass and composition of the player (Manore 2015). Basal metabolic rate (BMR), the thermic effect of food (TEF) and the thermic effect of activity (TEA), all contribute to total energy expenditure (TEE) equation. Thus, total energy expenditure is not easy to accurately calculate.
TEE= BMR + TEF + TEA.

The terms basal metabolic rate (BMR) and resting metabolic rate (RMR) are often used interchangeably. For the purpose of this course both may be defined as the amount of energy required by the players body at rest to maintain basic life functions; such as respiration, circulation, thermoregulation and brain activity.

DID YOU KNOW

The thermic effect of food is the increase in the players metabolic rate that is caused by the ingestion, digestion, metabolism and storage of the food. It is also known as diet induced thermogenesis.

The RMR of a player can be measured using indirect calorimetry (Fogelholm, Kukkonen-Harjula et al. 1995) or prediction equations. Common prediction equations to determine RMR include the Cunningham or Harris-Benedict equations (Cunningham, 1980; Harris & Benedict, 1918). Despite having been developed a century ago, the Harris and Benedict (1918) equation remains a common method to estimate RMR in clinical practices. This equation typically overestimates BMR by at approximately ~5%, and some studies report a variance of error between 10% and 15% (Frankenfield, Rowe, Smith, & Cooney, 2003). Lean body mass (muscle) remains metabolically active when at rest. Thus, lean body mass (LBM), is a good predictor of RMR. Based on this observation a simplified equation to estimate RMR was proposed by Cunningham in 1980. Gender-specific equations will not be required when using this equation as, in general, women players will have lower lean body mass and a greater fat mass in comparison to their male counterparts.

Harris and Benedict BMR equation:

Men: 66.5 + (13.75 x W) + (5 x H) - (6.76 x A)
Women: 655.1 + (9.56 x W) + (1.85 x H) - (4.68 x A)

Where
W: weight, in kg.
H: height, in cm.
A: age, in years.

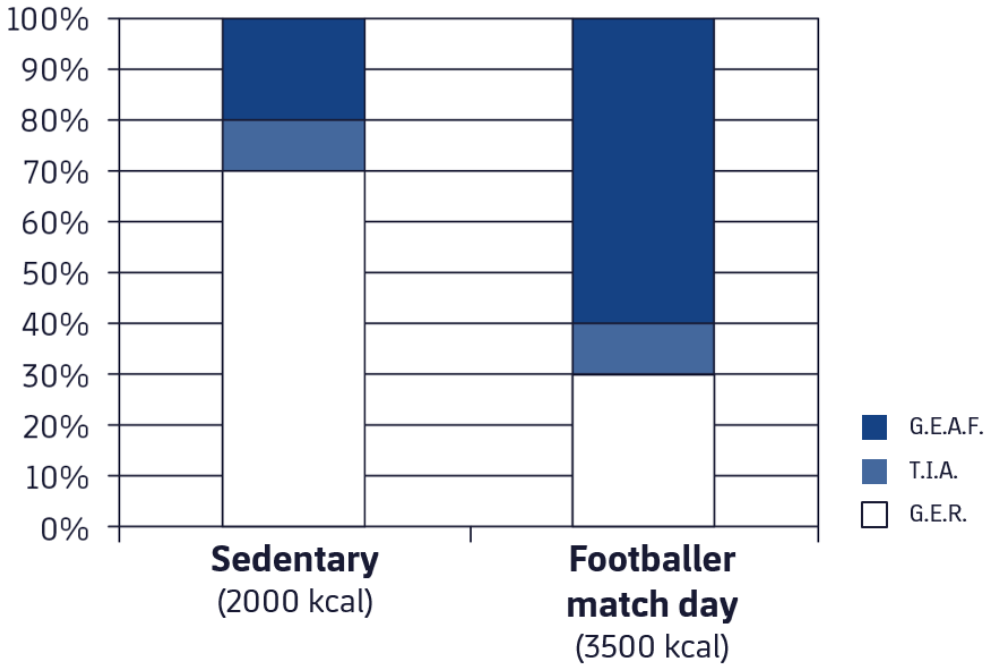
Cunningham (1980):

BMR = 500 + 22 x LBM

Where
LBM: lean body mass, in kg.

The resting energy expenditure of a sedentary adult represents between 60% and 75% of daily energy expenditure, but might be as low as 38-47% of total energy expenditure for football players engaged in intense training, who normally have a thermic effect of activity of approximately 50% of total energy expenditure (Manore & Thompson, 2006).

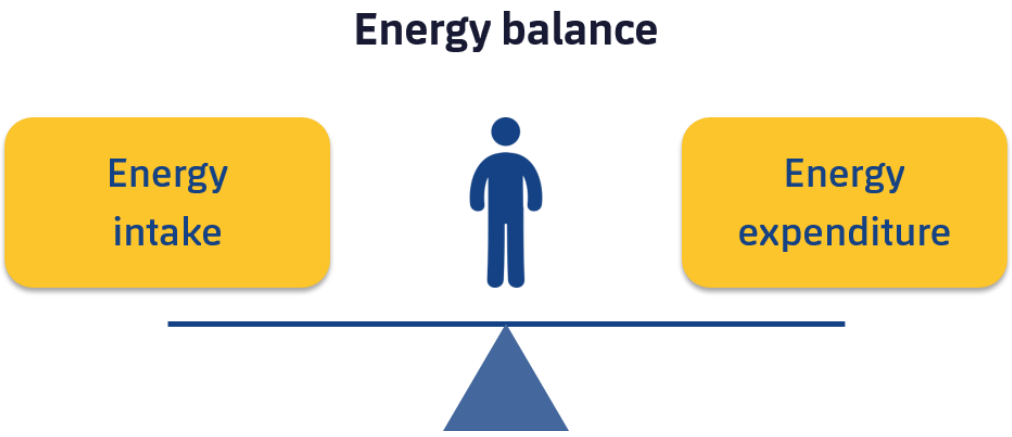
Figure 1. Total energy expenditure (TEE) in a sedentary person in comparison to a football player on match day.



Source: prepared by the author.

If the total energy expenditure of the player, including exercise-related expenditure and the energy required to support daily physiological function, exceeds that of energy intake, the player is said to be in negative energy balance. Alternatively, if energy intake exceeds total energy expenditure, the player will be in positive energy balance. The maintenance of body mass over time is an indication that the player is in a state of energy balance, where energy intake (total calories consumed) equals energy expenditure (total calories expended).

Figure 2:



Source: Prepared by the author.

It is important to recognise that when training is modified to expend more or less energy, players should also modify their diet to increase or reduce energy availability in the management of body composition (Loucks, Kiens et al. 2011). The main factors governing the energy expended during exercise are the intensity and duration of training/matches as well as the amount of muscle the player has. Other factors which also contribute to energy expenditure include exposure to cold or heat, stress, high altitude exposure, specific drugs or medications (e.g. caffeine), increases in lean mass and/or the luteal phase of menstrual cycle can also affect positively energy expenditure (Manore & Thompson, 2000). Conversely, in the event of immobilisation, such as if a player is injured, energy expenditure can be substantially reduced, and therefore energy intake should also be adjusted accordingly. To this end, the energy requirements will vary depending on the individual player and the phase of competition / training / recovery / rehabilitation they are involved in. The diet (energy intake) and training programs (energy expenditure) need to be carefully managed to modify body composition, achieve performance goals, optimise recovery and avoid ill health.

For example, a chronically low energy intake has been considered one of the potential factors contributing to overtraining (Leutholtz & Kreider, 2001). Thus, daily or weekly monitoring of player body mass can provide a gross assessment of a player's energy balance over the season. So that meaningful differences in body mass can be assessed, the players' weight should be recorded at the same time of day and when players are euhydrated.

DID YOU KNOW

Euhydrated means a "normal" state of body water content.

ENERGY EXPENDITURE IN FOOTBALL

The composition of the players' body and their metabolism will influence energy expenditure. For example, players with more muscle expend more energy, even when at rest. It is important to note that away from football, most professional players, on the whole, lead a sedentary lifestyle. For example, a study of Premier League football players reported that 79% of post-training time is spent engaged in sedentary behaviour (Weiler, Aggio et al. 2015). Thus, the major occasions of energy expenditure are training and matches.

There are various methods which can be used to assess energy expenditure in football. From a clinical research perspective, studies have used measurements of body temperature (Saltin and Hermansen 1966, Edwards and Clark 2006), continuous heart rate monitoring (Esposito, Impellizzeri et al. 2004, Eniseler 2005) and light weight portable oxygen analysers (Kawakami, Nozaki et al. 1992). These methods consistently report the mean metabolic load of a football match to be approximately 70% of a player's maximal oxygen uptake. The practicality of using these systems routinely during matches or day-to-day training sessions is not realistic. Furthermore, many of these methods do not provide information on the high intensity exercise component of football, which significantly increases the energy expenditure (Bangsbo 1994, Bangsbo 2014).

To estimate the energy cost of high intensity exercise (sprinting) during football, studies have investigated the correlations between the energy cost of running on flat terrain versus uphill running at constant speed (di Prampero, Fusi et al. 2005, di Prampero, Botter et al. 2015). The estimation of the energic cost of accelerations and decelerations has shown the high intensity efforts account for approximately 42% of the total energy expenditure during a game (Osgnach, Poser et al. 2010).

In order to adequately balance the players' energy intake with their energy expenditure, valid measurements that allow for the quantification of physical activity and energy expenditure are needed. The importance of adequately meeting the players' energy requirements is based on the fact that adequate energy intake is essential for maintaining lean body mass, as well as immune, skeletal health and reproductive functions, i.e. the overall health of the player. Secondary to health, energy intake can be adjusted to optimise the body composition of the player for the ultimate purpose of improving footballing performance (Thomas, Erdman, & Burke, 2016).

MATCHES

Over the last four decades the development of video filming during matches and subsequent computer-aided analysis has led to the accurate assessment of individual physical performance and is commonly used in professional teams (Reilly 1983, Carling, Bloomfield et al. 2008, Carling 2010, Castellano, Alvarez-Pastor et al. 2014, Carling, Bradley et al. 2016). Advanced techniques in video match analysis permit the detailed observation and capture of players' movement, team positioning as well as ball tracking throughout a 90-minute match. The data allows an estimation of energy expenditure of players using distances covered, relative speeds and technical performance (football control). Video analysis also provides valuable insight into the number of ball interactions, passing (number, precision, distance and pitch location), the percentage possession of the ball and areas of the pitch where the greatest activity has occurred (Carling, Le Gall et al. 2012, Schuth, Carr et al. 2016) (Module 1).

Importantly, data provided by global positioning satellite (GPS) may provide a valuable resource for clubs to monitor match (and training) activities which may be used to identify the different energy requirements between players. The GPS units are light weight, safe, easily worn and are unobstructive to the players natural movements. Data gathered from GPS systems can be processed "live" or downloaded rapidly following exercise. This data can be used to classify the time spent at different exercise intensities. The greater time spent at high intensity, the greater the energy expenditure. Energy expenditure is typically calculated by speed, acceleration and total distance data. At present, the current GPS systems and video analysis are unable to account for the energy expenditure associated with activities such as tackling, heading, kicking, dribbling or backwards running (Bangsbo 1994, Bangsbo 2014). As such, it is likely that common methods significantly underestimate total energy expenditure during football specific play (Murakami, Kawakami et al. 2016).

On the appropriate occasions, a player will control and dibble the ball leading up to 4 seconds of possession. Dribbling a ball has been reported to increase the energy cost (+5.2 kJ /min) of exercise (Reilly 1997). The increased energy cost is likely to be a consequence of the player breaking from their optimal stride pattern and the additional muscle recruited to control the ball and move it forward.

Tabulating the results of research investigating professional football reveals that the total distance covered in a match ranges from 10 to 13 km, with differences related to standard of play, position of the player and tactics of the team (Bangsbo 1994, Mohr, Krustrup et al. 2003, Bangsbo, Mohr et al. 2006, Bangsbo 2014). High energy demanding sprints are associated with the critical moments during a match (Gregson, Drust et al. 2010, Faude, Koch et al. 2012). The corresponding average energy expenditure during matches has been estimated to range between 1000-1500 Kilocalories (Kcal)

(Ekblom 1986, Bangsbo 1994, Stolen, Chamari et al. 2005, Bangsbo, Mohr et al. 2006).

It is important to note that greater energy expenditures (i.e. distance covered and high intensity running) do not necessarily translate to superior "performance" in football (Bradley, Lago-Penas et al. 2013, Di Mascio and Bradley 2013, Fernandez-Navarro, Fradua et al. 2016). For example, analysis of La Liga professional teams revealed that the top-class players performed less high-intensity activity (>19.1 km/h) during a game which they were winning in comparison to when they were losing (Lago, Casais et al. 2010). Therefore, it is important to note that the factors which influence the energy expended during matches are highly complex and are affected by, amongst many others, physical and mental fatigue, the phase of play and team tactics (Paul, Bradley et al. 2015) (module 1).

To date, few studies have reported the daily energy expenditure of professional players using the gold standard of doubly labelled water which would capture energy expenditure non-invasively under "free living" conditions (Westerterp, Saris et al. 1986). Those studies which have used doubly labelled water have measured both energy expenditure and energy intake during a two-game week playing schedule where consecutive games were separated by two days. Interestingly, the mean values of daily energy expenditure (3566 ± 585 kcal) and energy intake (3186 ± 367 kcal) of six premier league footballers are remarkably similar to those reported previously in seven professional Japanese players (3532 ± 432 and 3113 ± 581 kcal, respectively) (Ebine, Rafamantanantsoa et al. 2002, Anderson, Orme et al. 2017).

Table 2. Individual differences and average daily energy intake and average daily energy expenditure of professional football players during a 7-day period of the competitive season

Player	Energy intake (kcals)	Energy expenditure (kacls)	Body Mass Day 0 (kg)	Body Mass Day 8 (kg)
1 (CF)	2817	3047	90.1	89.2
2 (WD)	2905	3050	73.2	73.7
3(WM)	3563	4140	71.0	71.1
4(CDM)	3166	3179	80.1	79.1
5(CAM)	3701	3580	78.9	78.1
6(CB)	2961	4400	89.0	88.9
Mean ± *SD*	3186 ± 367	3566 ± 585	80.4 ± 7.9	80.0± 7.6

Note. Each player's position is shown in brackets. CF = center forward, WD=wide defender, WM= wide midfielder, CDM=central defending midfielder, CAM= central attacking midfielder and CD= central defender

Source: retrieved from Anderson et al., 2017.

Players at all levels of the game can experience fatigue as the duration of the match nears 90 min. This is evident through either a decrease in maximal sprint speed or a reduction in distance covered (5%–10%) in the second half (Bangsbo, Mohr et al. 2006, Krustrup, Mohr et al. 2006, Osgnach, Poser et al. 2010, Bendiksen, Bischoff et al. 2012). Fatigue is likely a consequence of the depletion of muscle glycogen; analyses of single muscle fibres after a game have revealed that a significant number of fibres are depleted or partly depleted (Krustrup, Mohr et al. 2006, Bendiksen, Bischoff et al. 2012). This observation highlights the importance of modifying energy intake, specifically with regard to carbohydrate ingestion on match day, to sustain performance for the duration of the match, as well as promoting glycogen resynthesis post exercise.

TRAINING

During a competitive season, professional players have been reported to complete up to 120 team training sessions (Gaudino, Iaia et al. 2015). This equates to approximately 3 training sessions a week during a 38-week season. Therefore, the time spent engaged in training exceeds that of competition. The energy expended during training will vary depending on the intensity and duration of exercise as well as the body composition of the player. Training will also vary depending on the phase of the season and managerial regime. It is common practice for professional clubs to monitor the external training load by GPS systems as well as heart rate and other measures such as player rating of perceived exertion (RPE) scores (Scott,

Lockie et al. 2013, Rampinini, Alberti et al. 2015). Total distances covered at high speed running (>14.4 km/h), number of impacts and accelerations (>3 m/s^2) are representative of higher training loads which can be reflected in the players subjective response to training i.e. via the 1-10 point RPE scale (Gaudino, Iaia et al. 2015). As training intensity and duration is likely to fluctuate given its proximity to match day, it is important for the player to recognise the increase or decrease in energy requirements (Impey, Hammond et al. 2016). Paradoxically, football specific activity, i.e. high intensity exercise, may blunt appetite-regulating hormones, which may consequently result in reduced energy intake and disrupt recovery strategies (Stensel 2010, Deighton, Karra et al. 2013, Bailey, Smith et al. 2015, Briggs, Cockburn et al. 2015). In these circumstances, energy intake can be modified by 1) delaying the intake of food post exercise to allow time for blood to redistribute to the gut from the exercising muscle, 2) adding calories via beverages in the players diet i.e. provide fruit juice or sports beverage rather than water, 3) provide "smaller" meals routinely, rather than a few "big" meals.

ENERGY INTAKE

All foods and several beverages in a player's diet are characterised by their composition of macro and micro nutrients. Macronutrients are carbohydrate, proteins and fats, whilst micronutrients include vitamins and minerals. The energy content of carbohydrate and protein is approximately 4 kcal/g, whereas the energy value of fat is 9 kcal/g (Table 1). The role and appropriate intake of protein and carbohydrate in the players diet are discussed in course 2. Fat is an essential component of the players' diet, providing energy, facilitating the absorption of fat-soluble vitamins and also providing an essential structural component of cell membranes. The recommended daily intake of fat is 1.2 - 1.4 g/kg body mass (Institute of Medicine (IOM) Food and Nutrition Board 2005). Diets abundant in high fat foods are discouraged as they can replace those foods which contain the other macronutrients essential for football performance, recovery and adaptation. Furthermore, because high fat foods are often energy dense, they also carry a risk of delivering excess calories. In general, players are recommended to limit the high fat foods that contain saturated fats, whilst encouraging the ingestion of unsaturated options (Course 2). It is important to note that although not a nutrient, water is the other essential component to a player's dietary intake. Accordingly, it has been postulated that fluid deficits >2% body weight can produce deleterious effects on sports performance, especially in hot weather (Shirreffs & Sawka, 2011).

It is important to note that the misuse of alcohol can be detrimental for achieving nutritional goals because of its potential impact on the player's dietary choices. This is particularly relevant in the post exercise occasion when muscle recovery and glycogen resynthesis should be prioritised (Maughan 2006). Alcohol-containing beverages have a relatively high energy content (7 kcal/g). However, the actions of alcohol on the central

nervous system, are likely to result in impaired skill and poor decision making that may negatively influence performance. The ingestion of excess alcohol is also likely to affect the player hours after ingestion (hangover). Importantly, studies have reported that alcohol consumption reduces rates of muscle protein synthesis following a bout of concurrent exercise, even when co-ingested with protein. Thus, alcohol ingestion will suppress the anabolic response in skeletal muscle. The blunted adaptive response may impair recovery from football training and/or subsequent match performance (Parr, Camera et al. 2014). Players are ultimately responsible for all the foods and drinks they ingest in their diet. Given the strong association between alcohol and football (success), nutritionists should encourage players to drink alcohol responsibly, and avoid excess consumption during the competitive season.

DID YOU KNOW

Concurrent exercise is a combination of resistance and endurance training.

Players are encouraged to work together with the club's professional sports nutritionist or dietician for meal planning based on energy requirements and individual goals, translating nutrient guidelines into food equivalents. Part of the players' nutritional education is to understand those foods which contain more or less of the macronutrients, as well as those foods which are rich in vitamins and minerals. Thus, the player should understand how to piece together meals on a daily basis which provide the appropriate quantity of macro and micro nutrients for health, body composition and performance. The challenge for the nutritionist will be to understand the food preferences of the player, so that nutritional recommendations are realistic. Information of players "routine" foods can be obtained via interview, questionnaires or food diaries.

DID YOU KNOW

A food preference is a greater liking for one food over an alternative. Quite simply, players will not eat or drink something if they do not like it.

Energy intake remains one of the most difficult measures to record accurately in sports nutrition. This is because the measures of energy intake are usually reliant on self-reporting or recall of those players completing them. This process frequently results in an under-reporting of dietary energy intake (Poslusna, Ruprich et al. 2009). Developing expertise in the assessment of energy intake requires an appreciation that there are different reasons for undertaking an assessment, different approaches to completing it and different tools that can be used (Burke 2015). A player's

energy intake from food, fluids and even supplements can be recorded by food weighing methods (taken every 3-7 days), multi-pass 24-h recalls, although such methods have intrinsic limitations, bias being the most prominent one (Thomas, 2016; Table 3). In order to avoid bias, extensive education regarding the purpose and protocols of recording methods is recommended. The gold standard of energy intake assessment would require the players to weigh and record all the food and beverages in their diet. This information is then entered into dietary assessment computer programmes for energy intake and breakdown of macro / micro nutrient content. Nevertheless, even accurate assessments only provide brief insights into the players' energy intake over the duration of the assessment. Food frequency questionnaires are used to assess the frequency, i.e. how often certain types of foods are ingested. This method does not provide information on total energy intake *per se* but can help identify common foods in a player's diet and those foods making the greatest contribution to total energy intake.

Table 3: Traditionally used methods for collecting dietary intake information

	Overwiew of methods	Period of interest	Pros	Cons
Retrospective				
24 h recall	Subject describes foods consumed over the last 24 h or a "typical day".	24 h	- Speedy to implement - Low burden for the subject - Interview can be structured around daily activities - Does not alter intake - Suited to epidemiological research	- Relies on subject's honesty, memory and food knowledge - Requires trained interviewer - Day for recall may be "atypical" - Suitable for group suverys, but not representative of individual's normal intake
Food frecuency Questionnaire (FFQ)	Subjects asked how often they eat foods from a standardized list and to estimate portion sizes often using photos or food models as a prompt	From 24 h period to open- endend	- Can be self- administered to lower burden on the investigator - Can be used to cross-check data obtained from other methods - Validated for ranking individuals - Can be modified to target certain nutrients - Can be automated to allow quick processing by investigator	- Relies on responder's honesty, memory, literacy and food knowledge - Validity dependent on the food list and the quantification method
Diet history	Open-ended inteview concerning food use, food preparation, portion sizes, food like/dislikes and a food checklist	Open-ended or over a specified period	- Accounts for daily variation in food intake by investigating a "typical" day - Can target contrasts between periods of interest as a sub-theme - Collects information on timing on timing of intake and factors that influence food patterns	- Relles on responder's honesty, memory, food knowledge - Labour intensive & time consuming - Requieres trained interviewer - Mostly appropriate for qualitative assessment rather tan quantitative
Prospective				
Written food diary (diet record)	Weighed	May be undertaken for 1-7 d, with increasing ability to track usual intake as duration increases, but reduced compliance	- Provides a more accurate quantification of foods than household measures - Considered the "gold standard for dietary assessment".	- Relies on participant's honesty and food knowledge - Time consuming for subjects to keep and investigator to process - Distorts food choice and quantity: subject alters their diet to improve their intake or to reduce the workload of recording
	Household measures (despriptions of cups, teaspoons, dimensions of food portions, etc)		- Improved compliance with subjects compared with weighed record - Less alteration of normal eating pattern compared to weighed or semi-weighed records	- See comments for weighed record - Requires checking by trained person - Needs standardized set of household measures - Subjective/inaccurate assessment of portion sizes

Source: retrieved from Burke (2015).

Technological advances, through web based or mobile tablet applications, have provided novel ways to collect and process energy intake information. Many of these systems provide electronic versions of paper and pen questionnaires, such as 24 h recall (Rangan, Tieleman et al. 2016). Key advantages of the technology are that applications can provide a huge data base of food pictures, be updated in real time and provide rapid feedback. In the coming years we expect to see these new methods being used to gather information on food practices of athletic populations, including footballers (Stumbo 2013, Burke 2015).

Table 4: New technologies and techniques for dietary assessments

Examples of new protocols	Potential benefits associated with new tolos and techniques
• Web-based food frequency questionnaires and 24 h recall systems using images to guide food portion selections PDA (Personal Digital Assistant) platforms for recording food diaries electronically from food database • Smart card technology to record meals chosen by inmates of a closed environment (e.g. hospital, school, prison) • Smartphone and Tablet apps for directly recording intake of foods from personalised food database, processing nutrient composition and transmiting data to sports nutrition professionals • Digital photography on mobile smartphones that time stamps and confirms food intake • Includes technology that can identify and quantify food intake from these images	• Enhancement of compliance with recording food intake in real time since the electronic device (e.g. mobile pone) may already be an habitual accesory in the athlete's lifestyle • Alternative techniques to gain information on food/fluid descriptions (e.g., automated calculations from digital photos) or food that may be less realiant on the subjetct's motivation or food literacy. • Less bias in alterning typical food patterns since the act of the recording (e.g. scanning, photographing) may be less intrusive, thus reducting the self-reporting • In the case of digital- savvy populations, wich includes most athletes, familiarity and ease of use. • Ability to automatically interface information on food and fluid intake into databases for food composition analyses, assessment and feedback: minimises handling errors and time burden on the researcher/sport dietitian • Ability to transfer information electronically and in realtime, enabling rapid and remote interaction with the sports nutrition professional or other feedback sources • Electronic integration with other data such as training log, energy expenditure calculations, health and physique parameters

Source: Retrieved from Burke (2015).

DID YOU KNOW

Food monotony is common in football players. i.e. players ingest the same types of food all year. The completion of food diaries can identify food monotony. Encourage players to eat sufficient quantities of different types foods to support intake of the various macro and micronutrients.

ENERGY AVAILABILITY

The ingestion of an appropriate amount of energy (energy intake) is the most basic and essential nutritional requirement for all football players. The energy used for vital physiological functions (e.g. maintaining cellular function, thermoregulation, growth, reproduction, immunity, movement, etc) is not available for other functions, such as energy expended when exercising. Thus, energy availability (EA) is the amount of residual energy available for the rest of the biological processes after deducting training energy expenditure.

Determining energy availability offers some advantages over the concept of energy balance when it comes to managing training and for nutritional programs attempting to optimize the players health and performance. One of these advantages is that calculating energy availability involves estimating training energy expenditure instead of a total energy expenditure, which has a larger degree of uncertainty and error. Recent research has identified an energy availability threshold which, when surpassed, shows that reproductive and bone health are negatively affected. The same threshold could also possibly be applied to other pathological conditions as well as other physiological processes such as protein synthesis. As a general rule for healthy adolescents and adults, diets should provide approximately 45 kcal/kg of fat free mass (FFM) per day. Diets providing $\leq$ 30 kcal/kg of FFM have been proposed as a threshold after which reproductive and bone growth formation would be altered (since this value corresponds very closely with resting metabolic rate) (Loucks, Kiens, & Wright, 2011). Insufficient energy availability will also have a negative effect on the immune and reproductive function, especially in female players (Loucks, 2001) (Table 1).

Steps to determine the energy availability in football players:

1- Determine the players fat free mass (FFM, Unit 2)
2- Determine exercise energy expenditure (EEE).
3- Choose an energy availability value appropriate for the player, aligned to the players current training objectives (Table 1).
4- Calculate the required daily energy intake

   EI kcal/day = EA + EEE
5- Build a diet plan that meets that EI, around players preferences.
6- Support the player in completing the diet plan, independent of the players hunger/appetite.

Table 5: A guide to determine the appropriate energy availability according to the players desired Objective

Energy Availability	Player Objective
>45 kcal/kg FFM/day	Gaining body mass, muscle hypertrophy, glycogen overload.
~45 kcal/kg FFM/day	Maintaining body mass, emphasis on motor ability development.
< 45 kcal/kg FFM/day	Losing mass or body fat

Source: Retrieved and adapted from Loucks (2013).

Summary

- An objective of the professional football player is to maintain a body mass that is “realistic” from both a health and performance perspective.
- Energy is measured in Kilocalories (kcal) which are units of heat or Kilojoules (KJ) which are units of work.
- Energy balance of a player is a product of their energy intake and energy expenditure. Routine assessment of a player’s body mass and composition is indicator of their energy balance.
- Energy is provided to the player via all foods and beverages (non-water) in their diet. Energy intake should be modified depending on the daily demands of training or matches (energy expenditure).
- Energy intake is difficult to measure but can be estimated via player interview or the collection of food diaries. From this information, modifications to the players diet may be recommended to achieve their individual goals.