Abstract

Soccer presents a metabolic challenge which is not necessarily matched by players' habitual dietary intake. To examine the effects of a bespoke diet, 22 players completed the $BEAST_{90mod}$ protocol, followed by 4 days of regulated nutritional intake. The diet consisted of 10 $g{\cdot}kg^{-1}$ BM and 1.7 $g{\cdot}kg^{-1}$ BM of carbohydrate and protein. On day five, players followed a pre-match nutritional strategy of 7 $g{\cdot}kg{\cdot}BM^{-1}$ of carbohydrate and 1 $g{\cdot}kg{\cdot}BM^{-1}$ of protein divided into three meals, and then repeated the $BEAST_{90mod}$. The players' pre intervention intake consisted of 49 ± 7.1% or 3.5 g ± 1.0 $g{\cdot}kg^{-1}$ BM for CHO and 19 ± 3.8% of TDEI or 1.3 g ± 0.5 $g{\cdot}kg^{-1}$ BM for protein. Following the tailor made dietary intervention players ran an additional 887 ± 233m (8.1%; d = 2.4). An acute dietary intervention provided a positive effect on a valid simulated soccer match play test.

Keywords: Dietary Intervention, nutrition; performance, $BEAST_{90mod}$

Introduction

Soccer is a physiologically demanding sport (Bangsbo, 1994; Mohr 2003) involving frequent and irregular changes of velocity and anaerobic efforts, combined with longer periods of low-level, moderate-intensity activity, representing a significant challenge to a range of physiological systems (Alghannam, 2013). In competitive matches at elite level, players typically perform between 1000 and 1400 different types of activity, mainly short in nature (~5 to 6s) (Mohr et al., 2003; Stolen, 2005). However, the majority of studies show that approximately 80-90% of soccer performance is spent engaged in low to moderate intensity activity, with the remaining 8-20% representing high intensity activities (Bangsbo, 1994). In terms of distance, this equates to approximately 8 to 9 km of low intensity running, and 1.5 to 2.5 km of running at high velocities and sprints (Bradley, 2010; Barros, 2007).

Irrespective of competitive standards however, fatigue tends to occur during and toward the end of each half and toward the end of matches (Bangsbo et al., 2007; Mohr et al., 2005). This manifests as a reduction in work rate and a reduced level of high intensity activity (Mohr et al., 2003). Although it is unclear what causes transient fatigue during soccer match-play, low muscle glycogen levels are considered to be a key contributor (Mohr et al., 2005). The energy cost of a standard 90-min match ranges from 1195 to 1700 kcal, depending on the total distance covered (~10 to 13 km) and the style of play (Mohr et al., 2003; Stolen, 2005). In an early study, Agnevik (1970) indicated using data obtained from muscle biopsy samples that following a match, players' glycogen stores were significantly reduced. Mohr and colleagues (2003) also quantified match-induced total muscle glycogen concentration reduction in the region of 40 to 90%.

A series of studies have also demonstrated that following a high carbohydrate (CHO) diet before a match has shown to enhance the ability to perform intermittent high intensity activity in both laboratory and field-based environments (Balsom et al. 1999; Pitsiladis and Maughan, 1999). Stored CHO has been shown to effectively fuel the intermittent demands of a match particularly during the second half (Guerra et al. 2001), and replenish depleted energy reserves (Burke et al., 2004). There is also evidence that CHO ingestion prior to activity has a positive influence on subsequent performance either by enhancing muscle glycogen stores, or ensuring availability of blood glucose in the later stages of exercise (Pitsiladis and Maughan, 1999).

Dietary guidelines for CHO intake suggest that soccer players require 5 – 7g·kg·bm^{-1} of CHO during periods of moderate training, or between 10-12g·kg·bm^{-1} of CHO during periods of intense training or match play (FIFA, 2006). Although some formal nutritional guidance has been established for soccer players, guidelines tend to be rather generic, and difficult to interpret in terms of percentages of total daily energy intakes (TDEI). Recent studies tend to also report the relevant values in terms of g·kg·bm^{-1}, a method which is thought to be more practical for nutritionists and players to adopt and interpret (Garcia-Roves et al., 2014). Early dietary surveys of soccer players consistently highlighted inadequacies in the dietary intake of basic essential nutrients in the recommended quantities (Jacobs et al. 1982; Maughan, 1977). More recent data of CHO consumption in soccer players is often also reported lower than that considered appropriate to match physical demands (Garcia-Roves et al., 2014), whereas protein intake is typically sufficient to accommodate even the highest demands (Garcia-Roves et al., 2014; Rico-Sanz et al. 1998). While dietary intake among male soccer players ranges between studies, the typical TDEI reported in a review study was 2500 to 3100 kcal (Garcia-Roves et al., 2014).

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 and semi-professional players as is the case in this study, or amateur players, who ultimately represent the vast majority of soccer players. In some scenarios players at semi-professional level find themselves performing in high level competitions such as the FA cup in England, or in international qualifying competitions for major tournaments like the soccer world cup. Therefore understanding the impact of an optimal nutritional practice on soccer specific physical performance in semi-professional soccer players could have wide ranging implications. Previous research (Sougilis et al., 2013) has examined the influence of high CHO diets on soccer performance by providing both the high and low CHO conditions. However the ecological validity of the impact of an optimal nutritional strategy in different populations is limited as their habitual diet has not been examined and any ergogenic impact of a High CHO diet not compared to the habitual dietary practices of the investigated populations.

The aim of this study therefore, was to examine the habitual dietary (HD) intake of these semi professional soccer players and quantify the impact of an intervention diet (ID) after a substantial nutrition education program which provides an optimal nutritional strategy on soccer-specific physical performance.

Methods

Twenty two semi-professional male soccer players, playing in the Malta BOV Premier League, training daily and having a single weekly competitive match on the weekend, were recruited for the study (Age: 27.1 ± 4.2 y, height: 174.8 ± 6.7cm, body mass: 75.5 ± 8.3 kg). The study was deemed ethically suitable by the departmental ethics committee of the University (SPA-REC-2012-0188), and participants signed informed consent after being informed verbally and in writing about the nature and demands of the study. Participants were screened for contraindications in preparation for the exercise and nutritional intervention according to the ACSM risk stratification guidelines (American College of Sports Medicine, 2017).

The study was carried out over a two week period towards the end of the competitive season, during a break in competition when players had no competitive match demands. Participants were asked to avoid any strenuous exercise apart from their regular training sessions during the two week data collection period. The researcher agreed with the team coach that there needed to be identical moderate intensity training sessions for the first three days of each week.

In the first week, the participants filled in a dietary diary from Monday to Thursday leading up to the first soccer specific exercise protocol (B1) having followed either their normal habitual diet or the experimental diet. The players performed the modified version of the Ball Sport Endurance and Sprint Test ($BEAST90_{mod}$, Akubat et al., 2014). This protocol was chosen due to its ecological validity as it incorporates movements and working intensities similar to a soccer match (Akubat et al., 2014). It has also been reported to show a high degree of reliability (CV <2%) (Akubat et al., 2014). Figure 1 shows the nature of the protocol. Participants were previously familiarised with the BEAST90$_{mod}$ protocol, one week prior to testing, during a scheduled club training session, and most players had experienced the BEAST90$_{mod}$ previously as part of national squad or club commitments.

**** Insert Figure 1 about here ****

In the intervention aspect of the protocol, on the Monday to Thursday preceding the second trial of the BEAST$_{90mod}$ (B2), the participants consumed their individualised diet (ID) consisting of 10 g·kg·bm^{-1} of CHO and 1.7 g·kg·bm^{-11} BM of protein (FIFA/FMARC, 2010). Fat intake did not exceed 30% of TDEI with no more than 10% from saturated fat. Translated to percentage values, the nutritional plans were in the range of 65%, 15% and 20% of TDEI for CHO, protein, and fat, respectively. An appropriate pre-match nutritional strategy was prescribed on the day of the exercise protocol consisting of 7 ± 1 g·kg·bm^{-1} of CHO and 1 ± 0.1 g·kg·bm^{-1} of PRO 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.

Participants were asked to fill in a seven-day Food and Exercise diary 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. 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.

The dietary intake and plans were analysed using specialised software (Microdiet, Downlee Systems Ltd, UK). The content of the nutritional plans generally consisted of the same food and drink items throughout, adjusting quantity according to the players' body mass and corresponding total daily energy requirements. Timing of meals varied where necessary according to the players' lifestyle and work schedule. Players were instructed to drink at least three litres of water throughout the day. Throughout the $BEAST90_{mod}$, players were allowed to sip water ad libitum at the 'stop' stations. At half time they were instructed to drink the 500ml sports drink provided (Gatorade isotonic drink, 5.8g of CHO per 100 ml).

In order to minimise the impact of circadian variation, both trials of the exercise protocol were conducted at the same time (18:30h). Temperatures were similar during both trials (18^{o}C vs 20^{o}C). A standard individual 10 min warm up which consisted of an individualised free running and mobility exercises at a moderate intensity carried out before the commencement of each of the trials. The trials were conducted on a rubber crumb based 3G AstroTurf surface that the players usually trained and played on.

Data Analysis

The exercise protocol data was analysed for the total number of laps and distance covered (m) by the participants in B1 and B2. The dietary record was analysed for TDEI and absolute measures of macronutrient quantities in terms of $g \cdot kg \cdot bm^{-1}$. A number of foods were inserted to the software database as raw data to cater for the consumption of distinctly local foods (Italian and Maltese foods), otherwise the McCance and Widdowson's latest version of foods within the software was used (24).

The data was analysed using IBM SPSS statistics 22 software (SPSS TM Inc., Chicago III, USA). Descriptive sample data are presented as mean (± SD). The effect of condition (pre-post) is analysed using marginal models with SPSS mixed procedure. Unlike repeated measures ANOVA they allow for missing data to be analysed through different covariance structure to be assumed. Effect sizes were calculated using Cohen's d and qualitative interpretations were defined using thresholds at: ≤ 0.2 (trivial), >0.2 (small), >0.6 (moderate), >1.2 (large), >2.0 (very large), and >4.0 (extremely large).

Results

A comparison of the total distance completed by the players in B1 and B2 indicated that players ran significantly further overall in the post dietary intervention compared to the pre dietary intervention (11839 ± 369 m vs 10952 ± 365 m; $p<0.01$**;** Cohens *d;* 2.4**,** very large effect). The data indicates that players ran further in the second half rather than they did in the first half at B1 (5628 ± 313 m vs 5324 ± 135 m; $p<0.01$; Cohens *d;* 1.36, large effect) and B2 (5953 ± 227 vs 5886 ± 153 m; $p<0.01$; Cohens *d;* 0.36, small effect). Furthermore, in the first half players ran a significantly greater distance after the post-dietary intervention test than in the pre-dietary intervention conditions (ID: 5886 ± 153 m vs HD: 5324 ± 135 m; $p<0.01$; Cohens *d;* 3.90, very large effect). In the second half again, players ran significantly further in the post-dietary intervention test than in the pre-dietary intervention (ID: 5953 ± 227 m vs HD: 5628 ± 313 m; $p<0.01$; Cohens *d*; 1.20, large effect).

The dietary analyses of the habitual dietary (HD) intake of carbohydrates, fats and proteins is shown in Table 1.

**** Insert Table 1 about here ****

Discussion

The main finding of the study was that following a dietary intervention where an optimal diet was consumed led to a very large increase in the total distance covered during the $BEAST_{90mod}$. Where previous research has demonstrated differences in work rates in soccer games according to playing level (Mohr et al., 2003), the results of this study demonstrate that at a semi-professional level an appropriate nutritional strategy will benefit a players' capacity for physical performance. Indeed, an improved capacity for physical performance (e.g. increased total distance) has the potential to enable players to have a greater impact upon match-play (e.g. involvements with the ball).

The data shows how in both trials players ran further in the 2nd half. This contradicts some match-play observations which usually report a decrease in distance covered during the 2nd half (Bangsbo et al., 2007; Mohr et al., 2005). However match play data is variable (Gregson et al., 2010) and the stimulus driven energy expenditure in match play situations is affected by a series of factors such as opposition, tactics, game situations, and formations (Akubat et al., 2014). This leads to the variability reported by Gregson et al. (2010) of up to 16%. The $BEAST_{90mod}$ CV is <2% which lends itself as a better tool in assessing nutritional interventions such as this. Furthermore the nature of the $BEAST_{90mod}$ and the instructions given to the players of covering as much distance as possible may have also led to the increased 2nd half distances with a knowledge of the endpoint of exercise. Nevertheless it is clear that the implementation of an optimal nutritional diet increases soccer specific running performance. The previous literature affirms performance enhancement outcomes in soccer in the technical (Abt et al., 1998; Ali et al., 2007; Russell and Kingsley, 2014) and physical aspects as a result of consuming a high CHO diet. This study showed that players on an optimal diet, high in CHO improved performance in the $BEAST_{90mod}$. An improvement in total distance covered (1.3 km) was also found by Sougilis et al. (2013) in players who followed an 84 h high- CHO diet (8 $g \cdot kg^{-1}$ BM), as opposed to players who followed a low CHO (3 $g \cdot kg^{-1}$ BM) diet for three days prior to an 11-a-side soccer match. Apart from improvements in soccer simulation tests as documented above, researchers have also seen improvements in a laboratory environment (Balsom et al., 1999) who showed that players on high CHO diets (65% of TDEI) performed at higher (33%) intensity during a 90min four-a-side indoor soccer game than those on low CHO diets (30% of TDEI). In addition to these findings, Bangsbo et al. (1992) demonstrate an increase of 0.9 km in the distance covered during intermittent running to fatigue by the high CHO group (8 $g \cdot kg^{-1}$ BM of CHO) at the end of the protocol when compared to the control group (4.5 $g \cdot kg^{-1}$ 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 (Karlsson and Saltin, 1971; Williams et al. 1992). 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 2 h 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. The current study contributes to this body of evidence with the addition of understanding the implications for soccer specific physical performance of an optimal diet over a habitual diet in semi-professional soccer players without nutritional support adding ecological validity.

The players' habitual TDEI was 2029 ± 593 kcal, and may be considered comparatively low as Chryssanthopolous et al. (2004) 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, 1999), 3066 (36) and 3127 kcal per day (Reilly, 1994), respectively.

In this study, mean CHO intake was 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 intake showed a discrepancy in CHO intake in comparison to the recommended guideline of 7 – 12 g·kg^{-1} BM for players engaged in moderate to high intensity training (Burke et al., 2004, Maughan et al., 2004). Low consumption of CHO typically corresponded with a generally low overall energy intake as previously discussed. 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.

The team's mean daily protein intake (1.3 ± 0.5 g·kg^{-1} BM) failed to meet the recommended guidelines 1.4-1.7 g·kg^{-1} BM according to Boisseau et al. (2002). The discrepancy between actual intake and recommended guidelines tend to be greater in the case of CHO than that of protein (15). The two players who exceeded the recommended intake (2.0 and 2.6 g·kg^{-1} BM) used protein shakes in their daily diet. Fat contributed to 31% of TDEI and can be considered close to recommended amounts (FIFA/FMARC, 2010). Where players tended to over consume this nutrient in their daily diets it was mainly as a result of excessive "junk food" intake according to the diet diaries. The highest percentage recorded for fat was 45% of TDEI, while the minimum intake was 24%.

The under reporting of energy intake (EI) though dietary diaries is well documented (Black et al., 1993; Livingstone et al., 1992; Rennie et al., 2007) and in this study the players it would seem, have significantly under reported their dietary intake. However in lean subjects, as are our soccer players, under reporting is reported to be less than in overweight subjects. Rennie and colleagues (2007) reported that men under reported their energy intake by 27% and, that 75% of men were classified as under reporters. Hence in future, it would seem reasonable to suggest that players are provided with a substantial education package in order to help them recognise the issues with under reporting.

Conclusion

The results of this study demonstrate that the habitual TDEI and CHO intake in semi-elite footballers, falls well below the recommended levels, though under reporting was a significant issue. The implementation of an optimal nutritional strategy, alongside a nutrition education plan, in semi-professional soccer players can have a large effect on their physical performance capability. This of practical importance as equivalent performance improvements from gains in fitness that may takes long periods of time or may not even be possible due to the genetic potential of studied players.

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Table and Figure Legends

Table 1. Descriptive data of the players' habitual diet

Figure 1. The Beast$_{90mod}$ (Akubat et al, 2014)