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Relationship between Body Composition and Nutrition of U17 Female Footballers, Members of the Algerian National Team

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Abstract

Nowadays, the study of nutrition in the field of sports has allowed for a better understanding of the importance of specific nutritional recommendations for the sports population, with recommended daily intakes particularly for carbohydrate and protein intake. Achieving athletes' results is linked to the combination of several factors, including: dietetics, rigorous training, technique, athlete's commitment, game system, and others. This prompted us to establish a dietary questionnaire to better understand the eating habits of our female footballers. We chose to work with high-level U17 female footballers (under 17 years old) with an average age of 16.71 ± 0.75 years, members of the national teams preparing for the 2024 World Championships. Indeed, this last category is of great importance in performing intense effort. The female footballer, at the end of growth, has higher needs in energy, proteins, vitamins, and minerals. We used anthropometric methods and bioimpedancemetry.

1. Introduction

In sports practice, new requirements impose long and intense training sessions on athletes, which significantly disrupt the body's metabolic processes. Energy resources are depleted, and the replenishment of these resources spent during physical effort is only possible with substantial food intake. The better the foods are chosen, the more they adhere to the standards and principles of sports nutrition, and the quicker the results will be felt. If an athlete's diet varies according to the sport practiced, sex, age, level of the practitioner, season, climate, but also the variation of training loads for competitors, their sports nutrition is subject to a few basic rules. Indeed, before even addressing specific nutritional strategies related to their practice, it is essential to know the fundamentals of a balanced diet with its various contributions in carbohydrates, proteins, lipids, water, vitamins, minerals, and trace elements to meet energy needs.

1.1. Literature Review

Training represents a multifaceted preparation of athletes for competition, this preparation includes specific nutrition to provide the necessary energy intake for the body and muscles to function optimally to achieve good performance. Therefore, it is conceivable to know what dietary regimen female footballers should follow during different training periods to achieve the best possible performance.

When talking about sports performance in relation to training, nutrition is sometimes placed on the back burner by practitioners of most disciplines, yet nutrition occupies a central place in achieving performance. It is crucial to have optimized dietary hygiene to strive for excellence. Eating well means knowing how to dose one's nutrition by favoring quality foods in the right quantities but also at the right time, meaning there are more opportune moments to eat. A good diet, therefore, corresponds to a balanced relationship between the athlete's dietary intake and their energy needs to respond to a targeted activity. Indeed, the contributions and needs will not be the same depending on the activity practiced, its duration, and its intensity, but also the athlete's profile, their sex, age, height, and weight. Energy needs depend on two distinct factors: basal metabolism (BM) and physical activity level (PAL).

Aside from maintaining an ideal weight, hydration plays a fundamental role in most physical activities. Even slight dehydration leads to a significant decrease in performance and is associated with increased injury risks. A 1% dehydration results in a 10% reduction in physical performance, and when we feel thirsty, our body has already lost 10% of its physical capacities (Fereira et al., 2015). For female athletes, the functioning of the body and metabolism is more complex than for men because it is necessary to consider chronobiological cycles and their hormonal implications, which are not always easy to manage. When discussing the nutrition of female athletes, we immediately think of two things: health and body weight. Good nutrition, therefore, helps to avoid these troubles and should be applied before, during, and after exertion, meaning ultimately all year round. These reasons make the study on the importance of nutrition to improve the performance level of young female footballers a necessity to determine whether following a dietary plan adapted to training has a remarkable or negligible impact on performance. Additionally, it is crucial to know whether young female footballers follow a dietary regimen, indicating whether they are genuinely supported by their club in strict compliance with the preparation system requirements.

There is a growing interest in establishing nutritional approaches that can improve health and performance in elite sports, and football is no exception. It is now well established that foods, dietary supplements, or specific diets can improve performance, accelerate recovery, or prevent injuries in football players (Abreu et al., 2021).The importance of nutrition was recently recognized as a significant factor in performance and injuries by the Fédération Internationale de Football Association (FIFA) in 2018 when a group of experts was created to specifically update recommendations on nutrition for football. The body composition of female footballers is of particular importance concerning their performance. It has been suggested that an increase in body mass or size would be associated with longer play duration (Norton and Olds, 2001).

Since performance heavily depends on morphology and body composition, measuring the changes that occur over time in an athlete is essential for both coaches and players. What differentiates a female athlete from a sedentary woman in terms of energy intake will be related to the difference in energy expenditure, which will be higher in the athlete and variable depending on the type of sport practiced, its intensity, the environment, the athlete's age, etc. Carbohydrate needs should constitute 55% of total daily energy intake,

reaching 70% in endurance sports. Proteins support the muscle mass of the athlete. Proteins should represent 15% of total daily energy intake, with a majority from animal sources (fish, meats, dairy products). For competitive endurance athletes (more than 3 training sessions per week), the needs will be increased to 1.5 g/kg/day of informative data on regional muscle mass (Bongiovanni et al., 2023). This can be a critical point for women, as the current recommendation for female athletes is far from reality, where only 26% of women consume the correct amount of protein per day (Alexander, 2020). Low protein intake will result in poorer muscle recovery, less protein synthesis, leading to greater muscle loss, and ultimately greater hunger. Although the requirements depend on the type of exercise, an intake of between 1.6 and 1.8 g of protein/kg body weight would be correct, unlike men, where it has been observed that 2.3 g/kg body weight can be a correct intake (Streit, 2021; Health Canada, 2022). The recommended daily caloric intake is 2000 calories per day for an average woman. It is important to note that this figure is given as an indication and that the amount of energy the athlete needs varies depending on sex, height, weight, activity level, and age. Moreover, caloric intake is not only a matter of quantity but also quality because the foods the athlete eats affect the body in different ways (Osilla, 2022). We assume that following a specific and personalized dietary plan for football players, especially the young (U17), particularly considering body composition and especially daily energy expenditure. A balanced diet has an undeniable impact on improving the performance level during both training and competitions. In this respect, it is assumed that to have effective training effects, knowing body composition and following a dietary regimen built on the characteristics of training contents leads to better performance during competition.

The main objective of our work is to determine the different components of the weight of Algerian female footballers and see if nutrition impacts performance.

2. Method and Materials

In our study, we focused on 24 high-level female footballers from the Algerian national team, all under the age of 17 (U17), residing at the national team regrouping center in SIDI MOUSSA. These athletes were measured during their preparations for the 2024 World Championships.

We specify that our athletes are female and play high-level football. The table below presents the average age and the number of athletes measured.

Table 1. Characteristics of the Algerian U17 Olympic footballers

	Mean	Standard Deviation	C.V
Age (years)	16,71	0,75	4,49
Weight (kg)	60,2	7,12	11,86
Height (cm)	163,24	6,41	3,93

Measurements were taken during the day (morning) at a temperature of approximately 22°C according to basic anthropometric techniques. These athletes have been engaged in regular physical training for more than five years, and they train with their national team outside of club regrouping periods, during which the weekly training volume varies from one club to another (between 4 and 5 sessions per week).

It is essential to understand that performance in amateur football does not depend solely on physical strength, technical skills, or game strategy. Nutrition is equally important. Proper nutrition provides the necessary energy for matches and training, aids in quick recovery after physical exertion, and helps prevent injuries. This study was followed by a dietary questionnaire consisting of 18 questions related to the players' nutrition.
To conduct this study, we favored the anthropometric method. We also calculated certain indices of physical development to better understand the physical development of the footballers:

- **Calculation of Body Surface Area:**

Expressed in m^2, its determination is the main indicator of an athlete's physical development. The body surface area is calculated according to the formula by Haycock et al. (1978), which takes both weight and height into account.

$$\mathbf{S\ (m^2) = 0{,}024265\ X\ T^{0.3964}\ X\ P^{0.5378}}$$

where:

- ✓ S: Body surface area in square meters (m^2)
- ✓ T: Height in centimeters (cm)
- ✓ P: Weight in kilograms (kg)

- **E. Schreider Index (1953):**

Expressed in kg/m², this index provides information about an individual's robustness. The formula for calculating this index is as follows:

$$\mathbf{IR = P/Sa\ kg/m^2}$$

where:

- ✓ IR: Robustness index expressed in kg/m²
- ✓ P: Body weight in kg
- ✓ Sa: Absolute body surface area in m²

- **Energy Expenditure Index:**

According to Touabti-Mimouni N. (2015), this index provides information about an athlete's energy expenditure degree based on their body surface area and weight. A smaller value indicates better energy efficiency, leading to greater resistance to work intensity. This index is calculated as follows:

$$\mathbf{SP = Sa/P\ \ cm^2/kg}$$

where:

- ✓ SP: Energy expenditure index expressed in cm²/kg
- ✓ Sa: Absolute body surface area in m²
- ✓ P: Body weight in kg

- **Quetelet Index:**

This index reveals the level of physical development of an individual. It is expressed in g/cm according to the formula by Quetelet (1869), with a value of 350 for sedentary individuals and more than 400 g/cm for high-level athletes (Mimouni 2015).

$$\mathbf{IQ = P/T\ \ g/cm}$$

where:

- ✓ IQ: Quetelet index in g/cm
- ✓ P: Body weight in kg
- ✓ T: Height in centimeters

- **Kaup Index (1921) or Body Mass Index (BMI):**

This index divides body weight by the square of height. It is expressed in g/cm² with the following formula:

$$\mathbf{IK=PT^2\ g/cm^2.}$$

For interpreting the results of this index, we rely on the scale developed by Davenport and cited by Vandervael (1980):

Interpretation	Values
Very thin	140 to 180
Thin	181 to 214
Medium	215 to 256
Corpulent	257 to 305
Obese	306 and above

Sheldon Index: This index provides information about an individual's elongation. It is also the inverse of Livi's index and is calculated using the following formula:

ISh=TP3ISh=3PT

where:

- ✓ ISh: Sheldon index expressed in cm/g
- ✓ T: Height in centimeters
- ✓ P: Body weight in kg

Body Weight Composition:

Body weight is one of the most important indicators of physical development. The components of body weight include fat mass, bone mass, and muscle mass. Body weight components are determined using the anthropometric method, which does not require sophisticated equipment and is easy to use.

To determine the components of body weight, we used the formulas of the Czech researcher Mateika Y (1921), namely: the fat component, the muscle component, and the bone component.

To better understand the different parameters of body composition, we also used bioelectrical impedance analysis. The accuracy of impedance analysis in predicting body composition heavily depends on the validity of the models in a given population (Varlet-Marie et al., 2009). For our research, we used the InBody 720 body composition analyzer.

Our investigations were conducted at the National Technical Center of the Algerian Football Federation, the permanent regrouping center for national teams.

Figure 1 : InBody 720 test on a female football athlete. **Figure 2 : Result sheet from the In body720**

In less than 60 seconds, the InBody 720 body composition summaries provide information on basal metabolism, lean mass, and fat mass for each athlete. The investigated parameters are represented in the result sheet (Figure 2). Age, height, weight, and sex are the key personal information needed for body composition analysis.

Calculation of Fat Mass Index: Formula by Deurenberg (1991) Body composition analysis involves quantifying and measuring the fat mass percentage in women (Deurenberg, 1991). To calculate the fat mass index, the following formula is used for women :

Fat Mass Index (FMI)=(1.20×BMI)+(0.23×Age)−(10.8×sex)−5.4Fat Mass Index (FMI)=(1.20×BMI)+(0.23×Age)−(10.8×sex)−5.4

where sex = 0 for a woman.

Table 3: Classification of Fat Mass Percentage in Women According to Deurenberg (1991):

Age Group	Low	Healthy	Overweight	Obese
20-39 years	< 21%	21-31%	31-39%	> 39%
40-59 years	< 23%	23-36%	36-40%	> 40%
60 years and above	< 25%	25-37%	37-42%	> 42%

For statistical processing, we used descriptive analysis (Champely S, 2004): arithmetic mean, standard deviation calculation, and coefficient of variation. All calculations were performed using Excel 2010 for Windows and the STATISTICA software (2011)

3. Results

Analysis of Total Parameters:

Table 4: Characteristics of the Algerian U17 Olympic Footballers

	Average	Standard Deviation	C.V
Age (years)	16.71		0.75
Weight (kg)	60.2		7.12
Height (cm)	163.24		6.41

Our sample has an average age of 16.71 years (± 0.75). The coefficient of variation is 4.49%, demonstrating a high level of homogeneity within the group. Regarding weight, the average recorded is 60.2 kg (± 7.12) with moderate homogeneity (C.V: 11.86%). The average height of our footballers is 163.24 cm (± 6.41) with a coefficient of variation of 3.93%, showing a high level of homogeneity.

Analysis of Physical Development Indices:

Physical development indices provide general information about the athlete's constitution and allow for better training planning.

Absolute and Relative Surfaces:

In our study, the body surface area of the footballers is 1.65 m^2 ± 0.12 for the girls. This indicates that the physical development of the athletes is well advanced. It is linked to weight and height. Thus, the larger these indices,

the greater the body surface area. Football is characterized by a system of weight variation among practitioners.

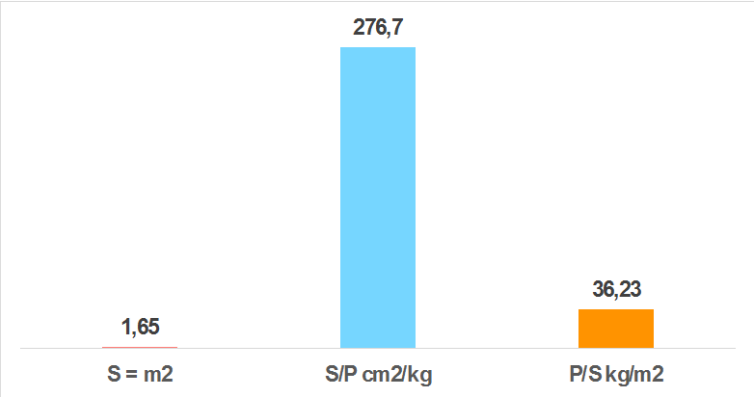

Figure 3: Representation of Absolute and Relative Body Surfaces

Body Surface Area Index:

This index provides information on the state of physical development. Izakson (1956) estimates that the larger this index, the better the physical development. An analysis of the absolute surface values shows an average surface area compared to high-level athletes (2 m²). The sample is homogeneous (C.V% = 7.14%).

The Schreider index, expressed by dividing weight by absolute surface area, provides a precise idea of the athlete's robustness. Our athletes show a good index (36.23 kg/m²) with a coefficient of variation of 5.12%, indicating high homogeneity within the group.

Table 5: Results of Physical Development Indices

Average	Standard Deviation	C.V%
I. Schreider (kg/m²)	36.23	1.86
SP (Energy Expenditure Index cm²/kg)	27.67	1.43
Quetelet Index (g/cm)	36.759	4.029
Kaup Index (BMI g/cm²)	22.54	2.53
Sheldon Index (cm/g)	41.79	1.85

Analysis of Body Composition :

Evaluating and interpreting body composition are fundamental aspects of football players' development. Several techniques allow the evaluation of different body composition parameters, each with its advantages and disadvantages.

In our work, we favored the calculation method of Mateigka (1921).

Table 6: Body Composition of Female Footballers

	Muscle Component (kg)	Bone Component (kg)	Fat Component (kg)
Average	23.22	8.73	
Standard Deviation	3.51	1.13	
C.V	15.14%	12.98%	

Analyzing the body composition of our footballers shows a muscle mass value of 23.32 kg, bone mass of 8.73 kg, and fat mass of 15.18 kg. While the group shows perfect homogeneity for muscle and bone components, the fat component is high and indicates heterogeneity within the group.

It is important to note that despite changes observed in body composition over the decades, female footballers do not form a homogeneous group of athletes, and differences can exist between athletes depending on their playing style. Supporting this assertion, Kraemer et al. (2005) observed that the fat mass of a particular position could be significantly higher in one athlete than in another. The authors suggested that differences in strength and conditioning exercises and nutritional interventions could contribute to the observed differences.

Results of Bioelectrical Impedance Analysis:

Body composition is undoubtedly one of the essential values that coaches must gather. It is both a good indicator of an individual's health and a valuable training tool. Body composition undergoes numerous variations depending on age, sex, and sports discipline.

In our work, we performed measurements using the In Body 720 bioelectrical impedance meter. We present the results below:

Figure 4: Example of a Test Conducted on a Player (15-year-old right-back)

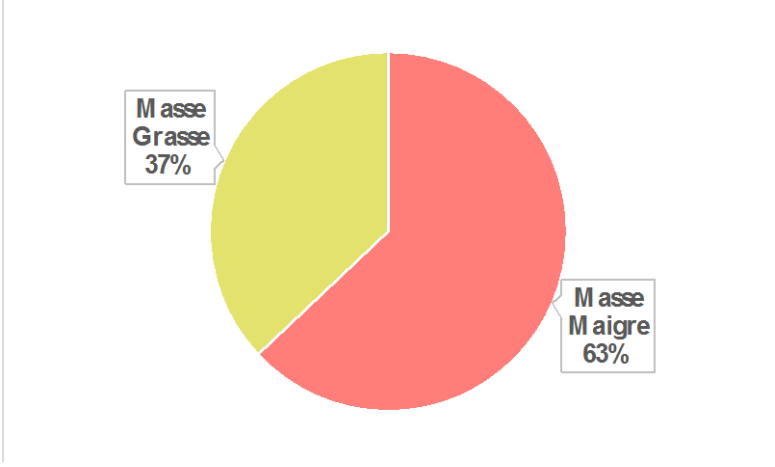

Figure 5: Body Composition Results According to In Body 720

Lean mass significantly influences basal metabolism (the minimum daily energy expenditure required for the body to perform its vital functions). Despite the homogeneity of the group of footballers, our athletes exhibit low energy expenditure.

The basal metabolic rate (BMR) is the amount needed to support bodily functions such as heart rate, breathing, and blood circulation at rest. It accounts for approximately 60 to 80% of total energy expenditure.

Table 7: Values of Body Composition According to Bioelectrical Impedance

Weight (kg)	Lean Mass (kg)	Fat Mass (kg)
Average	60.13	24.94
Standard Deviation	7.22	2.63
C.V	12.00%	10.56%
Max	73.2	29.7
Min	46.7	18.5

Fat mass corresponds to triglycerides stored in adipocytes. This fat mass can be divided into essential and "non-essential" fat. The body needs a certain amount of fat to function normally, notably to provide an important energy source, regulate body temperature, and protect internal organs (Heymsfield et al., 2005).

Our athletes exhibit overweight, highlighting a significant heterogeneity (C.V%: 29.44%). This should draw the coach's attention to the nutrition of certain athletes and foresee a higher training load to reduce this excess.

Ideal Body Composition According to Bioelectrical Impedance

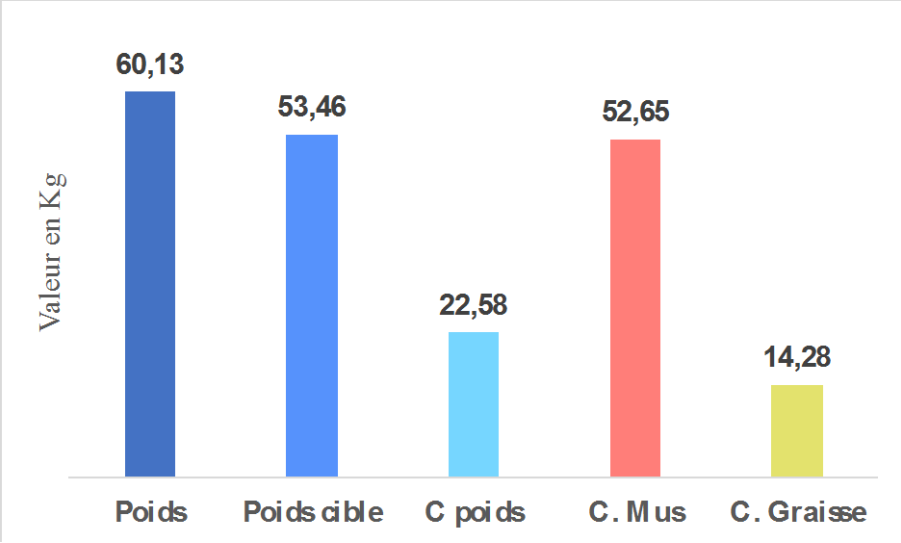

Figure 6: Ideal Body Composition According to Bioelectrical Impedance

The analysis of ideal values shows that our athletes exhibit overweight compared to the original weight (ideal weight = 53.46 kg). This impacts fat mass, where the athletes need to lose a total of 14.28 kg for the entire team. However, they show good muscle mass.

Basal Metabolism

Basal metabolism corresponds to the energy expenditure needed for the body to survive at rest. It is expressed in Kcal for a day.

Table 8: Basal Metabolism Values According to Bioelectrical Impedance

	Basal Metabolism (kcal)
Average	1338,65
Standard deviation	95,82

Analysis of Fat Mass Index

Having observed that several of our athletes exhibited overweight and significant fat mass, we calculated the fat mass index using Deurenberg's formula (1991). This calculation is based on BMI (Body Mass Index), age, and sex.

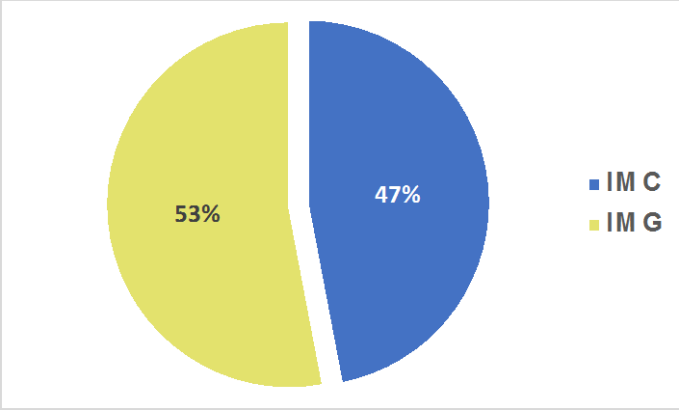

Figure 7: Percentage of Fat Mass Index (FMI) and Body Mass Index (BMI)

The interpretation of the obtained values clearly shows an excess of fat mass (25.32 kg) according to the reference table by Deurenberg (1991). When the fat mass percentage is too high, fat will be stored around organs and in certain body areas (abdomen, waist, hips, thighs). This can eventually cause overweight or obesity, making it difficult to move and be autonomous.

A very low-fat component can negatively influence athletic performance and, moreover, lead to health problems for female footballers. When body fat decreases significantly, the capacity to produce female hormones, such as estrogen, is reduced, leading to a higher incidence of injuries.

Hydration Balance Representation

Table 9: Hydration Balance of Female Footballers

Total Water (L)	Intracellular Water (EIC) (L)	Extracellular Water (EEC) (L)
Average	50.80	32.11
Standard Deviation	5.02	3.29
C.V	9.88%	10.26%

For the female footballers, the average total water is 50.80 L (± 5.02), divided between 32.11 L (± 3.29) inside the cells and 18.69 L (± 2.05) outside the cells. Optimal hydration is essential for high-level performance in training and matches, but it is not always possible under difficult training or competition conditions. Several factors contribute to ideal hydration, such

as the rate of sweating, the external environment, the intensity and duration of the effort, the body size, and the composition of the organism. It is possible to guard against the negative effects of dehydration by choosing the right type and volume of drinks and carbohydrates to consume before, during, and after training or matches, which can maximize performance and recovery of the player.

3. Discussion :

Football is a sport requiring varied intensity, as each technical action is specific on the field. It requires anaerobic endurance for quick actions and aerobic endurance for sustained effort (Shields et al., 1984). Moreover, power and aerobic endurance are also essential to maintain a high and constant intensity level, as efforts are short, intense, and repeated over several minutes without complete recovery. The physical demands of football thus necessitate a nutritional need of 55 to 65% carbohydrates, 15 to 20% proteins, and 20 to 30% lipids.

The energy balance equals total energy intake minus total energy expenditure. Thus, dietary intake and physical activity-related energy expenditure determine the plateau around which body weight and fat mass are regulated. The distribution of results according to BMI indicates that 40% of female footballers have a normal BMI (Fogelholm, 2003).

After evaluating fat mass, we found that the female footballers have a fat percentage above the norms (22%), with an average of 25.08 kg. These results do not meet high-level sports requirements. In high-level athletes, the daily energy expenditure is high; the best strategy for weight loss and fat mass reduction is to decrease total energy intake (reducing the number of kilocalories consumed, the percentage of fats, and the amount of high glycemic index carbohydrates) (Wilmore, 2006).

We observe that the highest average is muscle mass, represented by the value of 23.22 kg. These data align with the results of the questionnaire (Bigard and Guezennec, 2017). To avoid initiating the physiological process of proteolysis, the solution seems to lie in increasing the protein ration. It is even possible to increase muscle mass by consuming more than 2 g of protein per kg per day, despite a caloric restriction, by consuming supplements like "WHEY" (Koutedakis et al., 1994). Additionally, our players place great importance on hydration, as they report drinking 2 liters of water per day (Bigard and Koulman, 2017).

4. Conclusion

High-level athletes train hard and daily subject their bodies to strenuous activity. Our female footballers train five times a week with their respective clubs, in addition to permanent national team regroupings. They must adapt and respond to heavy training loads. Poor management of accumulated training loads can increase the risk of overtraining and decrease physical fitness. Quantifying the training load allows us to follow our planning and avoid injury, overwork, and overtraining risks, thus providing good training direction.

Women's football in Algeria suffers from several problems: the lack of sports infrastructure and recovery means (sleep, nutrition, recovery after training and matches). These parameters directly influence the players' fitness, fatigue, and stress levels.

The importance of nutrition is often underestimated. Yet, proper nutrition is a key factor that can make the difference between average and exceptional performance on the field. Female football players, like all athletes, have specific nutritional needs that must be met for them to perform at their best. Proper nutrition provides the necessary energy for matches and training, aids in quick recovery after physical exertion, and helps prevent injuries.

The results of our work showed that during the national team camps, the female footballers' diet seems balanced. However, variations in individual body composition indicate a certain deficiency in protein intake, with athletes not consuming enough. In terms of lipid consumption, some players are overweight and need to adjust their weight through a higher training load.

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