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Abstract: Sleep and nutrition play a crucial role for athletes, contributing to the quality of recovery, optimization of performance, as well as the preservation of health and injury prevention. This study aimed to explore the potential relationships between sleep quality, nutritional status, and dietary habits among Moroccan male professional footballs players during the competitive period, while examining the influence of sleep quality on nutritional behaviors. Methods: This descriptive research included 49 professional male football players. Sleep quality was measured using the Pittsburgh Sleep Quality Index (PSQI) to differentiate “good sleep” and “poor sleep” groups. Dietary intake was collected using the 24-hour recall and analyzed by validated nutritional software to obtain data on energy intake and dietary frequency.The results reveal that 36 participants are classified as having "Good Sleep" and 13 as "Poor Sleep quality." With a significant difference (4.0 ± 0.2 vs. 6.9 ± 0.9, $p < 0.001$), consecutively. The correlation study between the (PSQI score) and nutritional status variables has revealed significant associations: a negative correlation with total energy intake (TEI) ($r = -0.687$, $p < 0.01$), carbohydrates intake (CHO g/kg BM) ($r = -0.499$, $p < 0.01$); and well as (CHO%) and (PRO%) ratios ($r = -0.294$, $p < 0.05$), ($r = -0.292$, $p < 0.05$) consecutively. On the other side, the PSQI demonstrates a positive correlation with the (FAT%) and Fats and butter. Conclusions These results suggest an association between sleep quality and dietary intake, indicating a potential influence of sleep quality on dietary choices.

Keywords: Nutrition, Sleep, Football, Performance, Macronutrient Intake

Introduction

Football is an intermittent team sport that requires a high level of tactical, technical, and physical skill to succeed. During the match, players engage in a random combination of explosive and powerful activities, along with technical and tactical maneuvers, intermittently over a 90-minute game duration[1]. In modern football, the competitive phase represents a crucial period where teams engage in official matches, competitions, or tournaments. During this phase, the workload, whether from training sessions or matches, is intensive[2]. Teams strive to reach their peak performance, requiring refined management and meticulous assessment of players' potential to achieve collective performance[3].

It is acknowledged that sleep is an important strategy among others for psychological and physiological recovery[4]. Sleep promotes muscle regeneration by allowing the release of growth hormones, which stimulate muscle protein synthesis and repair damaged tissues during exercise. Additionally, it helps combat oxidative stress. Some studies have shown that chronic sleep deprivation is associated with an increase in injuries among football players[5]. They indicate that players with poor sleep quality are more prone to a higher incidence of musculoskeletal injuries[6]. For elite athletes, 8 hours of sleep per night is considered a crucial need to feel rested[7]. However, due to intense training, football players often face a lack of sleep. They frequently sleep less than 7 hours due to various factors related to football or not[8].

On the other hand, the importance of nutrition is indisputable for professional footballers, as it constitutes a crucial element alongside other key factors in players' performance and recovery[9]. According to the latest UEFA consensus (Union of European Football Associations), adequate nutrition contributes to meeting the increased demands of matches and training sessions[10]. It recommends that players should have a balanced diet, including macronutrients for necessary energy and micronutrients such as vitamins and minerals to support the immune system, recovery, and injury prevention. A metanalysis studies indicate that professional football players may not adequately meet their energy needs and that they have suboptimal energy intake compared to estimates of their energy expenditures[11].

The interrelation between sleep and nutrition was discussed approximately 30 years ago[12], but in the field of sports, it remains relatively unexplored, particularly regarding the effect of sleep on eating behavior. Research has shown that the usual duration of sleep is generally associated with a higher caloric intake as well as an absolute or relative intake of nutrients or foods[13]. Prolonged periods of wakefulness could promote increased meal frequency, including unhealthy snacks, and alter the timing of food intake, such as consuming late at night or during the night[14]. On the other hand, physiological sleep deprivation has been shown to affect appetite, including leptin and ghrelin, as well as hormonal homeostasis related to metabolism, such as cortisol, insulin sensitivity, and growth hormones. Recent research has also focused on the role of sleep in the quality of diet, highlighting a general association between shorter sleep duration and lower diet quality as well as irregular eating behaviors. Regarding dietary habits, it has been reported that players who sleep fewer hours tend to follow a lower-quality diet[6].

Taking this into consideration and based on the available literature, the field of nutrition associated with sleep in professional football in Morocco remains relatively unexplored. This has inspired us to launch this project, firstly to fill this information gap and enrich the scientific community, not only for Morocco but also for Africa, especially North Africa, and the Mediterranean region as a whole. This study aimed to explore the potential relationships between sleep quality, nutritional status, and dietary habits among Moroccan Professional male football players during the competitive. To achieve this, we attempted to address the following questions: (a) To what extent do Moroccan man football players adhere to scientific sleep guidelines and UEFA (Union of European Football Associations)? (b) What variations exist in the sleep status among players? (c) Are there correlations between sleep quality and nutritional balance in terms of total food intake? Finally, (d) can quality sleep nights promote healthier food decisions and, consequently, influence food choices and nutritional behaviors on the following day?

Methodology

Study design and competitive level:

We conducted an observational study using a cross-sectional design to explore the relationships between sleep quality and nutritional status among a total of 49 professional male football players who voluntarily participated in this study in the Moroccan professional league "Botola-Pro" over two consecutive weeks during the competitive phase. Each week included a training microcycle with a rest day, five training days, and a match at the end of the week, distributed as follows (match days (**MDs**) occurred at 6:00 p.m. on Sundays. Training sessions or Training Days (**TDs)** took place on Tuesday (MD+2), Wednesday (MD+3), Thursday (MD-3), Friday (MD-2), and Saturday (MD-1). No training sessions or Rest Days (**RDs**) occurred on Mondays (MD+1) **Fig1**. The sleep quality was evaluated using the Pittsburgh Sleep Quality Index (PSQI), and the dietary intake was assessed using the 24-hour dietary recall technique. All these measures were conducted daily from Monday to Sunday at 10 a.m. A correlation analysis was performed to explore the relationships between sleep quality and dietary intake. This study was conducted following the ethical principles outlined in the Declaration of Helsinki and received approval from the regional ethics committee of the Ibn Rôchd University Hospital Center in Casablanca, under the jurisdiction of the Ministry of Health in Morocco (Approval No: 22/2022). All participants voluntarily participated in the study and had the option to withdraw at any time.

Place Figure 1

Participants.

This comprised a total of forty-nine male professional football players aged 24.9 ± 3.1 years from three Moroccan clubs who were included in the sample for this study. Inclusion criteria required them to be professional players, while exclusion criteria applied to those who did not participate in training sessions and matches, were injured, or had incomplete PSQI or dietary surveys. Ultimately, our final sample consisted of 5 goalkeepers, 19 defenders, 14 midfielders, and 11 forwards. All solicited players actively participated in this project and underwent comparable training loads. Research data were collected using survey forms and face-to-face interviews; for 24-hour dietary recall (24HR) [15–17], the Pittsburgh Sleep Quality Index (PSQI)[18], and anthropometric measurements.

Anthropometric and body composition measurements

The measurement of body composition values is carried out using the InBody 120 bioelectrical impedance analyzer, developed by InBody Co., Ltd. This device utilizes advanced technology by applying an electric current of 150μA (± 50μA) at frequencies of 20 and 100 kHz throughout the body. The results provided by this analyzer encompass various critical parameters for a comprehensive evaluation of body composition. the measurements include total weight, Body Mass Index (BMI), body muscle mass (BMM), body fat mass (BFM), and basal metabolism (BM) estimate of energy expenditure at rest. The precision error for Fat-Free Mass (FFM), Fat Mass (FM), and % Body Fat (%BF) is less than 2% in 30 subjects. Athletes were directed to remove their shoes, and height measurements were taken using a stadiometer with a precision of ±0.1 mm for utmost accuracy (Portable Stadiometer-Seca 225, Hamburg, Germany)[19,20].

Assessment of sleep quality

The assessment of sleep quality is ensured through the use of the Pittsburgh Sleep Quality Index (PSQI).[18]. This instrument is considered a valid means to evaluate individual sleep quality over the preceding month and comprises a total of 19 questions. These 19 self-evaluation questions combine to form 7 "components," including subjective sleep quality, sleep latency, sleep duration, habitual efficiency, disturbances, use of medication, and daytime dysfunction. The overall score, ranging from 0 to 21, is calculated by summing the points from all subsections. A score exceeding 5 indicates poor sleep quality, while a score equal to or less than 5 indicates good sleep quality [18]. A pre-data collection training session was held during the week before the study commencement to familiarize all players with the Pittsburgh Sleep Quality Index (PSQI) Arabic version[21]. The purpose of this session was to clarify the survey completion process by providing practical examples. Throughout the two-week observation period, participants were kindly asked to fill out the questionnaire within the first two hours after waking up. They were then instructed to return it to the principal investigator the following day at 10 a.m., just before the training session commenced. Each time, the principal investigator provided a fresh copy for participants to complete the next day after their night of sleep, and this process continued seamlessly.

Assessment of diet intake:

The 24-hour recall dietary technique was employed to assess food consumption over a period of fourteen consecutive days[15–17]. The scientific community has endorsed a seven-day data collection period as optimal, as it aligns with obtaining accurate nutritional estimates for the comprehensive analysis of routine nutrient and energy intake while minimizing variability in coding errors[22,23]. This approach was implemented to ensure the accuracy of the gathered data. The Data on food consumption, including snacks, dietary supplements, and other consumables, were collected. To enhance accuracy, researchers assisted football players in estimating quantities consumed more precisely by using everyday household items such as spoons, glasses, and dinnerware. This complementary approach facilitated a more thorough examination of the food diaries[16,24]. Furthermore, we employed the Remote Food Photographic Method (RFPM)[25] .

The Nutrilog 3.30 professional software, utilizing the Ciqual 2020 food composition database, was employed to analyze dietary intake data. This extensive database provided detailed information on the total energy intake (**TEI**) expressed in kilocalories (kcal), the nutritional composition of various ingredients, including carbohydrates (CHO), sugars, proteins, fatty acids, salt, vitamins, minerals, and the energy content of meals [26] Similarly, macronutrient intakes were assessed and reported in grams (g) and grams per kilogram of body mass (g/kg BM) for comparison with "Union of European Football Associations" UEFA guidelines[10].

The results of the 24-hour Recall were used to extract data on the players' diet. The frequency of consumption for each food item was calculated to assess the usual daily or weekly intake foods. The food groups, and beverages commonly consumed in Morocco were considered, including vegetables, legumes, fruits, dairy products (milk, yogurt, and cheese), cereals (bread, cereals, rice, pasta, and couscous), meat (red meat: veal, lamb, camel, and goat; white meat: poultry and turkeys; processed meat), fish, Fats (this includes vegetable oils, butter, nuts, and seeds, providing essential fatty acids), olive oil, eggs, beverages (coffee, tea, and herbal infusions), sweets (sugar, jelly, candies, pastries, sweetened fruit juices), soda, and added fats (olive oil, other vegetable oils, and butter).

An expert nutrition researcher carried out the investigation to guarantee the highest level of accuracy in the findings. It is also important to emphasize that the medical staff monitored the consumption of products and dietary supplements to ensure uniformity in intake.

Statistical analysis

The statistical analysis was conducted using the Statistical Package for the Social Sciences (SPSS) software (IBM, SPSS Statistics, Version 27, Chicago, IL). The collected data were presented using descriptive statistics, including the minimum (min) and maximum (max) values, the mean value (x), and the standard deviation (SD). The normal distribution of differences between data pairs was checked using Kolmogorov-Smirnov tests ($p > 0.02$ for all variables). Additionally, the difference between "Good Sleep Quality" and "Poor Sleep Quality" was tested using the Student's t-test when the variable follows a normal distribution. This specifically applies to the following variables: TEI (Total energy intake), Carbohydrates “CHO” g/Kg BM (Body Mass), CHO %, Protein g/Kg BM (Body Mass), Protein %, Fat g/Kg BM (Body Mass), Fat %, and fibers. For variables that do not follow a normal distribution, including the seven "components" of the PSQI such as subjective sleep quality, sleep latency, sleep duration, habitual efficiency, disturbances, use of medication, and daytime dysfunction, the Mann-Whitney test was employed. This test was also adopted for food groups, including the 15 elements mentioned earlier in the dietary assessment section. Furthermore, Pearson's correlation coefficient (r) was used to examine correlations between sleep quality and nutritional status variables, while Spearman's coefficient was used for other variables that do not follow a normal distribution.

Statistically significant differences between the studied groups or associations between variables were confirmed if the p-value was less than 0.05. The confidence interval (CI) was set at 95%.

Results

Anthropometric Measurements and Sleep quality (PSQI) of male professional football players

This involves a total of 49 male professional football players. The descriptive characteristics of these participants are presented in the **(table 1)**, where the data is expressed as mean ± standard deviation (SD), along with the corresponding maximum and minimum values. The average age of these players is 24.9 ± 3.1 years, spanning from 20.0 to 34.0 years. Concerning body weight, the mean is 73.4 ± 6.2 kg, with a range of 62.5 to 88.0 kg. The average height of the players is 181.2 ± 6.6 cm, varying between 166.0 and 192.0 cm. The body mass index (BMI) has an average of 22.3 ± 1.2, with values oscillating between 20.1 and 25.3. The percentage of body fat (BFM) shows an average of 10.3 ± 2.2%, ranging from 6.5% to 15.0%. Finally, the basal metabolic rate (BMR) has an average of 1813.2 ± 111.2 Kcal, with respective maximum and minimum values of 2016.9 and 1600.7 Kcal.

Place Table 1

The results reveal that, among the 49 participants, 36 are classified as having "Good Sleep" “73%” while 13 are classified as having "Poor Sleep" “27%” based on their total score on the Pittsburgh Sleep Quality Index (PSQI). The analyses, expressed as mean ± standard deviation (SD), unveil significant differences between these two groups, assessed through the Mann-Whitney test, for various components of the PSQI **(table 2).**

Place Table 2

For players experiencing "Good Sleep" the mean scores are significantly lower in key areas, including subjective sleep quality (1.0 ± 0.1 vs. 1.8 ± 0.4, $p < 0.001$), sleep latency (1.2 ± 0.4 vs. 1.6 ± 0.5, $p < 0.05$), sleep duration (0.6 ± 0.5 vs. 1.3 ± 0.5, $p < 0.001$), sleep disturbances (0.1 ± 0.2 vs. 0.5 ± 0.7, $p < 0.001$), and the total PSQI score (4.0 ± 0.2 vs. 6.9 ± 0.9, $p < 0.001$).

It is noteworthy that no significant difference was observed between the two groups regarding sleep efficiency. Additionally, none of the players reported using sleep medication, explaining the absence of a significant difference in this component between the groups.

Sleep quality Energy intake and Nutritional status of the of male professional football players

The **(table 3)** provides a comprehensive analysis of the dietary habits of professional football players based on sleep quality. In terms of energy intake, the "Good Sleep" group exhibits a significantly higher total energy intake (3158.9±163.5 Kcal) compared to the "Poor Sleep Quality" group (2757.4±164.7 Kcal), with a notable overall difference ($p < 0.001$). Concerning nutritional intake, the Student t-test revealed significant variations, the group of football players with "Good Sleep " exhibits significantly higher ratios of carbohydrates (CHO %), carbohydrate intake per kilogram of body mass (CHO g/kg BM), and protein intake per kilogram of body mass (PRO g/kg BM) ($p < 0.001$ and $p < 0.05$, respectively), while the fat ratio (FAT %) is lower in this group ($p < 0.05$). Additionally, the dietary fiber intake is significantly higher with a significance level of ($p < 0.05$). The correlation study between the sleep quality score (PSQI) and nutritional status variables has revealed significant associations. The Pearson test showed that the PSQI score exhibits a significant negative correlation with total energy intake (TEI) (r = -0.687**, $p < 0.01$), carbohydrate intake per kilogram of body mass (CHO g/kg BM) (r =-0.499**, $p < 0.01$) also for carbohydrate (CHO%) and protein (CHO%) ratio with a (r =-0,294* $p < 0.05$), (r =-0,292* $p < 0.05$) consecutively, in the other side and concurrently, the PSQI demonstrates a positive correlation with the percentage of fats (FAT%) and fat intake per kilogram of body mass (FAT g/kg BM).

Place Table 3

However, the dietary intake frequency, assessed using the Mann-Whitney test, reveals significant disparities between the two groups. The results highlight statistically significant differences, the players with "Good Sleep" display significantly higher values than those with "Poor Sleep Quality" ($p < 0.05$ to $p < 0.001$), particularly in the consumption of vegetables and fish. Conversely, players with "Poor Sleep" present significantly higher values notably for the intake of processed meats, fats and butter, as well as sodas ($p < 0.05$ or $p < 0.001$). The Spearman test reveals a significantly negative correlation between the PSQI Score and the consumption of vegetables (r = -0.432**, $p < 0.01$) as well as fish (r = -0.298*, $p < 0.05$). Conversely, positive and significant correlations were observed with the consumption of processed meats (r = 0.387**), fats and butter (r = 0.375**, $p < 0.01$), and soda (r = 0.352*, $p < 0.05$). Regarding the frequency of daily meals, players with "Good Sleep Quality" show significantly higher frequencies, especially about the total number of meals per day, breakfasts per day, and snacks per day, with respective significance levels at ($p < 0.001$ and $p < 0.05$). In addition to this the Spearman test results expose significant negative correlations between PSQI and meals per day (r = -0.476**,p<0,01) Specifically, there are strong negative correlations with the frequency of, breakfasts per day (r = -0.477**, p<0,01), and snacks (r = -0.330**, p<0,01)

Discussion

The present research aimed to explore the possible relationship between sleep quality, nutritional status, and dietary habits among professional football players. The inclusion of scores from the Pittsburgh Sleep Quality Index (PSQI), along with data on energy intake and dietary frequency, allowed for a thorough analysis of how sleep statuses might influence nutritional behaviors.

To ensure alignment between training load and nutritional status, the UEFA [10)](Union of European Football Associations) has established recommendations indicating that caloric intake should be between 3400 and 4300 calories to optimize performance in football while also preserving health and preventing injuries for professional football players. Our study has revealed that the mean energy intake of the male professional football players was 3052,4±241,6. Kcal. The energy requirements of the football players we investigated exhibit noteworthy similarities across various leagues and player categories. [27–29]

The "Good Sleep" group exhibits a significantly higher total energy intake (3158.9±163.5 Kcal) compared to the "Poor Sleep Quality" group (2757.4±164.7 Kcal), with a notable overall difference ($p < 0.001$). Furthermore, the energy ratio distribution for CHO, proteins, and fats was 52±3 %, 15±2 % and 33±3 %, respectively. For players benefiting from "Good Sleep Quality" mean scores are significantly lower in key areas, including subjective sleep quality, sleep latency, sleep duration, and sleep disturbances. Our findings align with studies suggesting that elite athlete populations, often subjected to significant training loads and participating in competitions such as football matches, frequently face disturbances[8]. Studies report that 50% to 78% of elite athletes experience sleep disturbances, and 22% to 26% suffer from severe sleep disorders, reflecting on overall sleep quality[30–32].

Place Table 4

The nutrition status was associated with the sleep quality

The correlation analyses have revealed significant associations between the PSQI score, total energy intake (TEI), and macronutrient intake (carbohydrates and Protein) per kilogram of body mass (g/kg BM) **Fig 2**, highlighting an interesting link between sleep quality and the nutritional habits of football players.

Energy macronutrients intake and sleep quality:

The results of this analysis reveal significant associations between various aspects of sleep and energy intake among professional football players. A significant negative correlation is observed between subjective sleep quality and total energy intake ($r = -0,681$, $p < 0.001$), indicating that those who enjoy better sleep quality tend to have a balanced nutritional intake. also, the sleep latency shows a negative significant correlation with total energy intake ($r = -0.253$, $p < 0.050$), suggesting that the time taken to fall asleep are significantly influence overall energy intake. A significant negative correlation is also observed between sleep duration and total energy intake ($r = -0.462$, $p < 0.001$), meaning that longer sleep duration is associated with increased food intake. Additionally, a negative relationship is found between sleep disturbances and total energy intake ($r = -0.373$, $p = 0.008$), suggesting that fewer sleep disturbances are associated with greater energy consumption. Finally, daytime dysfunction shows no significant correlation with total energy intake ($r = -0.235$, $p = 0.108$), indicating that it does not significantly influence players' eating habits.

Regarding the macronutrients, a significant negative correlation is observed between subjective sleep quality and carbohydrate consumption per kg of body mass ($r = -0.473$, $p < 0.001$), as well as a with protein ($r = -0,288$, $p < 0.05$). And also a significant negative correlation with sleep latency ($r = -0.314$, $p = 0.028$) and ($-0,321, p < 0.05$) for carbohydrates and proteins respectively, a significant negative correlation is observed between PSQI score and carbohydrate consumption per kg of body mass ($r = -0,499$, $p < 0.001$), as well as with protein consumption per kg of body mass ($r = -0,296$, $p < 0.05$) and the percentage of fat in the diet ($r = -0,292$, $p < 0.05$), suggesting that players who benefit from good sleep quality tend to have a balanced intake of macronutrients. This was confirmed by a linear regression, highlighting a significant relationship between sleep quality and nutritional status, as represented by total energy intake (TEI), carbohydrates, proteins, and percentage of fat. The correlation coefficients of these variables with sleep quality are respectively (R^2=0.48, R^2=0.28, R^2=0.092, and R^2=0.1).

Several previous studies have examined the relationship between sleep and energy intake among athletes, providing a solid foundation for our argumentation. For instance, the study conducted by Halson et al. (2016)[33] found a significant association between sleep quality and energy intake among professional rugby players. This study used validated questionnaires to assess sleep quality and energy intake, revealing that players with better sleep quality tended to have a more balanced energy intake.

Another study, conducted by Mah et al. (2011)[34], investigated the effects of sleep on dietary intake among college basketball players. Researchers utilized objective sleep measures, such as polysomnography, along with dietary journals to evaluate participants' energy intake. Their findings showed that longer nights of sleep were associated with healthier food choices and improved appetite regulation.

Furthermore, a longitudinal study conducted by Beccuti and Pannain (2011) [35]examined the effects of sleep deprivation on energy intake and body weight among healthy adults. Results revealed that participants with insufficient sleep tended to consume more calories, particularly from carbohydrates and fats, which could contribute to long-term weight gain.

Place Figure 2

Frequency of dietary intake and sleep quality:

The analysis of correlations between sleep quality and the frequency of dietary intake among professional football players reveals several significant associations. The results show significant negative correlations between subjective sleep quality and the consumption of fibers ($r = -0.183$, $p <$

0.05), vegetables ($r = -0.340$, $p < 0.01$), fish ($r = -0.186$, $p < 0.05$), red meat ($r = -0.091$, $p < 0.05$), breakfast ($r = -0.554$, $p < 0.01$), snacks ($r = -0.383$, $p < 0.01$), as well as the number of meals per day ($r = -0.554$, $p < 0.01$). This suggests that players with poor sleep quality tend to consume less fiber, vegetables, fish, red meat, and have fewer snacks and meals per day.

Conversely, significant positive correlations are observed between subjective sleep quality and the consumption of processed meat ($r = 0.429$, $p < 0.01$), olive oil ($r = 0.355$, $p < 0.05$), as well as soda ($r = 0.438$, $p < 0.01$). This suggests that players with poor sleep quality tend to consume more processed meat, olive oil, and soda.

These results indicate an association between sleep quality and the dietary habits of professional football players, highlighting the importance of sleep on players' dietary behavior the following days.

Our findings align with other studies suggesting that training sessions and matches could have a negative impact on certain athletes [36,37], with indirect repercussions on other aspects of players' daily lives, such as nutrition. This stems from the identified negative correlations between perceived effort and sleep quality[38]. Additionally, Watson et al [39]also observed that a reduction in sleep duration could be linked to negative effects during higher training loads. These findings underscore the importance of adequate sleep management for healthy dietary behaviors in professional football players[40–42]. This was confirmed by the positive association found between the total PSQI score and the frequency of consuming processed meat, fats and butter, as well as soda, being ($r=0.387$), (r= ($r=0.375$), and ($r=0.352$) respectively. This suggests that players experiencing sleep disturbances tend to consume more of these mentioned foods. This could be attributed, as reported by several players, to delays in waking up, as players may not have enough time to prepare these meals. Therefore, some of them prefer to opt for fast food. Additionally, after the end of training sessions or matches, fatigued players also tend to choose prepared meals, which may explain the increase in the consumed fat content and the decrease in the level of dietary fiber.

On the other hand, the relationship between lack of sleep and nutritional intake, including appetite, is likely largely due to the involvement of psychological and endocrine factors. Scientifically, the link between lack of sleep and nutritional intake can be explained by various physiological and biochemical mechanisms. Firstly, sleep deprivation disrupts the balance of hormones regulating hunger and satiety. For example, leptin, a hormone that suppresses appetite, decreases, while ghrelin, which stimulates appetite, increases with sleep deprivation. This hormonal dysregulation can lead to increased appetite and less controlled eating behaviors[43]. Additionally, lack of sleep activates the sympathetic nervous system, triggering the release of cortisol, a stress hormone, which can also stimulate appetite and promote consumption of calorie-rich food. Furthermore, lack of sleep impairs cognitive functions such as decision-making and impulse control, which can result in less healthy food choices. Lastly, lack of sleep can affect emotional state, increasing stress, anxiety, or depression, leading to seeking comfort in food. In summary, lack of sleep disrupts hormonal regulation, increases stress, impairs cognitive functions, and affects emotional state, thereby contributing to changes in eating habits and increased nutritional intake[44].

Study Limitations and Strength

While our study sheds light on these associations, certain limitations need to be acknowledged. Additionally, factors such as training load, stress, and individual differences related to playing position can influence these relationships and require further investigation. The practical implications of these findings are extensive, paving the way for targeted interventions aimed at improving the sleep quality of professional football players and, consequently, optimizing their athletic performance and overall well-being. However, the exact correlation between sleep quality and dietary habits remains a research topic requiring in-depth exploration for a more profound understanding of this complex relationship; longitudinal studies and clinical trials could provide a robust foundation for developing specific and tailored recommendations in the field of footballers' nutrition and sleep management.

Conclusion

Our results suggest an association between sleep quality and dietary intake in athletes, highlighting the potential influence of sleep quality on the dietary choices of professional football players. These findings underscore the importance of considering sleep quality in the nutritional planning of footballers, particularly with a view to optimizing their energy intake, especially in terms of macronutrients, to ensure optimal athletic performance. Players are advised to seek guidance from qualified professionals in both sports' nutrition for any nutritional periodization and sleep specialists to ensure optimal adaptations to training and recovery.

Data availability statement

The original contributions presented in the study are included in the article, further inquiries can be directed to the corresponding author

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Statement of Ethics

This study was conducted following the ethical principles outlined in the Declaration of Helsinki and received approval from the regional ethics committee of the Ibn Rôchd University Hospital Center in Casablanca, under the jurisdiction of the Ministry of Health in Morocco (Approval No: 22/2022). All participants voluntarily participated in the study and had the option to withdraw at any time.

Conflict of Interest Statement

"The authors have no conflicts of interest to declare".

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Author Contributions

Conceptualization: OUKHEDA M, TAKI H, SAILE R. Data curation: OUKHEDA M, TAKI H, SAILE R. Formal analysis: OUKHEDA M, TAKI H. Investigation: OUKHEDA M, TAKI H, SAILE R. Methodology: OUKHEDA M, TAKI H, SAILE R. Project administration: TAKI H, SAILE R. Resources: all authors. Software: OUKHEDA M, TAKI H. Supervision: TAKI H, SAILE R. Validation: TAKI H, SAILE R. Writing—original draft: OUKHEDA M, TAKI H. Writing—review & editing: OUKHEDA M, TAKI H, SAILE R.

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Table 1: Characteristics of professional football players (n=49)

Table 2: Sleep Quality and difference between groups of the professional football players

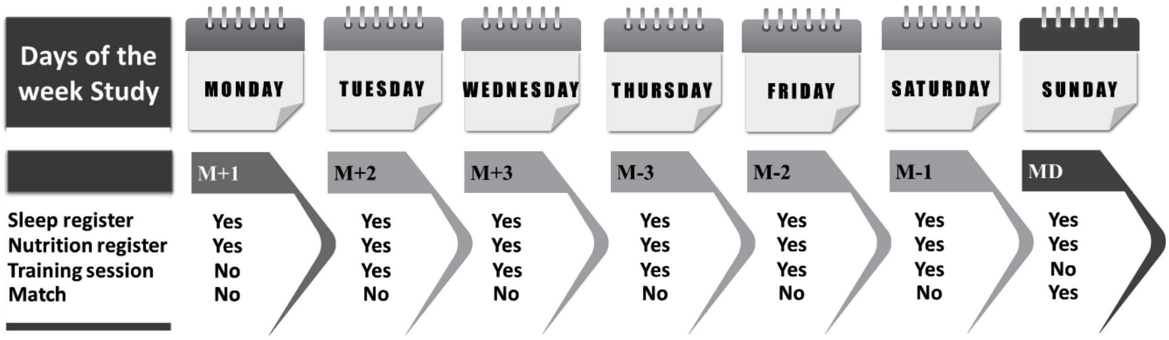
Table 3. Energy intake, nutritional status, and diet intake Frequency according to sleep quality “Good Sleep” and “Poor Sleep” of the professional football players

Table 4. Correlation between Sleep quality and Energy intake, nutritional status, and diet intake Frequency of the professional football players

LEGEND OF THE FIGURES

Figure 1: Protocol of study design and training microcycle (MD: match day; MD+1: one days after match day); MD+2: two days after match day; MD+3: three days after match day; MD-3: three days before match day; MD-2: two days before match day; MD-1: one day before match day).

Figure 2: Association between nutritional status and score of PSQI. The dote represent the soccer players participants (n= 49);and the area is for confidence interval (CI:95%)



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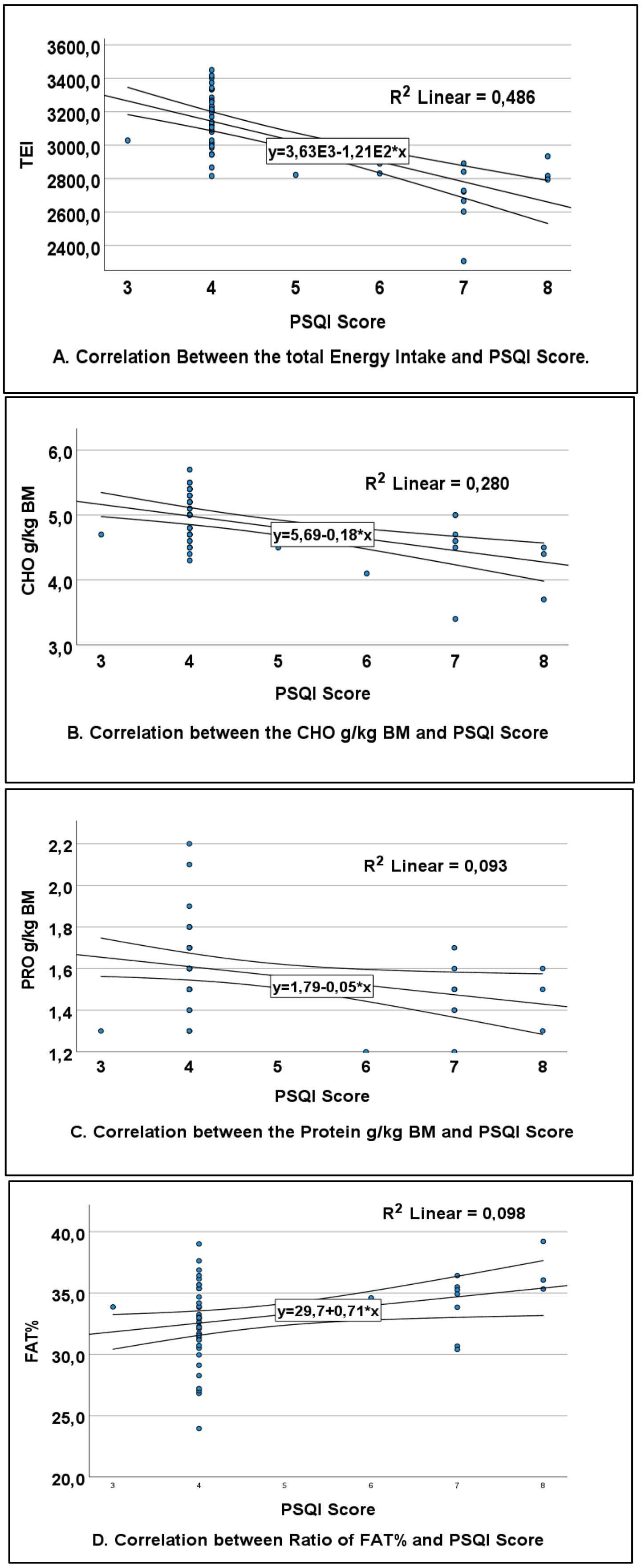

A. Correlation Between the total Energy Intake and PSQI Score.

B. Correlation between the CHO g/kg BM and PSQI Score

C. Correlation between the Protein g/kg BM and PSQI Score

D. Correlation between Ratio of FAT% and PSQI Score

Figure 2: Association between nutritional status and score of PSQI.The dote represent the soccer players participants (n= 49); and the area is for confidence interval (CI:95%)

Table 1: Characteristics of the male professional football players (**n=49**)

	Mean±SD	**Maximum**	**Minimum**
Age (years)	24,9±3,1	34,0	20,0
Weight (kg)	73,4±6,2	88,0	62,5
Height (m)	181,2±6,6	192,0	166,0
BMI	22,3±1,2	25,3	20,1
BFM	10,3±2,2%	15,0%	6,5%
BMR	1813,2±111,2	2016,9	1600,7

SD: standard deviation; BMI: body mass index; BFM: body fat mass; BMR Basal metabolic rate.

Table 2: Sleep Quality and difference between groups of the professional the male professional football players

	Sleep Quality			
	Good Sleep (73%) (n=36)	**Poor Sleep (27%) (n=13)**	**Total (n=49)**	***P-value***
	Mean±SD	Mean±SD	Mean±SD	
Subjective sleep quality	1,0±0,1	1,8±0,4	1,2±0,4	<0,001**
Sleep latency	1,2±0,4	1,6±0,5	1,3±0,5	<0,05*
Sleep duration	0,6±0,5	1,3±0,5	0,8±0,6	<0,001**
Sleep efficiency	0,4±0,5	0,6±0,5	0,5±0,5	0,226
Sleep disturbance	0,1±0,2	0,5±0,7	0,2±0,4	<0,001**
Use of sleep medication	0,0±0,0	0,0±0,0	0,0±0,0	-------
Daytime dysfunction	0,8±0,5	1,1±0,9	0,9±0,6	0,281
Score (PSQI)	4,0±0,2	6,9±0,9	4,8±1,4	<0,001**

Mean±SD: Mean and standard deviation.
PSQI: Pittsburgh Sleep Quality Index
Correlation is significant at the 0.01 level (2-tailed). **
Correlation is significant at the 0.05 level (2-tailed). *

Table 3. Energy intake, nutritional status, and diet intake Frequency according to sleep quality "Good Sleep" and "Poor Sleep" of the male professional football players

Variable	Groups			Cohen's d effect size.	t	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference	
	Good Sleep (n=36)	Poor Sleep (n=13)	Total (n=49)					Lower	Upper
Energy Intake									
TEI	3158,9±163	2757,4±164	3052,4±241,6	2,81	7,57	<0,001	401,53	294,91	508,14
Nutritional status									
CHO%	52±3 %	50±3 %	52±3 %	1,40	2,15	<0,05	2,07	0,13	4,00
CHOg/kgBM	5,0±0,4	4,4±0,5	4,9±0,5	1,63	4,48	<0,001	0,57	0,31	0,82
PRO%	15±2 %	15±2 %	15±2 %	0,19	-0,07	0,944	-0,04	-1,28	1,19
PROg/kgBM	1,6±0,2	1,5±0,2	1,6±0,2	1,51	2,63	<0,05	0,16	0,03	0,29
FAT%	33±3 %	35±2 %	33±3 %	2,90	-2,11	<0,05	-2,09	-4,09	-0,10
FATg/kgBM	1,6±0,2	1,5±0,1	1,6±0,1	0,14	1,45	0,056	0,06	-0,02	0,16
Fibresg	27,4±1,7	26,3±1,4	27,1±1,7	1,64	2,06	<0,05	1,09	0,02	2,17
Diet Frequency									
Vegetables	5,3±0,6	4,5±0,7	5,1±0,7	1,64	3,64	<0,001	0,73	0,33	1,14
Legumes	0,7±0,7	0,7±0,6	0,7±0,7	0,72	0,12	1,001	0,02	-0,43	0,49
Fruits	3,5±0,5	3,4±0,8	3,4±0,6	0,58	0,46	0,928	0,08	-0,29	0,46
Cereals	5,3±0,8	5,2±0,4	5,2±0,7	0,70	0,08	0,710	0,01	-0,43	0,47
Sweets	1,4±0,5	1,5±0,5	1,4±0,5	0,50	-0,10	0,916	-0,01	-0,34	0,31
White meat	5,3±0,7	5,2±0,4	5,3±0,7	0,68	0,21	0,617	0,04	-0,39	0,48
Red meat	4,2±0,6	4,1±0,6	4,2±0,6	0,61	0,87	0,392	0,17	-0,22	0,57
Fish	3,4±0,5	2,9±0,8	3,2±0,6	1,60	2,23	<0,05	0,43	0,04	0,83
Processed meat	1,4±0,5	1,8±0,4	1,5±0,5	1,46	-3,02	<0,05	-0,45	-0,76	-0,15
Eggs	5,3±0,5	5,3±0,5	5,3±0,5	0,47	-0,01	0,988	-0,00	-0,30	0,30
Daitry produis	2,5±0,5	2,5±0,7	2,5±0,5	0,55	0,06	0,876	0,01	-0,34	0,36
Fats	4,2±0,4	4,7±0,5	4,3±0,5	1,42	-3,63	<0,001	-0,49	-0,77	-0,22
Olive oil	3,6±0,5	3,5±0,5	3,6±0,5	0,54	0,85	0,413	0,14	-0,20	0,50
Beverages	3,7±0,5	3,6±0,5	3,7±0,5	0,48	0,32	0,741	0,05	-0,26	0,36
Soda	0,8±0,6	1,5±0,7	1,0±0,7	1,62	-3,11	<0,05	-0,62	-1,03	-0,22
Frequency of Meals									
Meals per day	3,0±0,0	2,7±0,5	2,9±0,3	---	---	<0,001	0,30	0,15	0,46
Breakfast per day	1±0,0	0,7±0,5	0,9±0,3	---	---	<0,001	0,30	0,14	0,46
Lunch per day	1±0,0	1±0,0	1±0,0	---	---	1,00	0,15	0,03	0,27
Dinner per day	1±0,0	1±0,0	1±0,0	---	---	1,00	0,00	0,00	0,00
Snacks per day	2,0±0,0	1,8±0,4	2,0±0,2	---	---	<0,05	0,20	0,26	0,57

TEI: Total Energy Intake (Kcal); CHO %: Ratio of Carbohydrates; CHO g/kg BM: Carbohydrate's g/kg BM; PRO %: Ratio of Proteins; PRO g/kg BM: Protein's g/kg BM, Ratio of FAT %, FAT g/kg BM, PSQI, Pittsburgh Sleep Quality Index.
∗Frequency of consumption per day; ∗∗Frequency of consumption per week. Dairy products (milk, yogurt, and cheese), cereals (bread, cereals, rice, pasta, and couscous), beverages (coffee, tea, and herbal infusions), sweets (Sugar, jelly, candies, pastries, and sweetened fruit juices), white meat (poultry and turkeys), and red meat (veal, lamb, camel, and goat). Variables are presented as mean and SD (standard deviation). Statistically significant differences are defined as *P*<0.05.

Table 4. Correlation between Sleep quality and Energy intake, nutritional status, and diet intake Frequency of the male professional football players

		1	2	3	4	5	6	7
1	**Subjective sleep quality**	1						
2	**Sleep latency**	0,487**	1					
3	**Sleep duration**	0,524**	,078	1				
4	**Sleep efficiency**	0,180	,305*	-,424**	1			
5	**Sleep disturbance**	0,431**	,069	,189	0,036	1		
6	**Daytime dysfunction**	0,015	-0,584**	0,141	-0,267	-0,120	1	
7	**PSQI Score**	0,900**	0,435**	0,577**	0,234	0,478**	.	1
8	**TEI**	-0,681**	-0,299*	-0,460**	0,020	-0,370**	-0,144	-0,687**
9	**CHO%**	-0,270	-0,257	-0,039	-0,197	-0,220	0,066	-0,294*
10	**CHO g/kg BM**	-0,453**	-0,404**	-0,152	-0,183	-0,201	-0,039	-0,499**
11	**PRO%**	-0,019	-0,056	0,147	-0,129	0,206	-0,048	0,020
12	**PRO g/kg BM**	-0,288*	-0,321*	-0,030	-0,158	0,088	-0,097	-0,296*
13	**FAT%**	0,266	0,280	0,036	0,211	0,120	-0,027	0,293*
14	**FAT g/kg BM**	-0,197	-0,132	-0,254	0,198	-0,038	-0,129	-0,222
15	**Fibers g**	-0,183	-0,306*	-0,152	-0,017	0,021	-0,005	-0,236
16	**Vegetables**	-0,340*	-0,426**	-0,272	-0,046	-0,043	-0,034	-0,432**
17	**Legumes**	-0,053	-0,291*	-0,094	0,044	0,180	0,195	0,021
18	**Fruits**	-0,020	0,048	0,014	0,172	0,083	-0,176	0,032
19	**Cereals**	-0,011	-0,153	0,167	-0,028	0,161	-0,075	0,017
20	**Sweets**	0,006	-0,121	0,120	-0,191	0,163	0,219	0,064
21	**White meat**	-0,109	-0,244	0,005	0,045	0,063	0,094	-0,050
22	**Red meat**	-0,091	0,208	-0,208	0,275	-0,060	-0,283	-0,087
23	**Fish**	-0,186	-0,381**	-0,185	-0,066	00,063	0,027	-0,298*
24	**Processed meat**	0,429**	0,315*	0,119	0,185	0,216	0,012	0,387**
25	**Eggs**	-0,145	0,058	-0,103	-0,092	-0,059	0,000	-0,087
26	**Dairy products**	-0,075	-0,070	0,072	-0,002	0,077	-0,014	0,034
27	**Fats and butter**	0,355*	0,121	0,276	-0,132	0,269	0,141	0,375**
28	**Olive oil**	-0,208	-0,086	-0,105	0,005	-0,003	0,025	-0,136
29	**Beverages**	-0,019	-0,004	0,057	0,084	-0,132	-0,240	-0,090
30	**Soda**	0,438**	0,235	0,319*	-0,244	0,094	0,200	0,352*
31	**Meals per day**	-0,554**	-0,129	-0,345*	-0,018	-0,066	-0,175	-0,477**
32	**Breakfast**	-0,554**	-0,129	-0,345*	-0,018	-0,066	-0,175	-0,477**
33	**Snacks**	-0,383**	0,125	-0,239	0,194	-0,182	-0,363*	-0,330*

TEI: Total Energy Intake (Kcal); CHO %: Ratio of Carbohydrates; CHO g/kg BM: Carbohydrate's g/kg BM; PRO %: Ratio of Proteins; PRO g/kg BM: Protein's g/kg BM, Ratio of FAT %, FAT g/kg BM, PSQI, Pittsburgh Sleep Quality Index.

Horizontal line: 1) Subjective sleep quality; 2) Sleep latency; 3) Sleep duration; 4) Sleep efficiency; 5) Sleep disturbance; 6) Daytime dysfunction; 7) PSQI Score.

Correlation is significant at the 0.01 level (2-tailed). **

Correlation is significant at the 0.05 level (2-tailed). *