Article

Not peer-reviewed version

Macronutrients Intake, and Performance of Professional Football Players from Morocco in a Pre-season Training Period

Mourad Oukheda * , Khawla Bouaouda , Karima Mohtadi , Halima Lebrazi , Abdelfettah Derouiche , Anass Kettani , Rachid Saïle , Hassan Taki

Posted Date: 23 August 2023

doi: 10.20944/preprints202308.1600.v1

Keywords: Dietary Intake; Macronutrients; Sport Nutrition; Sport Performance; Football; VO2max

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 23 August 2023 doi:10.20944/preprints202308.1600.v1

Article

Macronutrients Intake, and Performance of Professional Football Players from Morocco in Pre-Season Training Period

Mourad Oukheda [1], Khawla Bouaouda [1], Karima Mohtadi [1], Halima Lebrazi [1], Abdelfettah Derouiche [1], Anass Kettani [1,2], Rachid Saile [1] and Hassan Taki [1,*]

[1] Laboratoire de recherche en biologie et santé, URAC 34, faculté des sciences Ben M'sik, Centre de recherche en Biotechnologie, Université Hassan II de Casablanca, Maroc, Avenue Cdt Driss El Harti, B.P. 7955, Sidi Othmane, Casablanca, Morocco, Mourad.oukheda@gmail.com; khawla.bouaouda-etu@etu.univh2c.ma, karima.mohtadi@univh2c.ma, Halima.lebrazi@univh2c.ma, afderouiche@gmail.com, akettani9@yahoo.fr, anass.kettani@univh2c.ma , sailerachid@yahoo.fr, rachid.saile@univh2c.ma, hassantaki308@yahoo.fr; hassan.taki@univh2c.ma

[2] Mohammed VI Center for Research and Innovation, Mohamed Al Jazouli Street, Rabat, akettani9@yahoo.fr, anass.kettani@univh2c.ma

* Correspondence: Mourad.oukheda@gmail.com; Tel.: (+212701268660)

Abstract: This study represents the first to examine the nutritional status of Moroccan football players. The aim of this research is to assess the energy and macronutrient intake of professional players from a club competing in the Moroccan professional league "Botola-Pro." Moreover, the study tries to find the potential correlation between nutritional intake and physical performance. A total of 27 professional players participated in a seven consecutive-day study, during a microcycle of the preseason period. The dietary intake was evaluated using the self-reported, complemented by a 24-hour recall. The InBody 120 bioelectrical impedance was employed for assessing body composition measurements, while the Yo-Yo test was utilized to evaluate physical performance; which estimates the maximal oxygen consumption level (VO2max). Among these players, their protein intake levels aligned with recommendations (1.6 to 2.2 g/kg of Body Mass). On the other hand, fat intake slightly surpassed the recommended values. However, carbohydrate intake was relatively subdued compared to recommendations of the Union of European Football Associations (UEFA) in the pre-season training phase. A positive correlation was observed (P-value of < 0.001 and R=0.831) between carbohydrate intake and the measure of VO2max. This suggests that an increase in carbohydrate consumption is associated with enhanced performance, especially within the range of 6 to 8 g/kg BM per day. Conversely, a negative correlation was identified (P-value of < 0.01 and R= − 0.847) between the percentage of dietary fat and the VO2max. The findings of this study highlight areas of nutrition that could be enhanced among professional football players to optimize their performance. In effect, nutritional education is necessary for this category of athletes. Thus, an individual care approach is strongly recommended.

Keywords: dietary intake; macronutrients; sport nutrition; sport performance; football; VO2max

1. Introduction

During intermittent physical activity like in football[1] , the body undergoes multiple biochemical and biological changes to meet heightened demands for energy and oxygen. At the cellular level, particularly in muscle and liver cells, exercise stimulates an increased demand for energy needed for muscle contraction. This triggers the breakdown of glucose and fatty acids, generating adenosine triphosphate (ATP), the primary cellular energy source. These metabolic processes, such as glycolysis, beta-oxidation of fatty acids, and the Krebs cycle, ensure the necessary ATP production to support muscle activity[2]. Concurrently, the cardiovascular system becomes active, and oxygen consumption rises, prompting faster respiration and increased lung ventilation to supply sufficient oxygen to active muscles[3]. When oxygen supply can't meet energy demands, anaerobic glycolysis comes into play, producing lactic acid as a byproduct. The accumulation of lactic acid can lead to a sensation of muscle burning and fatigue. Due to lactic acid accumulation and increased carbon dioxide production, heightened metabolism generates free radicals that act as molecular signals, triggering cellular adaptations and regulating cellular signaling (acid-base balance). However, an excessive production of reactive oxygen species (ROS) can lead to oxidative damage. The body's buffer systems, like proteins and bicarbonate ions, stabilize pH by neutralizing $H+$ ions and limiting pH fluctuations[4].

Football players engage mutually anaerobic and aerobic systems simultaneously during training sessions and matches, with their specific energy and nutritional needs varying based on the category and phases of training and competition[5]. As a result, nutrition plays a fundamental role in performance optimization and sustaining overall health and training resilience during the season[6].

Referring to an analysis of the literature review conducted using scientific search engines such as "Scopus," "Science Direct," and "PubMed," there is currently no available data in Morocco concerning the analysis of nutritional status in terms of macronutrients and their impact on the performance of professional football players during the preseason preparation period. This lack of data is surprising, given that nutrition has always been considered a key factor for performance and physical development, adequate consumption of macronutrients, micronutrients, and fluids promotes better energy supply essential for health on one hand, and on the other hand, meets the demands of physical activity during training, thus optimizing sports performance and ensuring optimal recovery to prevent injuries[7].

Indeed, the aim of this study is to evaluate the nutritional intake (energy, carbohydrates, proteins, and lipids) of professional football players from a club competing in the Moroccan professional league "Botola-Pro." Additionally, the study aims to investigate potential correlations between nutritional intake and physical performance, using the validated physiological Yo-Yo Test, which estimates the maximal oxygen consumption level (VO2max)[8]. The goal is to emphasize the importance of monitoring nutritional intake as a method to optimize players' performance and prevent any dietary imbalances. To achieve this, we will refer to the latest recommendations from UEFA consensus on sports nutrition experts[9]. We will verify whether these footballers consume the recommended quantities of protein (1.6 to 2.2 g/kg of body weight), carbohydrates (6 to 8 g/kg of body weight), and lipids (20 to 35% of the energy ratio) in order to meet the requirements of this pre-season period, as well as to support the physiological demands of the Yo-Yo Test and achieve the greatest distance.

2. Materials and Methods

It is a professional club ranked higher in the Moroccan professional championship "Botola-Pro." Our study was conducted during the preparation period of the 2022 sports season. To address the subject, we conducted a literature review on scientific research platforms, including Scopus, Web of Science, and ScienceDirect.

This study was conducted following the ethical guidelines outlined in the Declaration of Helsinki and obtained approval from the regional ethics committee of the Ibn Rochd University Hospital Center in Casablanca, Ministry of Health, Morocco (Approval No. 22/2022). The subjects participated voluntarily and could withdraw at any time. The dietary analysis adhered to the scientific protocols used in this type of work, and the results regarding nutritional intake were compared to the UEFA recommendations.

2.1. Participants

This consists of a total of twenty-seven professional players from a professional team in Morocco. Goalkeepers have been excluded due to the differences in their training methods compared to outfield players. Our sample includes 12 defenders, 10 midfielders, and 5 forwards. It is noteworthy that two player profiles were excluded from the study: those with long-term injuries and those who submitted incomplete dietary records. All surveyed players actively took part in the summer general preparation period and were subjected to similar training loads (Table 1).

 doi:10.20944/preprints202308.1600.v1

Additionally, it is worth emphasizing that the consumption of products and dietary supplements was monitored by medical staff, ensuring uniformity in intake.

Table 1. program training.

Days	Training option	Duration (min)
Day 1	Morning: Physical training	90
	Afternoon: Technical training	90
Day 2	Morning: Technical and strength training	90
	Afternoon: Tactical training	90
Day 3	Morning: Interval training	90
	Afternoon: Technical training	90
Day 4	Morning: Physical training: endurance	90
	Afternoon: Technical training	90
Day 5	Morning: Power, and speed training	90
Day 6	Afternoon: worm up and Yo-Yo test	90
Day 7	off	---

2.2. Anthropometric Measurements

The participants' characteristics are presented in Table 2. All measurements were conducted using the InBody 120 bioelectrical impedance analyzer, developed by InBody Co., Ltd. This analyzer operates at frequencies of 20 and 100 kHz, generating a current of 150 µA (± 50 µA). It provides comprehensive results, including weight, BMI, body muscle mass (BMM), body fat mass (BFM), and basal metabolism (BM)[10,11].

All measurements were taken over a period of seven days, in parallel with the dietary survey. Athletes were instructed to remove their shoes and any other weighted objects that could affect the measurement. Height measurements of the subjects were taken using a stadiometer with a precision of ±0.1 mm to ensure maximum accuracy. All measurements were conducted before the morning training session to maintain consistency.

2.3. Nutritional Assessment

The dietary intake was assessed over a period of seven consecutive days using the self-reported uniform diet diary method, accompanied by a 24-hour recall[12]. This evaluation took place during the first half of the 2022 competitive season, specifically in the initial microcycle of the general physical preparation period, with the objective of determining and examining the players' VO2max and others technical capacities.

The seven-day data collection period was chosen as it's considered favorable by the scientific community, representing the timeframe associated with providing valid nutritional estimates to reasonably and accurately analyze habitual energy and nutrient intake while reducing variability in coding errors[13]. This was aimed at ensuring the validity of the collected data.

A series of lectures and training sessions were organized by the lead researcher to inform the players and club coaching staff. Energy intake was assessed and expressed in kilocalories (kcal) and kilocalories per kilogram of lean body mass (kcal/kg BM). Similarly, macronutrient intakes were analyzed and presented in grams (g) and grams per kilogram of body mass (g/kg BM) for comparison with UEFA recommendations.

As mentioned earlier, the daily recording technique was reinforced by a 24-hour recall conducted by the research team in our laboratory to recover any potentially omitted information by the players when recording their food diaries. The aim was to collect data on food consumption, including snacks, dietary supplements, and other consumables. During this process, common household measurements such as spoons, glasses, and dinnerware were utilized by the researchers

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 23 August 2023 doi:10.20944/preprints202308.1600.v1

to assist the players in providing a more accurate estimation of the quantities consumed, thus facilitating a complementary analysis of the food diaries.

Furthermore, in accordance with scientific research, particularly the work conducted by Martin et al. (2009)[14], we employed the Remote Food Photographic Method (RFPM) to accurately measure energy intake. This approach allows for better assessment of portion sizes and offers the opportunity to retrieve any potentially omitted information by the players when recording their food diaries.

This step was scheduled one hour before the training and immediately after each session to avoid disrupting the players' training program.

Dietary intake analysis was analyzed using the Nutrilog 3.30 professional software[15] ,which relied on the Ciqual 2020 food composition database. This extensive database provided detailed information on the nutritional composition of different components, including carbohydrates, sugars, proteins, lipids, fatty acids, salt, vitamins, minerals, and energy values of foods. To ensure utmost accuracy in the results, the analysis was conducted by a specialized nutrition researcher.

2.4. Performance assessment

The sports performance of the participants was evaluated using the Yo-Yo Intermittent Test, following the protocol established by Bangsbo et al[8] and Estimated VO2max was completed using the following formula:

VO2max (ml/min/kg) = Yo-YoIR1 distance (m) 3 0.0084 + 36.4.

This test was conducted on an outdoor grass training field to ensure as similar conditions as possible for all players in terms of temperature, wind, and other weather conditions.

Before the test, a warm-up session was supervised by the team's fitness coach, and all players participated to prepare for the test. The pace of each run was controlled using an imposed audio recording, gradually accelerating throughout the test. Each participant had to adhere to the prescribed pace and stay in their designated lane. If a player was unable to keep up with the prescribed pace, it indicated that their abilities were surpassed, and in such cases, the player was informed to leave the test area.

A doctor was also present throughout the testing process to ensure a safe environment. After completing the test, the participants had the option to continue running at a lower intensity for a while to cool down.

2.5. Statistical analysis

The analysis of the collected data was performed using the Statistical Package for the Social Sciences (SPSS) software (IBM, SPSS Statistics, Version 27, Chicago IL). Descriptive statistics were determined: minimum (min) and maximum (max) value, mean value (x) and standard deviation (SD). Additionally, The normal distribution of differences between data pairs was verified with Shapiro-Wilk tests (P>0.02 for all variables) and the categorical variables were tested using the Chi2 test; the differences between the groups and means were compared using the Student’s and ANOVA, the test Pearson’s correlation coefficient (r) was used to examine correlations between the selected variables. Statistically significant differences between the studied groups or association between variables were confirmed if the p-value was less than 0.05

3. Results

3.1. Sample characteristics

This concerns a total of 27 professional players who compete in the Moroccan professional championship 'Botola Pro'. The Table 2 presents the anthropometric characteristics along with their means and standard deviations. The average age of the subjects was 25 years, with the youngest participant being 21 years old and the oldest being 35 years old. Generally, Attackers have a lower average age compared to defenders and midfielders, with an average of 24 ± 4.0 years. On average, the players were 179 cm tall, with defenders and Attackers being the tallest. These players weighed an average of 72 kg, while midfielders tended to be lighter with an average of 67 ± 5.4 kg. The mean body mass index (BMI) was estimated at 22.4 kg/m², showing no significant variation across playing positions. Furthermore, a significant variation in fat mass (ranging from 6.9% to 14.1%) was observed, with an average of 10.1 ± 2.1%

Table 2. Participant characteristics.

	Post Playing				
	Defender	Midfielder	Attacker	Total	
	Mean±SD	Mean±SD	Mean±SD	Mean	Range
Age (years)	25± 3,6	25±4,1	24±4,0	25±3,7	21–35
Weight (kg)	74±5,7	67±5,4	75±9,0	72±6,9	60–88
Height (cm)	181±6,2	174±9,5	183±8,1	179±8,4	158–195
BMI	22,5±1,0	22,3±1,1	22,2±0,9	22,4±1,0	20,7–24,3
BFM (%)	10,5±2,6	9,4±2,0	10,3±0,6	10,1±2,1	6,9–14,1

SD—Standard Deviation; BMI—Body Mass Index; BFM—Body Fat Mass.

3.2. Energy and Macronutrient Intake

The Shapiro-Wilk test revealed that the data pertaining to the total energy intake follows a normal distribution (p-value > 0.02 was observed). Concerning these players, their average dietary intake amounts to 3015.8 ± 369.2 kcal, distributed as 50% carbohydrates, 16% proteins, and 34% fat in terms of energy ratio. The intake values vary, ranging from 2365.8 kcal (minimum) to 3744.2 kcal (maximum), as shown in Table 3.

A significant difference with a p-value < 0.001 was observed in comparison with the UEFA (Union of European Football Associations) consensus sports nutrition recommendations from 2020.

The energy distribution, as illustrated in Figure 1(a), highlights that approximately half of the team under study had a dietary intake exceeding 3000 Kcal. Conversely, one quartile reflects a comparatively moderate energy consumption, ranging from 2400 to 2800 Kcal, a level noticeably lower than the established recommendations of the scientific community.

The fiber consumption has remained relatively adequate in comparison with scientific recommendations, averaging 27.1 ± 1.7 grams.

Table 3. Energy and Macronutrient intake.

	Recommendations	Mean±SD	Range	*P value*
Energy Intake				
TEI (Kcal/day)	3400–4300[16]	3015,8±369,2	2365,8–3744,2	< 0.001
Fiber by g/d	20–40[16]	27,1±1,7	24,3–31,2	< 0.001
Carbohydrates				
CHO (% Energy)	–	50±4,5	41,6–57,4	
CHO g/kg BM	6–8[9]	5,2±0,8	3,8–6,5	< 0.001
Protein				

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 23 August 2023 doi:10.20944/preprints202308.1600.v1

PRO (% Energy)	–	16±1,6	13,7–19,6	
PRO g/kg BM	1,6–2,2[9]	1,7±0,2	1,3–2,3	< 0.05
Fat				
FAT (% Energy)	20–35 %[9]	34±5,1	25,0–42,0	
FAT g/kg BM	–	1,5±0,2	1,2–1,8	< 0.001

TEI—Total Energy Intake; CHO— Carbohydrates; PRO—Protein; BM—Body Mass.

Following the Shapiro-Wilk test, it was observed a (P-value > 0.02 was noted) that the data concerning the intake of carbohydrates, proteins, and fat in grams per kilogram of body Mass (g/kg BM) - follow a normal distribution.

The mean daily carbohydrate consumption by these football players was 5.2 ± 0.8 g/kg BM, with a range from 3.8 to 6.5 grams. The energy ratio was 50%. A significant difference was observed between this mean and the recommended value (p-value < 0.001, Table 3).

As depicted in Figure 1(b), a minority of 5.44% had a dietary intake of less than 4 g/kg of body mass per day, 19.29% ranged between 4 and 5 g, 40.35% between 5 and 6 g, and finally, a percentage of 34.91% had a higher carbohydrate intake exceeding 6 g.

The protein intake of the analyzed players was assessed at 1.7 ± 0.2 g/kg BM. The lowest recorded value was 1.3 g, while the highest reached 2.3 g (Table 3). The distribution, as illustrated in Figure 1(c), demonstrates that over half exceed the threshold of 1.6 g, while 25 to 30% of players fall below recommendations. This observation was supported by a significant difference with a (P value < 0.05). The energy ratio of this protein consumption is indicated by a value of 16%.

The Fat contribute at a rate of 34% in terms of energy ratio. The highest value is represented by a percentage of 42%, while the lowest is recorded at 25% (Table 3). Additionally, an observation has been made (Figure 1 (d)) that the mean is aligning more closely with the recommended limit, as it approaches the threshold of 35%. Only a quarter (25%) of the players exhibit values ranging from 25% to 30%, whereas 75% surpass the 30% mark, including a quarter that exceeds 37.5%.

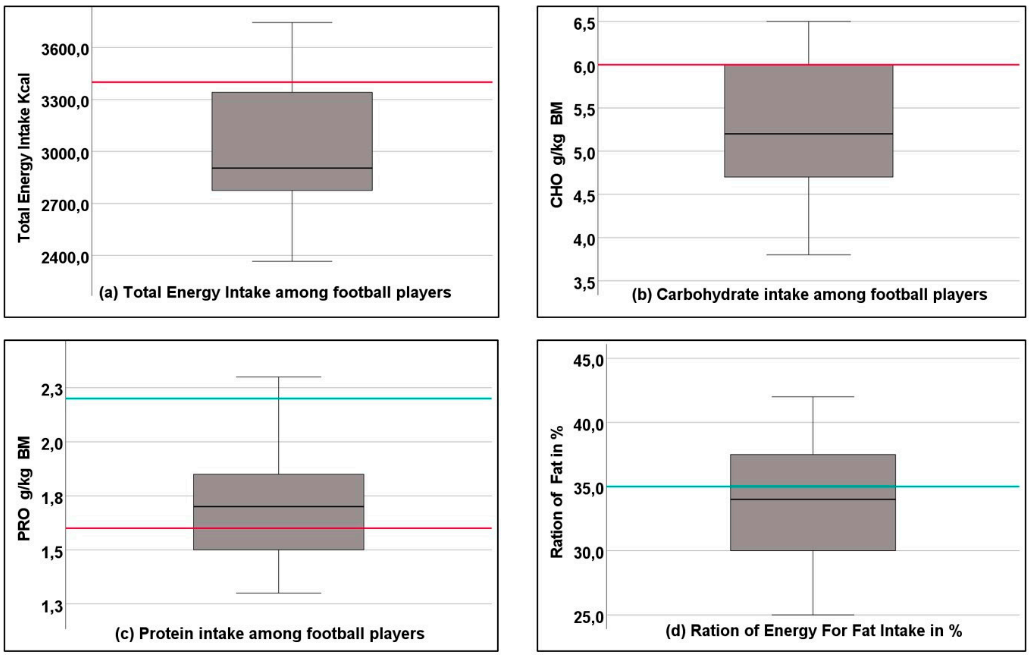

Figure 1. Energy, and Macronutrient's intake among football players. The red line indicates the lower limit of the recommended and the green line the upper limit of the recommended intake

3.3. Performance

The Table 4 highlights the distances covered during the Yo-Yo test in meters, along with estimates of VO2max in ml/min/kg and the maximum aerobic velocity (VMA) in km/h. The professional players achieved an average distance covered of 2512.6 ± 554.4 meters. The farthest distance recorded was 3580 meters, while the lowest was 1860 meters. These findings correspond to a maximal oxygen volume of 57.5 ± 4.7 ml/min/kg, with a range spanning from 52.0 to 66.5. These data demonstrate a normal distribution consistent with the standard curve. This observation was substantiated by a p-value > 0.02 in the Shapiro-Wilk normality test.

Table 4. Yo-Yo test total distance and estimated VO2max (ml/min/kg).

	Mean±SD	Range
Yo-Yo test	2512,6±554,4	1860,0–3580,0
VO2max	57,5±4,7	52,0–66,5
VMA	16,4±1,3	14,9–19,0

3.4. Comparison of Absolute Values of Macronutrients Intake and Physical Performance

After confirming the previously mentioned normality, we proceeded with parametric tests. In this section of our analysis, we employed the Pearson correlation test to assess the relationships between variables. More specifically, we examined the correlations between VO2max values and total energy intake firstly, followed by carbohydrate intake, then protein intake, and finally the energy ratio provided by fat.

3.4.1. Energy Intake and Physical Performance (VO2max)

The Pearson test unveiled a significant positive correlation, with a P-value of < 0.01, between energy intake level and VO2max, showing a coefficient R of 0.556. This correlation is vividly showed in Figure 2 (a), where the coefficient of determination R^2 reaches 0.31. These findings substantiate that higher energy intakes are linked to enhanced performance.

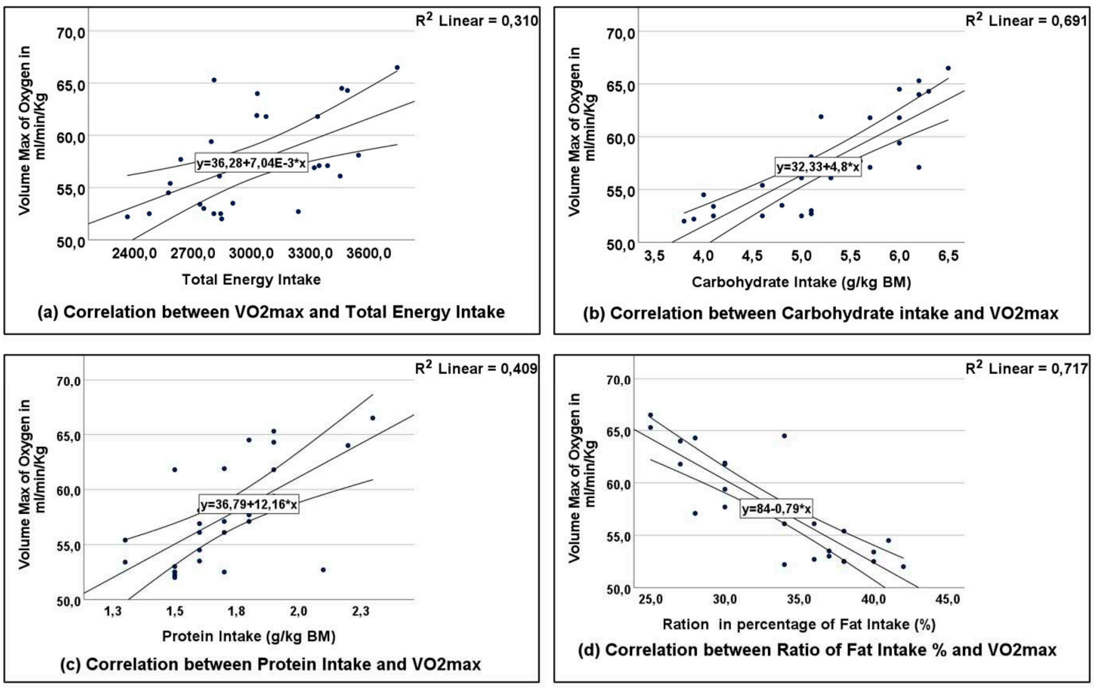

Figure 2. Correlation between (Energy, and Macronutrient's intake among football players) and VO2max in ml/min/Kg. The Dots represent individual participants and the area indicates 95% CI.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 23 August 2023 doi:10.20944/preprints202308.1600.v1

3.4.2. Carbohydrate Intake and Physical Performance (VO2max)

In relation to carbohydrates, a significant positive correlation was observed with a P-value of < 0.001 between carbohydrate intake levels (CHO) and VO2max, with a coefficient R of 0.831. This correlation is illustrated in Figure 2 (b) and displays a linear relationship, with a coefficient of determination R^2 of 0.691. This indicates that a higher carbohydrate intake is associated with better performance.

Given this significant correlation, we opted for a one-way analysis of variance (ANOVA) (with post hoc tests and the Tukey test) to determine which carbohydrate intake level enhances sports performance. To do so, participants were divided into four groups based on the amount of carbohydrates consumed (less than 4 g, 4 g to 5 g, 5 g to 6 g, and over 6 g). The results of this test showed that groups with carbohydrate intake exceeding 6 g exhibited the highest performance ($P < 0.01$, $F = 17.85$) compared to the other groups.

3.4.3. Protein Intake and Physical Performance (VO2max)

On the other hand, the Pearson correlation test revealed a significant positive correlation (P-value < 0.01) between protein intake level and VO2max, with a coefficient R of 0.64. This correlation is clearly depicted in Figure 2 (c), with a coefficient of determination R^2 of 0.40. However, this correlation is not as strong as the one observed for carbohydrates. Nevertheless, these results also demonstrate that having an adequate protein intake can enhance performance.

3.4.4. Ratio of Fat energy and Physical Performance (VO2max)

In contrast to the previous correlations observed for macronutrients such as carbohydrates and proteins, the Pearson test this time highlighted a significant negative correlation. A P-value of < 0.01 was observed for the relationship between energy intake from fats and VO2max. The obtained coefficient R is -0.847, clearly illustrating this correlation. This representation is visualized in Figure 2 (d), where the coefficient of determination R^2 reaches -0.717. These findings demonstrate that the higher the players' fat consumption, the more likely their performances are to be affected. Due to this significant correlation, we opted for a one-way analysis of variance (ANOVA) (with post hoc tests and the Tukey test) to determine which level of intake could potentially impact sports performance. To do so, participants were divided into three groups based on their fat energy intake (from 25% to 30%, from 30% to 35%, and over 35%). The results of this test showed that groups with an intake exceeding 35% exhibited the lowest performances ($P < 0.01$, $F = 25,02$) compared to the other groups.

5. Discussion

Thoughtful nutritional choices can significantly contribute to the health and performance of football players, particularly in terms of the type, quality, quantity, and timing of food, fluids, and supplements consumed. These factors can have a notable impact on players' performance and recovery during and between matches. This becomes particularly evident in light of the rapid evolution of the game itself. This evolution is seen as an additional constraint to be considered by those in charge, from the players themselves to the medical and coaching staff[7]. During a 90-minute football match, players cover an average distance of 9 to 13 kilometers, resulting in an energy expenditure ranging from 1000 to 1500 calories. This underscores the pivotal role of tailored nutrition in the preparation for the competitive period[17] .Additionally, it's recommended that footballers adopt an appropriate energy intake to facilitate physical exercises, promote an increase in lean body mass, and decrease body fat mass, as per the recommendations by Burke et al.[18]. These researchers estimate that a player's energy requirements vary between 40 and 70 calories per kilogram of body weight.

The preparation phase has a crucial role in players' fitness and in their physical, technical, and mental readiness. This phase is typically structured as a macrocycle, divided into smaller microcycles, to achieve the set objectives. Despite the absence of official matches, which usually form the main component of competition, the planning includes physiological tests and friendly matches. These activities also necessitate essential energy and nutritional intake to meet the demands of this period.

This is the first study conducted in Morocco to examine the macronutrient intake over a week during the preparatory phase of a professional football team, in order to assess its impact on VO2max performance.

Our study has revealed that the mean energy intake of the professional soccer players was 3015.8 ± 369.2 kcal, spanning from 2365.8 kcal (lowest) to 3744.2 kcal (highest). Furthermore, the distribution of energy ratio for carbohydrates, proteins, and fats was 50%, 16%, and 34% respectively.

The energy consumption of the football players we examined demonstrates a significant similarity across various leagues and player categories. Indeed, our findings indicate comparability with the consumption observed among Dutch Premier League (Eredivisie) players, as evidenced by the study conducted by Bettonviel et al.[19] in the Netherlands in 2016, this research included 14 players with an average age of 22.8 ± 3.7 years, the conclusions of this study revealed an average energy consumption of 2988 ± 583 kcal. Similarly, our observations align with the energy consumption of Brazilian professional players (2924 ± 460 kcal), as illustrated by the study conducted by Raiz el et al.[20] in Brazil in 2017, this research involved 19 Brazilian players with an average age of 20.7 ± 2.0 years. Furthermore, an approximate similarity was noted with the energy consumption of a senior players from the Spanish elite division (3030 ± 141 kcal), as examined in the study conducted in 2005 by Ruiz et al.[21], these players had an average age of 20,09 ± 0,5 years.

Nevertheless, our values are below those observed in football players, as evidenced by the study conducted by Hassapidou et al.[22] in 2000, which involved 21 players with an average age of 24.8 ± 5.5 years from an elite Greek football team during the competitive season, the reported average energy consumption was 3442 ± 158 kcal. Similarly, our findings demonstrate lower energy consumption compared to a sample of 6 senior players aged 27 ± 3 years from the English Premier League (3186 ± 367 kcal), as shown in the study conducted by Anderson et al.[23] during the 2015-2016 season.

Furthermore, the study conducted by Brinkmans et al.[24] from November to April 2019, involving 41 players with an average age of 23 ± 4 years in the Dutch Premier League, reveals an energy value of 3285 ± 354 kcal.

Our findings in terms of energy intake stand out as being higher compared to those observed among Australian, Maltese, Polish, and Slovenian players. Indeed, our observations highlight a superiority in energy consumption compared to Australian players, as demonstrated by the study conducted in 2016 by Devlin et al.[25] this research included 18 players with an average age of 27 ± 5 years and an average reported energy intake of 2247 ± 550 kcal. Similarly, our results also exceed the energy intake of Maltese players, as revealed by the study conducted in 2018 by Bonnicci et al.[26] which focused on the BOV Premier League, this study included 22 players with an average age of 27.1 ± 4.2 years and an average reported energy intake of 2164 ± 498 kcal. Moreover, our findings significantly differ from the estimated energy intake of Polish players (2655.7 ± 448.7 kcal), as mentioned in the study conducted by Książek et al.[27] in 2020. This research was carried out among 26 football players from the Polish "Ekstraleague" with an average age of 27.0 ± 3.7 years. Similarly, the results of our study stand out with higher energy intake compared to Slovenian players, as shown by the study recently conducted in 2022 by Macuh et al.[28] This research, involving 25 professional football players aged 18 to 35 years, revealed an average reported energy intake of 2694 ± 49 kcal.

Although the exercise load of Moroccan football players may be lower than that of professional clubs, especially in Europe, our results indicate that the football players we studied are not consuming enough energy to meet the training demands, particularly during this preparatory phase. It's also worth noting that this preparation period is characterized by long and intense training sessions, making it challenging to replenish their energy even with a balanced diet[18]. Additionally, it's recognized that after intense effort, athletes' appetite decreases significantly. Therefore, the lack of appetite and time might have contributed to the observed energy levels.

Regarding the average carbohydrate consumption (CHO), it showed to 5.2 ± 0.8 g/kg of body weight. The lowest recorded value was 3.8 g/kg, while the highest was 6.5 g/kg of Body Mass, as indicated in the analysis section. Approximately 75% of the players fall below 6 g/kg of BM, as illustrated in Figure 1 (b). This carbohydrate intake by the team differs from the recommended guidelines of 6 to 8 g/kg of body mass for players engaged in moderate-intensity training (UEFA). This observation is further supported by the previously observed strong and significant positive correlation between carbohydrate intake levels (CHO) and VO2max, as depicted in Figure 2 (b). To delve deeper, the ANOVA test revealed that players with carbohydrate consumption exceeding 6 g exhibited the highest performances ($P < 0.01$, $F = 17.85$) compared to the other groups. This implies that an increase in carbohydrate consumption is associated with improved performance.

Our findings are comparable to those of Brazilian professional players [20](5.4 ± 1.9 g/kg body mass/day) during the pre-season period in 2017, observed over three non-consecutive days (two non-consecutive weekdays and one weekend day). Additionally, this aligns with the average daily consumption of dietary carbohydrates by Polish football players [27](5.1 g/kg BM /day) after the supplementation of food carbohydrates.

Additionally, a low consumption of carbohydrates (CHO) generally corresponded to a low overall energy intake, as discussed earlier, the literature also confirms performance improvements in soccer, both at the technical level[29,30], and in physical aspects, due to the consumption of a carbohydrate-rich diet (CHO). This is why nutritional education is crucial at this level of competition, in order to ensure proper energy fueling. This can only be achievable through improved nutritional periodization, as well the exercise triggers numerous molecular pathways[31], the many research has shown that these pathways play a role in the adaptive restructuring of skeletal muscle[32]. These identical pathways overlap with various nutrient sensing mechanisms[33,34]. This interaction between pathways responsive to nutrients and those responsive to exercise suggests that

 doi:10.20944/preprints202308.1600.v1

nutritional strategies could potentially impact not only immediate exercise performance by fueling the activity but also the extent of the adaptive response after a period of structured training.

Due to their crucial role in maintaining and increasing lean muscle mass after intense muscle exercises, thereby contributing to performance enhancement[35], it is generally recommended for adult athletes to increase their protein intake compared to sedentary individuals[17]. Consequently, professional athletes as well as young football players are encouraged to follow the guidelines established by UEFA (which advocate a daily protein consumption ranging from 1.6 to 2.2 grams per kilogram of body weight) with the aim of ensuring adequate intake to support their health and optimize their performance. The findings of this study suggest that the examined players adhered to these protein intake recommendations for adult football practitioners, with a recorded consumption of 1.7 ± 0.2 g/kg. The observed extreme values were 1.3 g/kg as the minimum and 2.3 g/kg as the maximum, equivalent to 16% of the overall energy intake (see Table 2). The distribution, illustrated in Figure 1(c), demonstrates that over half of the players exceed the threshold of 1.6 g.

In addition to overall energy intake and the intake of carbohydrates and proteins, we have also chosen to continue determining whether differences in macronutrient intake, particularly the energy ratio derived from fats, would also influence players' performance in the Yo-Yo test and thus their VO2max level. A negative correlation was observed between the percentage of energy derived from fats in the diet and the achieved performances ($p = -0.847$), visually depicted in Figure 2 (d), where the coefficient of determination R^2 reaches -0.717. To delve further into our discussion, we opted for a one-way analysis of variance (ANOVA) with post hoc tests and the Tukey test. These results demonstrate that higher fat consumption by players is more likely to affect their performances, particularly among groups with an intake exceeding 35%. These groups exhibited the lowest performances ($P < 0.01$, $F = 25.02$) compared to the other groups. Our results were in line with similar studies previously conducted among elite or professional athletes, such as the investigation by Macuh et al.[28], which also revealed a negative correlation between the percentage of energy from dietary fats and the distance covered in the Cooper test ($p = 0.037$). Within this study, it was observed that the proportion of energy derived from fats slightly exceeded the recommended thresholds. Variations in individual players' dietary habits could account for this excess, whether stemming from a preference for fatty meat products, limited dietary diversity, or the consumption of fast food. It is important to underscore the significance of fats in a balanced diet, as they serve to provide energy through lipid breakdown, particularly during intense exertions such as matches or high-intensity training sessions[1,36] as well as during recovery periods. Simultaneously, n-3 fatty acids play an anti-inflammatory role by mitigating the production of pro-inflammatory eicosanoids (prostaglandins, leukotrienes, and thromboxanes), cytokines, and reactive oxygen species[37], which holds particular benefit in a competitive context.

Nevertheless, it is crucial to note that many experts consider fat consumption exceeding 30 to 35% of total energy intake to potentially engender various issues and lead to impaired muscular performance during sporting activities[38]. These findings emphasize the necessity of paying specific attention to the proper allocation of different types of fatty acids within athletes' dietary regimens.

6. Conclusions

As the first study conducted in Morocco, this research aims to gain a better understanding of the dietary habits concerning macronutrients among high-level football players participating in the professional "Botola-Pro" league. Additionally, it seeks to assess the impact of these habits on their performance during the preparation period. Our findings revealed that protein intake levels among football players were in line with recommendations. Conversely, fat intake slightly exceeded the recommended values. However, carbohydrate intake was relatively low compared to the pre-season training phase. The average fiber intake among football players fell within a moderately acceptable range according to recommendations. It is also worth noting that this deficit observation is not limited solely to these players, but is also supported by the results of previous research conducted outside of Morocco. All these studies demonstrated a lower yet still significant average daily energy deficit.

However, a positive correlation was observed between carbohydrate intake and the measure of fitness expressed as VO2max. This suggests that an increase in carbohydrate consumption is associated with enhanced performance, especially within the range of 6 to 8 g/kg BM per day. Conversely, a negative correlation was identified between the percentage of dietary fat and the estimated VO2max level through the Yo-Yo physiological test. No statistically significant differences in terms of performance were noted between groups with appropriate or inadequate protein intake.

Therefore, it would be appropriate to consider additional interventions and raise awareness about nutritional strategies for professional players, taking into account the demands of training and matches. Employing individualized approaches when planning carbohydrate intake for each athlete could assist in supporting their daily nutritional goals.

Author Contributions: Conceptualization, Mourad OUKHEDA, Khawla BOUAOUDA, karima MOHTADI, Halima LEBRAZI, Abdelfettah DEROUICHE, Anass KETTANI, Rachid SAÏLE and Hassan TAKI; Data curation, Mourad OUKHEDA, Halima LEBRAZI, Abdelfettah DEROUICHE, Rachid SAÏLE and Hassan TAKI; Formal analysis, Mourad OUKHEDA, karima MOHTADI, Halima LEBRAZI, Anass KETTANI, Rachid SAÏLE and Hassan TAKI; Investigation, Mourad OUKHEDA, Khawla BOUAOUDA, karima MOHTADI, Halima LEBRAZI, Abdelfettah DEROUICHE and Hassan TAKI; Methodology, Mourad OUKHEDA, Halima LEBRAZI, Abdelfettah DEROUICHE, Rachid SAÏLE and Hassan TAKI; Project administration, Halima LEBRAZI, Rachid SAÏLE and Hassan TAKI; Resources, Halima LEBRAZI; Software, Mourad OUKHEDA, Rachid SAÏLE and Hassan TAKI; Supervision, Halima LEBRAZI, Abdelfettah DEROUICHE, Anass KETTANI, Rachid SAÏLE and Hassan TAKI; Validation, karima MOHTADI, Halima LEBRAZI, Abdelfettah DEROUICHE, Anass KETTANI, Rachid SAÏLE and Hassan TAKI; Visualization, Halima LEBRAZI, Anass KETTANI, Rachid SAÏLE and Hassan TAKI; Writing – original draft, Mourad OUKHEDA, Khawla BOUAOUDA, karima MOHTADI, Halima LEBRAZI and Hassan TAKI; Writing – review & editing, Mourad OUKHEDA, Halima LEBRAZI and Hassan TAKI.

Funding: This research received no external funding.

Data Availability: All data used to support the findings of this study are available from the corresponding author upon reasonable request.

Ethical Approval: This study was conducted in compliance with the principles outlined in the Declaration of Helsinki and received approval from the regional ethics committee of Ibn Rochd University Hospital Center in Casablanca, under reference number 22/2022. Prior to participating in the study, all participants provided their informed consent, which was obtained with the authorization of the club's administration and medical staff.

Acknowledgments: The authors would like to express their heartfelt gratitude to the Department of Biology at the Faculty of Sciences Ben M'sik, Hassan 2 University, and the Professional Football Club for providing the necessary facilities to conduct this study.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. J. Bangsbo, M. Mohr, and P. Krustrup, "Physical and metabolic demands of training and match-play in the elite football player," *J Sports Sci*, vol. 24, no. 7, pp. 665–674, Jul. 2006, doi: 10.1080/02640410500482529.
2. R. A. Robergs, F. Ghiasvand, and D. Parker, "Biochemistry of exercise-induced metabolic acidosis," *Am J Physiol Regul Integr Comp Physiol*, vol. 287, no. 3, pp. R502-516, Sep. 2004, doi: 10.1152/ajpregu.00114.2004.
3. S. K. Powers and M. J. Jackson, "Exercise-induced oxidative stress: cellular mechanisms and impact on muscle force production," *Physiol Rev*, vol. 88, no. 4, pp. 1243–1276, Oct. 2008, doi: 10.1152/physrev.00031.2007.
4. T. L. Merry and M. Ristow, "Mitohormesis in exercise training," *Free Radic Biol Med*, vol. 98, pp. 123–130, Sep. 2016, doi: 10.1016/j.freeradbiomed.2015.11.032.
5. T. Stellingwerff, J. P. Morton, and L. M. Burke, "A Framework for Periodized Nutrition for Athletics," *International Journal of Sport Nutrition and Exercise Metabolism*, vol. 29, no. 2, pp. 141–151, Mar. 2019, doi: 10.1123/ijsnem.2018-0305.
6. K. B. et al, "Role of nutrition in performance enhancement and postexercise recovery | EndNote Click." https://click.endnote.com/viewer?doi=10.2147%2Foajsm.s33605&token=WzM2MjAzMjEsIjEwLjIxNDcvb2Fqc20uczMzNjA1Il0.nBEcwwxfhYgRFEDBCQvgjfZ38Is (accessed Aug. 12, 2023).

7. "Nutrition for football: The FIFA/F-MARC Consensus Conference," *Journal of Sports Sciences*, vol. 24, no. 7, pp. 663–664, Jul. 2006, doi: 10.1080/02640410500482461.
8. J. Bangsbo, F. M. Iaia, and P. Krustrup, "The Yo-Yo Intermittent Recovery Test: A Useful Tool for Evaluation of Physical Performance in Intermittent Sports," *Sports Medicine*, vol. 38, no. 1, pp. 37–51, 2008, doi: 10.2165/00007256-200838010-00004.
9. J. Collins *et al.*, "UEFA expert group statement on nutrition in elite football. Current evidence to inform practical recommendations and guide future research," *Br J Sports Med*, vol. 55, no. 8, p. 416, Apr. 2021, doi: 10.1136/bjsports-2019-101961.
10. A. Fürstenberg and A. Davenport, "Assessment of Body Composition in Peritoneal Dialysis Patients Using Bioelectrical Impedance and Dual-Energy X-Ray Absorptiometry," *Am J Nephrol*, vol. 33, no. 2, pp. 150–156, 2011, doi: 10.1159/000324111.
11. A. C. Utter and P. G. Lambeth, "Evaluation of Multifrequency Bioelectrical Impedance Analysis in Assessing Body Composition of Wrestlers," *Medicine & Science in Sports & Exercise*, vol. 42, no. 2, pp. 361–367, Feb. 2010, doi: 10.1249/MSS.0b013e3181b2e8b4.
12. S. A. Bingham *et al.*, "Comparison of dietary assessment methods in nutritional epidemiology: weighed records *v* . 24 h recalls, food-frequency questionnaires and estimated-diet records," *Br J Nutr*, vol. 72, no. 4, pp. 619–643, Oct. 1994, doi: 10.1079/BJN19940064.
13. A. J. Braakhuis, K. Meredith, G. R. Cox, W. G. Hopkins, and L. M. Burke, "Variability in Estimation of Self-reported Dietary Intake Data from Elite Athletes Resulting from Coding by Different Sports Dietitians," *International Journal of Sport Nutrition and Exercise Metabolism*, vol. 13, no. 2, pp. 152–165, Jun. 2003, doi: 10.1123/ijsnem.13.2.152.
14. C. K. Martin, H. Han, S. M. Coulon, H. R. Allen, C. M. Champagne, and S. D. Anton, "A novel method to remotely measure food intake of free-living individuals in real time: the remote food photography method," *Br J Nutr*, vol. 101, no. 3, pp. 446–456, Jul. 2008, doi: 10.1017/S0007114508027438.
15. M. Garcin, L. Doussot, L. Mille-Hamard, and V. Billat, "Athletes' dietary intake was closer to French RDA's than those of young sedentary counterparts," *Nutrition Research*, vol. 29, no. 10, pp. 736–742, Oct. 2009, doi: 10.1016/j.nutres.2009.10.004.
16. D. Benardot, *Advanced sports nutrition*, 2nd ed. Champaign, IL: Human Kinetics, 2012.
17. M. Briggs, E. Cockburn, P. Rumbold, G. Rae, E. Stevenson, and M. Russell, "Assessment of Energy Intake and Energy Expenditure of Male Adolescent Academy-Level Soccer Players during a Competitive Week," *Nutrients*, vol. 7, no. 10, pp. 8392–8401, Oct. 2015, doi: 10.3390/nu7105400.
18. L. M. Burke, A. B. Loucks, and N. Broad, "Energy and carbohydrate for training and recovery," *J Sports Sci*, vol. 24, no. 7, pp. 675–685, Jul. 2006, doi: 10.1080/02640410500482602.
19. E. O. Bettonviel A, Y. J. Brinkmans N, K. Russcher, F. C. Wardenaar, and O. C. Witard, "Nutritional Status and Daytime Pattern of Protein Intake on Match, Post-Match, Rest and Training Days in Senior Professional and Youth Elite Soccer Players," *Int J Sport Nutr Exerc Metab*, vol. 26, no. 3, pp. 285–293, Jun. 2016, doi: 10.1123/ijsnem.2015-0218.
20. R. Raizel *et al.*, "Pre-season dietary intake of professional soccer players," *Nutr Health*, vol. 23, no. 4, pp. 215–222, Dec. 2017, doi: 10.1177/0260106017737014.
21. F. Ruiz, A. Irazusta, S. Gil, J. Irazusta, L. Casis, and J. Gil, "Nutritional intake in soccer players of different ages," *J Sports Sci*, vol. 23, no. 3, pp. 235–242, Mar. 2005, doi: 10.1080/02640410410001730160.
22. M. N. Hassapidou, M. G. Grammatikopoulou, and T. Liarigovinos, "Dietary intakes of Greek professional football players," *Nutrition & Food Science*, vol. 30, no. 4, pp. 191–194, Aug. 2000, doi: 10.1108/00346650010330234.
23. L. Anderson *et al.*, "Energy Intake and Expenditure of Professional Soccer Players of the English Premier League: Evidence of Carbohydrate Periodization," *Int J Sport Nutr Exerc Metab*, vol. 27, no. 3, pp. 228–238, Jun. 2017, doi: 10.1123/ijsnem.2016-0259.
24. N. Y. J. Brinkmans *et al.*, "Energy expenditure and dietary intake in professional football players in the Dutch Premier League: Implications for nutritional counselling," *J Sports Sci*, vol. 37, no. 24, pp. 2759–2767, Dec. 2019, doi: 10.1080/02640414.2019.1576256.
25. B. L. Devlin, M. D. Leveritt, M. Kingsley, and R. Belski, "Dietary Intake, Body Composition, and Nutrition Knowledge of Australian Football and Soccer Players: Implications for Sports Nutrition Professionals in Practice," *Int J Sport Nutr Exerc Metab*, vol. 27, no. 2, pp. 130–138, Apr. 2017, doi: 10.1123/ijsnem.2016-0191.
26. D. Caruana Bonnici, I. Akubat, M. Greig, A. Sparks, and L. R. Mc Naughton, "Dietary habits and energy balance in an under 21 male international soccer team," *Res Sports Med*, vol. 26, no. 2, pp. 168–177, 2018, doi: 10.1080/15438627.2018.1431537.
27. A. Książek, A. Zagrodna, and M. Słowińska-Lisowska, "Assessment of the Dietary Intake of High-Rank Professional Male Football Players during a Preseason Training Week," *IJERPH*, vol. 17, no. 22, p. 8567, Nov. 2020, doi: 10.3390/ijerph17228567.

28. M. Macuh, J. Levec, N. Kojić, and B. Knap, "Dietary Intake, Body Composition and Performance of Professional Football Athletes in Slovenia," *Nutrients*, vol. 15, no. 1, p. 82, Dec. 2022, doi: 10.3390/nu15010082.
29. M. Russell and M. Kingsley, "The efficacy of acute nutritional interventions on soccer skill performance," *Sports Med*, vol. 44, no. 7, pp. 957–970, Jul. 2014, doi: 10.1007/s40279-014-0184-8.
30. A. Ali, C. Williams, C. W. Nicholas, and A. Foskett, "The Influence of Carbohydrate-Electrolyte Ingestion on Soccer Skill Performance," *Medicine & Science in Sports & Exercise*, vol. 39, no. 11, pp. 1969–1976, Nov. 2007, doi: 10.1249/mss.0b013e31814fb3e3.
31. G. L. Close, D. L. Hamilton, A. Philp, L. M. Burke, and J. P. Morton, "New strategies in sport nutrition to increase exercise performance," *Free Radic Biol Med*, vol. 98, pp. 144–158, Sep. 2016, doi: 10.1016/j.freeradbiomed.2016.01.016.
32. B. Egan and J. R. Zierath, "Exercise metabolism and the molecular regulation of skeletal muscle adaptation," *Cell Metab*, vol. 17, no. 2, pp. 162–184, Feb. 2013, doi: 10.1016/j.cmet.2012.12.012.
33. D. G. Hardie, "Sensing of energy and nutrients by AMP-activated protein kinase," *Am J Clin Nutr*, vol. 93, no. 4, pp. 891S–6, Apr. 2011, doi: 10.3945/ajcn.110.001925.
34. L. G. Weigl, "Lost in translation: regulation of skeletal muscle protein synthesis," *Current Opinion in Pharmacology*, vol. 12, no. 3, pp. 377–382, Jun. 2012, doi: 10.1016/j.coph.2012.02.017.
35. K. D. Tipton, T. A. Elliott, M. G. Cree, A. A. Aarsland, A. P. Sanford, and R. R. Wolfe, "Stimulation of net muscle protein synthesis by whey protein ingestion before and after exercise," *Am J Physiol Endocrinol Metab*, vol. 292, no. 1, pp. E71-76, Jan. 2007, doi: 10.1152/ajpendo.00166.2006.
36. P. M. García-Rovés, P. García-Zapico, A. M. Patterson, and E. Iglesias-Gutiérrez, "Nutrient intake and food habits of soccer players: analyzing the correlates of eating practice," *Nutrients*, vol. 6, no. 7, pp. 2697–2717, Jul. 2014, doi: 10.3390/nu6072697.
37. J. F. Horowitz and S. Klein, "Lipid metabolism during endurance exercise," *Am J Clin Nutr*, vol. 72, no. 2 Suppl, pp. 558S–63S, Aug. 2000, doi: 10.1093/ajcn/72.2.558S.
38. A. Muscella, E. Stefàno, P. Lunetti, L. Capobianco, and S. Marsigliante, "The Regulation of Fat Metabolism during Aerobic Exercise," *Biomolecules*, vol. 10, no. 12, p. 1699, Dec. 2020, doi: 10.3390/biom10121699.