

Athletes during an Ramadan Fasting Period

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The Ramadan fasting period (RFP) means abstaining from consuming food and/or beverages during certain hours of the day—from sunrise to sunset. Engaging in exercise and sports during the RFP leads to the lipolysis of adipose tissue and an increase in the breakdown of peripheral fat, leading to an increase in fat consumption. The effects of the RFP on functional, hematological, and metabolic parameters needs further study as existing studies have reported contradictory results. The differences in the results of various studies are due to the geographical characteristics of Muslim athletes, their specific diets, and their genetics, which explain these variations.

Keywords: diet ; intermittent fasting ; calorie restriction ; dehydration ; exercise ; balanced hormones ; health promotion ; hypoglycemia

1. Nutritional Considerations for Athletes during an RFP

Macronutrients are very important for athletes. During an Ramadan fasting period (RFP) and energy restriction, athletes lose weight due to reduced food intake. Therefore, a proper diet plan during this period can help an athlete achieve a good balance between energy intake and consumption ^{[1][2]}. However, athletes should not focus on micronutrients, but rather they should include macronutrients in their diets ^[3].

1.1. Protein

Consuming protein is one weight management strategy that increases the feeling of satiety as well as heat production ^[4] ^[5]. People with high-protein diets do not have a big problem because they are used to consuming less energy ^{[6][7]}. Therefore, planning a high-protein diet can be a solution for athletes during RFPs. High-protein diets increase satiety, increase thermal energy, and reduce fat consumption ^[8]. Using protein supplements, along with resistance training and other supplements, such as creatine and beta-hydroxy-beta-methylbutyric acid (HMB), helps maintain energy ^{[9][10]}.

1.2. Lipids

Adequate lipids in the diet are very important due to the structural and storage properties of this nutrient ^[11]. Therefore, engaging in resistance training during energy restriction can induce the consumption of carbohydrates and lipids, and it can eliminate the consequences of an RFP. The dietary recommendation for RFPs is to consume a low-fat meal with a high carbohydrate level ^{[12][13][14]}. It has been suggested that fasting increases the number of beta-adrenoceptors in adipose tissue in rats ^[15], but a decrease in beta-adrenoceptors has been observed in human adipose tissues ^[15]. Fasting conditions lead to an increase in the basal lipolysis of adipose tissue, but the lipolytic response (even of antihypertensives) to catecholamines decreases ^[16]. Fasting increases the levels of catabolic hormones, such as GH ^[17] and glucagon ^[16], as well as catecholamines, which leads to increased lipolysis ^[18].

1.3. Hydration Strategies

Maintaining a water–salt balance during an RFP is important for athletes, but it is challenging when they must continue their training and competition programs ^{[19][20][21]}. A lack of water can create three conditions for Muslim athletes:

- The RFP prevents athletes from being hydrated during a race, and they become dehydrated.
- The lack of water causes a drop in performance.
- The lack of water disrupts the balance of water and electrolytes ^[21].

Many factors affect exercise performance during RFP conditions ^[21]. The duration of exercise is an important factor as short-term activities are less affected by RFP conditions. As the duration of food and water deprivation increases during

Ramadan, so does the condition of hypohydration [22][23]. It has been observed that the deprivation of fluids reduces one's level of consciousness and results in mental fatigue, ultimately causing functional impairment [24][25]. However, ambient temperatures and humidity can affect the hydration of the athlete [26][27]. Many criteria can be used to diagnose dehydration, such as the frequency, volume, and color of the urine [28]. Using the following solutions can prevent dehydration in the body during an RFP:

- Reduce the time in situations where there is a possibility of dehydration, such as exposure to sunlight.
- Be sure to check the hydration status of the body.
- Before an RFP begins, fluids should be selected according to the conditions and contain minerals and energy that reduce water loss.
- The consumption of fluids when a person is not participating in an RFP should be regular, such as during the night.
- As much as possible, one should train and compete for 2 to 3 h after sunset [29].

2. Response of Hematocrit to an RFP in Athletes

During 1 of the 12 months of the Islamic calendar ("Ramadan"), mature and healthy Muslims abstain from drinking and eating from sunrise to sunset [29]. An RFP during the holy month of Ramadan can cause many changes in the psychological and physiological characteristics of a person [30][31]. Physiological changes that have been observed include dehydration [30], metabolic responses [30][31], sleep and wakefulness changes, hormone secretion, and the function of various organs of the body [31]. Athletes must manage these changes by developing a proper training plan [32]. By considering one's water supply and nutrition during Ramadan, the stability of the athlete's blood counts can be maintained [33].

2.1. Erythrocyte States

Studies have shown conflicting results regarding Ramadan's effect on the body's iron status. Boehlell et al. [34] observed a significant increase in hematocrit (Hct) and hemoglobin (Hb) concentrations in rugby players at the end of Ramadan compared to a control. However, Hosseini and Hejazi [35] observed a decrease in Hct, Hb, and red blood cells (RBC) in young football players following an RFP. Additionally, Hosseini et al. [36] failed to observe significant changes after a Ramadan RFP in Hct and Hb but saw a decrease in RBC [36]. When considering different times of the day, Maughan et al. [37] reported small changes (less than 2%) in the Hct levels of football players during Ramadan.

2.2. Platelet Count

When examining the effect of an RFP on blood platelet count in three sports, an increase in the number of cells was seen in wrestlers [35], but this increase was not observed in football players [38] or weightlifters [39].

3. Immunosuppression and Related Cells during an RFP

Malnutrition is a dangerous factor affecting the homeostasis of the body and the maintenance of the physiological balance of living organisms. Usually, all living organisms have a way to control their energy reserves. When energy availability is high, the body stores the excess energy in fat tissue, and when the energy availability is low, the fat tissue is used. Malnutrition and overnutrition can cause cytokine and hormone responses to these conditions. One of the first reports regarding this included tumor necrosis factor-alpha (TNF- α). Overfeeding was found to increase levels of TNF- α , whereas undernutrition caused a decrease in TNF- α levels [40]. TNF- α is a known pro-inflammatory cytokine essential for the acute phase response. Studies have shown that reducing energy intake can suppress the immune system and increase the incidence of infectious diseases [41]. **Figure 1** shows the impact of energy deprivation and malnutrition on the immune system.

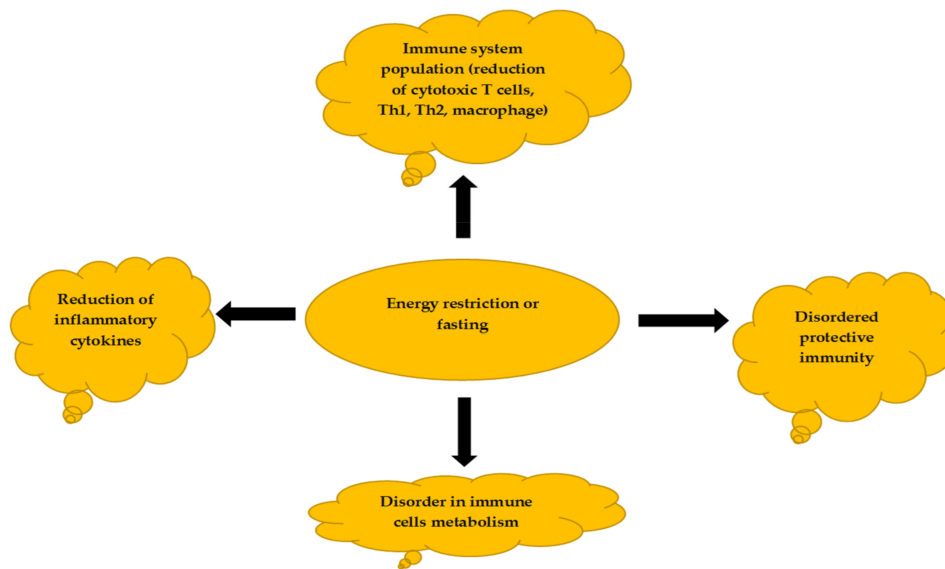
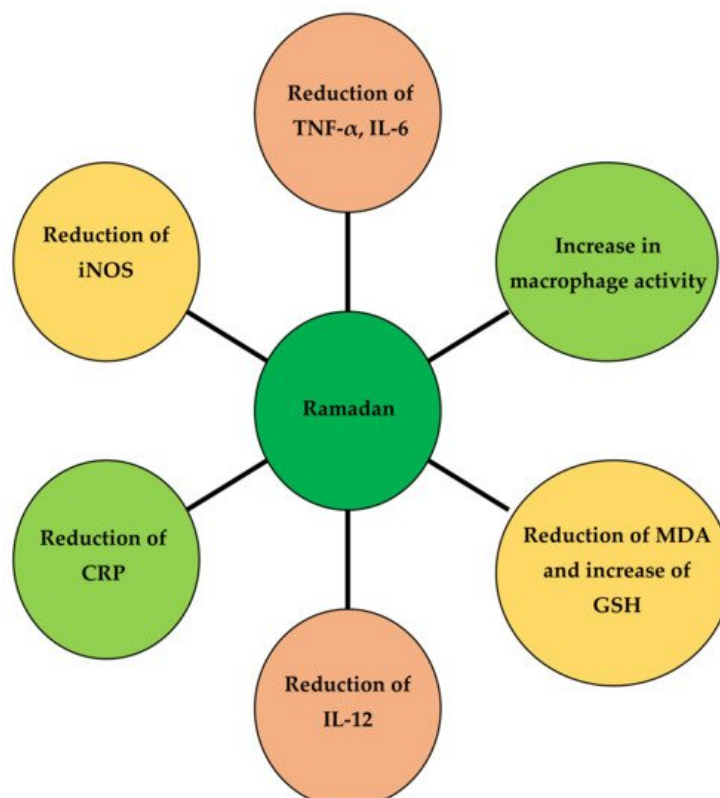


Figure 1. Changes in energy availability can drastically impact immune cell functions.

4. Response of the Immune System to an RFP in Athletes

An RFP significantly reduces inflammation and reduces the incidence of cancer in animal models ^[42]. In a human study (with 21 males and 29 females), changes in circulating pro-inflammatory cytokines, such as interleukin 1 β (IL-1 β), interleukin 6 (IL-6), and tumor necrosis factor (TNF), were evaluated ^[43]. TNF- α and immune cells (total leukocytes, monocytes, granulocytes, and lymphocytes) were observed during 3 periods: 1 week before Ramadan, 3 weeks after Ramadan, and 1 month after Ramadan. It was observed that the pro-inflammatory cytokines IL-1 β , IL-6, and TNF- α decreased significantly during Ramadan ^[44]. In addition, a significant decrease in immune cells was observed during Ramadan, but they returned to baseline ^[45]. The effect of Ramadan on oxidative stress and cell damage in healthy individuals was evaluated in 14 healthy volunteers. Researchers observed no significant changes in oxidative stress by measuring malondialdehyde (MDA), glutathione ^[46], glutathione peroxidase ^{[46][47]}, and catalase levels after Ramadan ^[48]. An RFP decreased IL-12 levels during weeks 1 and 4 of Ramadan as compared to week 3. Changes in IL-12 levels can be a result of changes in diet and sleep patterns ^[49]. It has been observed that an RFP can increase macrophage levels and decrease bacterial levels in the body. In addition, this research showed that an RFP can increase interferon-gamma (IFN- γ), which activates antimicrobial mechanisms in the body ^[50]. The chart in **Figure 2** clearly shows the impact of Ramadan on the immune system.



5. Changing the Performance and Record of Athletes during Ramadan

Many studies have examined the effects of energy restriction and RFPs on physical activity [51], but most of these studies included beginner athletes [52]. Few studies have examined the effect of RFPs and energy constraints on the performance of professional athletes [53][54][55]. The positive effects of physical exercise and an RFP on the body and overall health have been proven. Both are positive ways to increase the lipolysis of adipose tissue and muscle and reduce body fat [56]. This is also very important for Muslim athletes, as they take care of their bodies and try to maintain and improve their athletic performances [56]. It is important for Muslim athletes to be in an RFP state and exercise as it is important for them to perform their religious duties and maintain and strengthen their performance and training record [56]. When examining the effect of energy restriction and short-term RFPs on exercise performance, it was observed that physical function decreased, and this decrease was evident during an RFP. This result has been observed during moderate-term RFPs (24 to 55 h), and its main causes have been associated with dehydration; prolonged, tedious exercise; and/or very high levels of exercise. Contrary to these findings, researchers did not observe a significant reduction in athletic performance during short RFPs (11 to 24 h) [57][58]. For example, studies by Fashi et al. [55] and Stannard et al. [59] found that even a short fast can have a positive effect on a muscle's physiological adaptation to endurance exercises. Of course, this research was performed on beginners and non-professionals. The changes observed in endurance performance during Ramadan are not limited to the training protocol, and the physiological adjustments resulting from an RFP can lead to a slowing of the metabolism during these conditions [60]. In the first week of an RFP, serum sodium, chloride, and protein levels usually increase (during the dehydrated period), a process that results in a loss of 1.13 kg of body weight, which is mostly due to dehydration. Following an increase in these factors, the release of catecholamines is suppressed, causing less venous blood to return to the heart, ultimately leading to a decrease in sympathetic function. An RFP also reduced functional capacity and maximal oxygen consumption. These changes returned to their original state when the fasting was over [60][61].

5.1. Endurance Training

Aragon-Vargas [62] reviewed the effects of an RFP lasting from 24 h to 4 days on endurance exercise and concluded that it had a negative effect on endurance. Most studies on RFPs have looked at the short-term effects, with few studies evaluating the long-term effects of RFPs. According to the literature, it takes 10 days to adjust to an RFP. In addition, most studies have examined the effect of an RFP on animal models [63][64]. Studies on animal models are difficult to correlate to humans. Zerguini et al. [65] observed a decrease in physical performance in Algerian players during Ramadan.

5.2. Resistance Training

The reduced energy-intake during an RFP can lead to a decrease in lean mass and strength, which could reduce one's production of force and power [66]. Real-Hohn et al. [67] evaluated a fasting period (20:4) for 4 days a week and did not observe a significant effect on muscle production and muscle cross-section. Several other studies have not observed a significant effect of RFPs on energy production or power. Trabelsi et al. [68] examined the effect of an RFP on bodybuilders and did not observe a significant difference in body mass or body composition.

5.3. Sprint Performance

Various studies have shown a decrease in anaerobic capacity during Ramadan. Salama et al. [69] showed that an RFP reduced aerobic performances in the 100- and 800-m races. However, many studies [22][70] observed only a slight decrease in the mean sprint performances, but these findings were not statistically significant. Additionally, by keeping the training load constant during Ramadan, sprint speeds were significantly faster [71].

5.4. Power-Output Measure

Studies have shown that an RFP had no significant effect on a participant's performance on Wingate anaerobic tests (peak power and average power) [72][73] but they showed a significant reduction in anaerobic capacity compared to the non-RFP hours of 17:00 and 21:00 [73].

5.5. Blood Lactate Concentration

RFPs did not have a significant effect on lactate accumulation and the time required to reach maximum blood lactate levels [55][74]. Furthermore, researchers did not observe a significant effect on blood lactate concentrations due to a 20-min

run during Ramadan [75]. Additionally, another study examining the 30-s vertical jump test in judo did not observe significant changes [52].

Conflicting results have been observed in many studies. There are several reasons for such differences, including the length of fasting and the physical characteristics of the study participants. According to various studies, athletes should be advised to remain moderately active during Ramadan to ensure adequate performance and energy storage. It is recommended that more studies be performed on fasting status and athletic performance. These studies should evaluate the different mechanisms the body uses to respond to fasting conditions during Ramadan and compare them to the results of Ramadan fasting on the physiologic variables of athletes.

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