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Effect of Prolonged Dietary Restriction during Ramadan Fasting on Body Mass Index, Basal Metabolic Rate, Total Energy Expenditure, and selected metabolic parameters in soccer players

Amar MOUISSA [*1], Aissa SLIMANI [2], Kamel SADOUKI [3]

[1] Phd student, Laboratory of Sciences and practices of the sports and artistic physical activities, IEPS, University of Algiers 3, Algeria, mouissa.amar@univ-alger3.dz

[2] Phd, Laboratory of Sciences and practices of the sports and artistic physical activities, IEPS, University of Algiers 3, Algeria, slimsport21@gmail.com

[3] Phd, Laboratory of biological sciences applied to sport, higher school of sport science and technology, Dely Ibrahim, Algiers, sadouki_kamel@yahoo.fr

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Abstract:

This study aimed to evaluate the effect of prolonged dietary restriction during Ramadan fasting on weight, BMI, basal metabolic rate, total energy expenditure, and blood glucose levels in soccer players under the age of 15 years. Twenty-four U15 Algerian amateur soccer players voluntarily participated in this study (mean ± SD: age = 14.25 ± 0.60 years, body height = 54.34 ± 8.19 cm). Measurements were made over three periods: before Ramadan (BR), middle of Ramadan (Mid-R), and after Ramadan (AR). Blood sugar levels, weight were measured, and calculate body mass index, total energy expenditure, and basal metabolic rate. Weight, body mass index (BMI), and basal metabolic rate (BMR) remained stable during the middle of Ramadan (Mid-R) compared to before Ramadan (BR) and after Ramadan (AR), i.e. there were no significant ($p > 0.05$). However, there are significant between the BR and Mid-R periods ($p < .001$), and between Mid-R and AR in blood sugar level (BSL) ($p < .001$). and there are significant between the period middle of Ramadan (Mid-R), before Ramadan (BR) and after Ramadan (AR) in total energy expenditure (TEE) ($p = 0.017$) ($p < 0.05$). In conclusion Ramadan fasting is often associated with metabolic and physiological changes, such as sleep disturbances, decreased physical activity, hormonal activity, and dietary intake, these changes in our study affected total energy expenditure and blood glucose levels.

Keywords: Ramadan fasting; Basal metabolic rate; Body mass index; Total energy expenditure; Blood sugar levels; Soccer players.

Corresponding author: Amar MOUISSA, E-mail: mouissa.amar@univ-alger3.dz

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1. Introduction

According to the Islamic lunar year, Ramadan is the 9th month, and it is the 4th pillar of Islam. While Muslims fast from dawn until sunset, fasting Muslims usually consume two main meals during Ramadan, one before sunrise, known in Arabic as “Suhoor”, and the other after sunset, known as “Iftar”. The month of Ramadan covers a period of 28 to 30 days. The dates of observance differ each year because Ramadan is set to a lunar calendar. The time of sunrise and sunset varies between 12 h at the equator and about 22 h at 64° of latitude in summertime, thus altering substantially the daily fasting event (Berbari et al., 2012).

Fasting during Ramadan involves alternating between depleting and replenishing the liver's glycogen stores. The morning portion of the fasting day is characterized by a predominance of carbohydrates as the primary energy source, while the importance of fats increases as the afternoon approaches and as the time for breaking the fast at sunset (iftar). During the fasting days of Ramadan glucose homeostasis is maintained by meals taken before dawn and by liver glycogen stores (Azizi, 2010), This is due to the hormone glucagon; whose primary function is to raise blood sugar levels by stimulating the liver to release stored glucose. It has also been reported that physical activities During Ramadan, tend to decrease from a fear of feeling too weak (Ziaee et al., 2006). However, high-intensity exercise, like sprinting, relies primarily on muscle glycogen. Theoretically, the maintenance of muscle glycogen stores up to the time of exercise suggests that energy requirements during sprinting remain similar to those of non-fasting. During repeated sprint ability performed shortly before the iftar meal, working muscles require high-energy phosphates (ATP and CP) and glucose. Since blood glucose balance is primarily regulated by insulin/glucagon balance, hepatic activation, and ketone metabolism, it can be concluded that intramuscular glycogen stores are sufficient for high-intensity muscle activation (Özbay et al., 2024).

Ramadan fasting is accompanied by changes in sleep and activity patterns, as well as alterations in the circadian rhythms of hormones, including cortisol, insulin, leptin, ghrelin, growth hormone, prolactin, and adiponectin (Lessan & Ali, 2019). Ramadan fasting contributes to a reduction in waist circumference, body fat percentage, body mass index (BMI), blood glucose levels, cholesterol, LDL cholesterol, VLDL cholesterol, triglycerides, systolic and diastolic blood pressure, and anxiety levels (Meo & Hassan, 2015). After a few hours of fasting, blood glucose levels slightly decrease from 70 mg/dL to 60 mg/dL, stimulating gluconeogenesis in the liver due to increased sympathetic nervous system activity and glucagon release (Azizi, 1996). Improvements in blood lipid levels, blood pressure, and insulin sensitivity have been consistently reported (Kalam et al., 2019). However, the effect of Ramadan fasting on body composition is inconclusive, as some studies indicate significant reductions in body weight (Ziaee et al., 2006) and many other failing to show any relevant changes.

Basic metabolism includes all the biochemical processes in the organism involved in the production and release of energy to sustain life during a period of complete rest, and the term ‘basal’ was used to distinguish between the energy expended while performing physical

Corresponding author: Amar MOUISSA, **E-mail:** mouissa.amar@univ-alger3.dz

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activity and being at rest, and represents the amount of energy in kilocalories used over a given period of time (e.g., 24 h) to perform the most basic functions of the body. It is usually expressed as heat production or oxygen consumption per unit body size (Henry, 2005). Total energy expenditure (TEE) is composed of the energy costs of the processes essential for life, of the energy expended in order to digest, absorb, and convert food, and the energy expended during physical activities (Westerterp, 2013). A sustained imbalance between energy intake and energy expenditure (requirement) may impair bodily functions under certain circumstances. Negative energy balance could impair growth and development in childhood (Richard et al., 2012), physiological responses to physical activity. In contrast, a positive energy balance could lead to obesity and associated comorbidities (Jastreboff et al., 2019). Understanding how energy expenditure and energy stores change throughout the life course is therefore relevant for human health. In this study, we examine the effect of prolonged dietary restriction during Ramadan fasting on weight, BMI, basal metabolic rate, total energy expenditure, and blood glucose levels in soccer players under the age of 15.

2. Method

2.1 Participants

Twenty-four U15 Algerian amateur soccer players voluntarily participated in this study (mean ± SD: age = 14.25 ± 0.60 years, body height = 54.34 ± 8.19 cm). Before starting the experiment, the authors confirmed that all players were free from diseases and informed them about the study's objectives, duration. The study adheres to the Declaration of Helsinki.

2.2 Design and Procedures

Data were taken, and blood levels were also evaluated from the players. The experimental protocol consisted of three phases: one week before Ramadan (BR), middle of Ramadan (Mid-R), and Three weeks after Ramadan (AR).

2.3 Data Collection

Weight Measurement & Body mass index: Weight was measured using a balance at three different times: before Ramadan (BR), middle of Ramadan (Mid-R), and Three weeks after Ramadan (AR). The measurements were taken before the training session, and participants were asked to remove their shoes before stepping onto the balance. The BMI equation: weight (kg) / [height (m)] ^{2}.

Monitored blood glucose (MBG): blood sugar levels were measured by Fingerstick testing using a glucometer, which is an easy and widely used method for short-term blood sugar monitoring. The measurement was carried out over three periods, before Ramadan (BR), middle of Ramadan (Mid-R) and After Ramadan (AR).

Basal metabolic rate (BMR) & Total energy expenditure (TEE): Based on the data we obtained, we used the Harris and Benedict equations published in 1918: BMR = 66.4730 + (13.7516 × weight in kg) + (5.0033 × height in cm) - (6.7550 × age in years), and total energy expenditure: TEE = BMR x Activity coefficient.

Corresponding author: Amar MOUISSA, **E-mail:** mouissa.amar@univ-alger3.dz

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2.4 Statistical Analysis

All statistical tests were processed using SPSS version 30.0.0. Mean and SD (standard deviation) values were calculated for each variable. The Shapiro-Wilk W-test of normality revealed that the data were normally distributed ($p > 0.05$). Once the assumption of normality was confirmed, parametric tests were performed. one-way analysis of variance (ANOVA) used and the Bonferroni test to determine the between the study periods. Except for the BMI data, they are not normally distributed ($p < 0.05$) in the three study periods BR, Mid-R, AR, ($P = 0.009$), ($P = 0.005$), ($P = 0.012$) respectively, so the Kruskal-Wallis test and the Mann-Whitney test were used.

3. Results

Basal metabolic rate (BMR) remained stable during the middle of Ramadan (Mid-R) compared to before Ramadan (BR), i.e. there were no significant ($p = 0.998$) ($p > 0.05$). However, there are significant between the period middle of Ramadan (Mid-R), before Ramadan (BR) and after Ramadan (AR) in total energy expenditure (TEE) ($p = 0.017$) ($p < 0.05$). And also there are significant between the period middle of Ramadan (Mid-R), before Ramadan (BR) ($p <.001$) and between middle of Ramadan (Mid-R), after Ramadan (AR) ($p <.001$). There were no significant between before Ramadan (BR) and after Ramadan (AR) ($p = 1.000$) in blood sugar level (BSL).

Table 1. Blood sugar level, Basal metabolic rate, and total energy expenditure during three periods, before Ramadan (BR), middle of Ramadan (Mid-R) and After Ramadan (AR), (mean ± SD).

	BR	Mid-R	AR
BSL (mmol/l)	1,2 ± 0,17	0,95 ± 0,1 &*	1,22 ± ,09
BMR (kcal/day)	1552.62 ± 120.28	1551.57 ± 121.52	1553.7 ± 119.55
TEE (kcal)	2794.72 ± 216.51	2637.67 ± 206.59 &*	2792.45 ± 214.87

Note. BR: Before Ramadan; Mid-R: Middle of Ramadan; AR: After Ramadan; BSL: Blood sugar level; BMR: Basal metabolic rate; TEE: Total energy expenditure; BMI: Body mass index; &: Significant difference compared to BR; *: Significant difference compared to AR.

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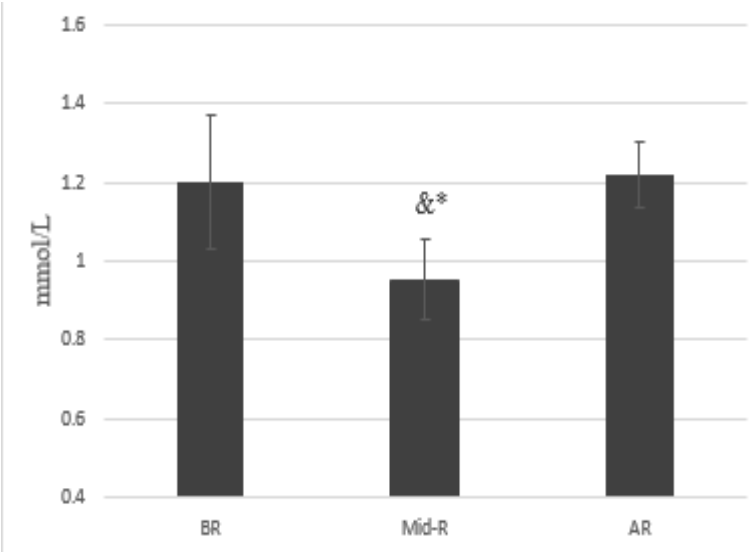


Figure 1. Blood sugar level, during three periods, before Ramadan (BR), middle of Ramadan (Mid-R) and After Ramadan (AR), (mean ± SD).

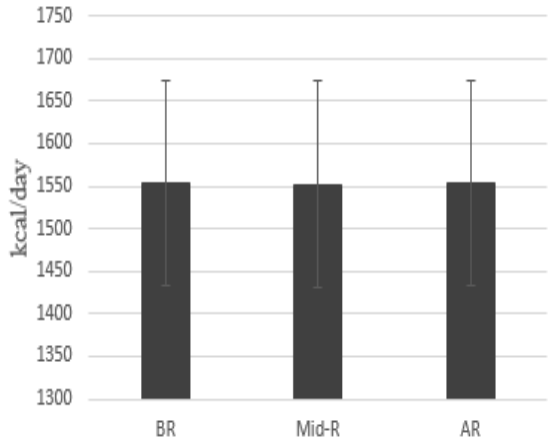


Figure 2. Basal metabolic rate, during three periods, before Ramadan (BR), middle of Ramadan (Mid-R) and After Ramadan (AR), (mean ± SD).

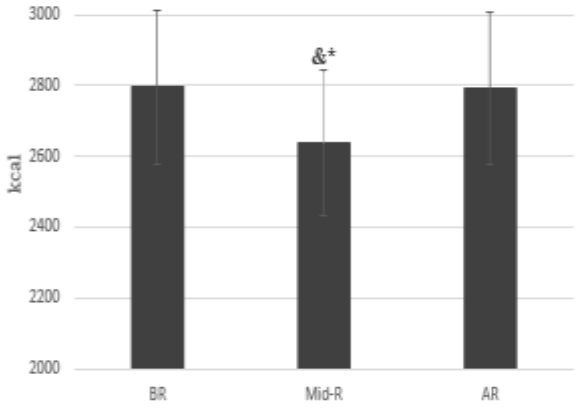


Figure 3. Total energy expenditure, during three periods, before Ramadan (BR), middle of Ramadan (Mid-R) and After Ramadan (AR), (mean ± SD).

Table 2. Weight, and Body mass index during three periods, before Ramadan (BR), middle of Ramadan (Mid-R) and After Ramadan (AR), (mean ± SD).

	BR	**Mid-R**	**AR**
Weight (kg)	54.34 ± 8.19	54.38 ± 8.21	54.37 ± 8.18
BMI (kg/m^2)	19.55 ± 3.08	19.5 ± 3.1	19.64 ± 3.04

Note. BR: Before Ramadan; Mid-R: Middle of Ramadan; AR: After Ramadan; BMI: Body mass index.

Corresponding author: Amar MOUISSA, **E-mail:** mouissa.amar@univ-alger3.dz

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There is no significant difference between before Ramadan (BR) and middle of Ramadan (Mid-R) ($p = 0.16$), and between middle of Ramadan (Mid-R), after Ramadan (AR) ($p = 1.00$), and between before Ramadan (BR) and after Ramadan (AR) ($p = 0.64$) in weight. There is also no significant difference between before Ramadan (BR) and middle of Ramadan (Mid-R) ($p = 0.98$), and between middle of Ramadan (Mid-R), after Ramadan (AR) ($p = 0.82$), and between before Ramadan (BR) and after Ramadan (AR) ($p = 0.85$) in Body mass index.

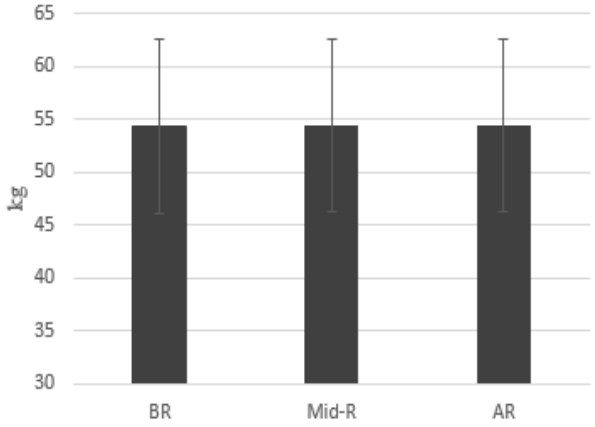


Figure 4. Weight during three periods, before Ramadan (BR), middle of Ramadan (Mid-R) and After Ramadan (AR), (mean ± SD).

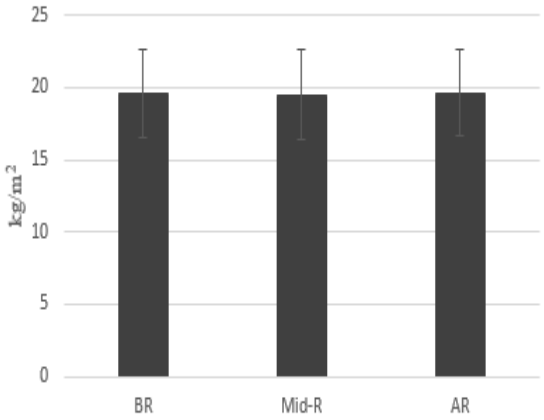


Figure 5. Body mass index during three periods, before Ramadan (BR), middle of Ramadan (Mid-R) and After Ramadan (AR), (mean ± SD).

4. Discussions

The effect of Ramadan on metabolism is very complex. Many bodily mechanisms are involved in maintaining balance while fasting, and changes in the physical activity level, mealtime, and bedtime alter the metabolism discretely. However, it is difficult to determine the exact effects of each factor alone on the metabolism while fasting. In the present study, Ramadan fasting did not affect the basal metabolic rate (BMR) compared to before Ramadan (BR) and after Ramadan (AR), which is consistent with the results obtained by Pishbin et al., (2021) which concluded that Ramadan fasting can effectively improve metabolic markers and prevent a decrease in basal metabolic rate if accompanied by nutritional support and healthy dietary recommendations. Therefore, Ramadan fasting can be considered a therapeutic alternative, particularly for individuals with metabolic syndrome, cardiovascular disease, or metabolic disorders (Aljaloud, 2020).

Fasting during the month of Ramadan did not affect the body mass index (BMI). When observing the results obtained in the weight variable, we find that there is a decrease, but it was not significant compared to before Ramadan (BR) and after Ramadan (AR). Most studies have also found that fasting during the month of Ramadan affects weight and body

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mass index, Correia et al., (2020) reported that Ramadan fasting leads to significant reductions in Body mass index, fat mass (relative and absolute), and body weight. The study by Nachvak et al., (2019), which was conducted on 160 healthy men, indicated that the body weight and BMI decreased significantly during Ramadan. Fernando et al., (2019) reported that Ramadan fasting leads to significant reductions in weight, fat mass (both as a percentage of body weight and as absolute mass), and lean mass. Majid et al., (2023) reported a slight increase in average weight during the second week of Ramadan, while a decrease of 0.4 kg occurred during the fourth week. However, weight and BMI returned to normal levels within two to three weeks after Ramadan. During Ramadan, changes in meal time and fluid intake, as well as decreased frequency, may cause various physiological changes. It is clear that dietary habits and choices vary across cultures, and the proportion of energy derived from carbohydrates, proteins, and fats varies across Islamic countries (Sadeghirad et al., 2014).

The handful of studies on energy consumption during Ramadan fasting indicate generally insignificant changes in total energy expenditure (TEE). The results obtained in the current study indicate that Ramadan fasting (Mid-R) affect total energy expenditure (TEE), compared to before Ramadan (BR) and after Ramadan (AR). The number of training sessions decreased from 5 to 4. The activity coefficient before and after Ramadan was 1.8, while it was 1.7 in the middle of Ramadan, this affected the total energy expenditure. Lessan et al., (2018) reported that Ramadan is associated with decreased physical activity and reduced RMR after the first week of fasting. However, these decreases in energy expenditure components did not translate into an overall decrease in total energy expenditure. In contrast to our findings, McNeil et al., (2014) concluded that there were no significant differences in RMR, thermic effect of food, and TEE in Ramadan and post-Ramadan periods (2224 compared with 2121 kcal/d). Alsubheen et al., (2017) reported that daytime fasting had an effect on the daily contribution of substrates to energy expenditure and on the metabolic profile of the blood.

During the afternoon phase of Ramadan Fasting, skeletal muscles exhibit metabolic flexibility, shifting from carbohydrates to fats as the primary energy source to maintain hepatic glycogen stores and blood glucose levels (Lessan & Ali, 2019a). Since blood glucose balance is primarily regulated by insulin/glucagon balance, hepatic activation, and ketone metabolism, it can be inferred that intramuscular glycogen stores are sufficient for high-intensity muscle activation. However, the cognitive impairments associated with low blood glucose levels suggest that even when muscle cell metabolism is regular, disruptions in neurotransmission pathways to the muscle cells.

The results obtained in the current study indicate that Ramadan fasting affect blood sugar levels (BSL), compared to before Ramadan (BR) and after Ramadan (AR). These results are consistent with the research of Salih et al., (2024) which indicates that fasting can significantly alter glucose metabolism and insulin sensitivity. It is quite normal for blood sugar levels to drop during Ramadan fasting in healthy individuals. We measured blood sugar levels in healthy individuals, and this is due to the lack of studies on blood sugar levels during Ramadan fasting, as most of these studies have been on diabetics, it's also related to physical performance.

Corresponding author: Amar MOUISSA, **E-mail:** mouissa.amar@univ-alger3.dz

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Limitations

The findings may not apply to other populations or regions, and caution should be exercised when generalizing the results. With some limitations, future research should aim to include a more comprehensive set of factors that influence changes in weight, BMI, basal metabolic rate, blood sugar level, and total energy expenditure during Ramadan, such as sleep patterns, food intake, stress levels, and mental health. Longitudinal studies could provide a deeper understanding of the long-term effects of Ramadan fasting on these variables across different population groups.

5. Conclusions

To the best of our knowledge, the present study represents the inaugural investigation of the effect of prolonged dietary restriction during Ramadan fasting on weight, BMI, basal metabolic rate, total energy expenditure, and blood glucose levels in soccer players under the age of 15 years. Because Ramadan fasting is often associated with metabolic and physiological changes, such as sleep disturbances, decreased physical activity, hormonal activity, and dietary intake, these changes in our study affected total energy expenditure and blood glucose levels. Fasting during Ramadan can also affect weight, or be an ideal opportunity to lose weight.

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Corresponding author: Amar MOUISSA, **E-mail:** mouissa.amar@univ-alger3.dz

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Corresponding author: Amar MOUISSA, **E-mail:** mouissa.amar@univ-alger3.dz

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