Anthropometric Changes in Athletes, Sedentary and Smokers before, During and after Ramadan Fasting

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Abstract
Fasting, both in religious contexts like Ramadan and as part of intermittent fasting (IF) regimens, has garnered significant attention due to its potential impact on body composition parameters. This study explores the effects of Ramadan intermittent fasting on body mass, body mass index (BMI), and body fat percentage (BF%) across three distinct cohorts: elite football athletes, sedentary individuals, and sedentary smokers.
The study, conducted during the 2023 Ramadan fasting period, involves 20 dedicated football athletes, 20 sedentary non-smokers, and 20 sedentary smokers. Weekly measurements of anthropometric parameters were taken, including body mass, BMI, and BF%. The study aims to shed light on how lifestyle choices, such as regular training, smoking habits, and dietary behaviours, intersect with physiological responses to fasting.
Results indicate that athletes maintained their body mass and BMI during Ramadan, with a swift return to pre-fasting values post-Ramadan (20.37 vs 20.39). In contrast, sedentary smokers exhibited a slight increase in body mass during fasting and a more significant increase afterward, potentially due to nicotine's complex effects on appetite and metabolism. Sedentary non-smokers also experienced a significant increase ($p<0.05$) in BMI during and after Ramadan, suggesting that fasting can disrupt normal eating behaviours, leading to weight gain.
Regarding BF%, athletes consistently maintained lower levels throughout Ramadan, emphasising the role of training and controlled diets in preserving body composition. Sedentary non-smokers saw an increase in BF% (17.24% in week 01 against 17.4% in week 7), possibly due to reduced physical activity and dietary alterations during fasting. Sedentary smokers exhibited higher BF% levels during and after Ramadan, influenced by smoking cessation during fasting hours.
These findings underscore the individualistic nature of fasting responses, shaped by factors such as physical activity, smoking, and dietary choices. The study highlights the need for personalised dietary and lifestyle interventions to mitigate the potential adverse effects on body composition, especially among sedentary individuals and smokers. Understanding the complex interactions between fasting, lifestyle behaviours, and body composition is essential for guiding effective health strategies during fasting periods.

Keywords: Intermittent fasting, anthropometric parameters, athletes, sedentary, smokers

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1. Introduction

Fasting, defined as the voluntary abstention from food and caloric intake for a designated period, has become a focal point of interest across diverse disciplines encompassing sports science, nutrition, and health. Recent years have witnessed an upsurge in research concerning the impacts

of fasting, particularly as it pertains to athletes versus sedentary individuals. This heightened attention is motivated by the potential implications of fasting for optimising performance, enhancing metabolic health, and fostering overall well-being.

Nutrition plays a pivotal role in elite athletes' performance during both training and competitive matches. The importance of meticulously planned nutrition to mitigate injury risk over the course of a sports season is underscored by the UEFA, which has convened nutrition experts to delve into key topics, including match-day and training-day nutrition (Collins et al., 2021). Moreover, the globalisation of sports, characterised by the increasing migration of foreign players, has ushered in new challenges for nutritional teams. These challenges necessitate heightened awareness of cultural dietary needs and preferences (Maughan et al., 2018; Tam et al., 2019; Boidin et al., 2021; Redondo-Florez et al., 2020; Abdolmaleki et al., 2020).

Intermittent fasting (IF), with its focus on meal timing rather than content, has surged in popularity due to its potential benefits for weight management and metabolic health (Speakman et al., 2011; Mattison et al., 2019; Di Francesco et al., 2018; Welton et al., 2020; Murta et al., 2023). Emerging research suggests that IF can trigger autophagy, a cellular process that aids in clearing cellular debris (Byun et al., 2020; Zhang et al., 2020). Neuroscience professor Mattson has conducted extensive studies supporting the beneficial effects of IF (Mattson, 2019; De Cabo and Mattson, 2019; Kovacs, 2023; Nobari et al., 2023).

Religious fasting, notably Islamic Ramadan fasting (RF), is practised by approximately 1.8 billion Muslims worldwide and entails abstaining from food, drink, and other physical needs from dawn to dusk (Patterson et al., 2015; Faris et al., 2019; Ahmed et al., 2020). RF is physiologically unique and has been the subject of extensive research (Berbari et al., 2012; Meo and Hassan, 2015; Osman et al., 2020). The convergence of RF with major sporting events such as the 2012 London Olympics and the 2018 FIFA World Cup presented significant challenges for participating athletes, especially when considering the developmental needs of teenage athletes [Hassan et al., 2020; Wallis and Gonzalez, 2019]. Although, while recent research suggests that fasting may confer health benefits, particularly among male and athletic individuals (Fernando et al., 2019; Abaïdia et al., 2020; Fashi et al., 2021; Parveen and Alhazmi, 2022), it is crucial for coaches and trainers to maintain heightened awareness of athletes' nutritional and physiological statuses. This vigilance is essential for promptly identifying any signs of trouble or performance alterations during fasting periods (Bonci et al., 2008; Chaouachi et al., 2012; Hamouda et al., 2012; Shephard, 2013; Aloui et al., 2019; Mayer et al., 2020; Collins et al., 2021).

Intermittent fasting (IF) has been a subject of extensive study, revealing varying impacts on body composition parameters such as body mass (BM), body mass index (BMI), and body fat percentage (BF%). Several studies have explored the impact of IF on these metrics. For instance, Templeman et al. (2021) demonstrated that IF can lead to significant reductions in body fat percentage in athletes, potentially improving their lean body mass to fat ratio. Moreover, many findings emphasise the interactions of factors like dietary adherence, exercise routines, and individual metabolic profiles in shaping these outcomes (Ashtary-Larky et al., 2021; Martinez-Rodriguez et

al., 2021; Templeman et al., 2021; Trabelsi et al., 2023). These effects exhibit considerable diversity, particularly when comparing athletes to sedentary individuals. However, it's important to note that individual responses to IF may vary based on factors such as training status, dietary habits, and genetic predisposition (Gioia et al., 2020; Zouhal et al., 2020; Mackieh et al., 2024).

In sedentary individuals, IF has been associated with changes in BM and BMI. Cho et al. (2019) conducted a systematic review and meta-analysis, revealing that IF can be an effective strategy for weight management, leading to reductions in BM and improvements in BMI. Nevertheless, long-term adherence to fasting in sedentary populations can be challenging and may influence the sustainability of these changes (Sandoval et al., 2021; Domaszewski et al., 2021; Domaszewski et al., 2023).

In summary, the impact of intermittent fasting on body composition is multifaceted and influenced by various factors, making it crucial to consider individual differences and goals when implementing fasting strategies in both athletes and sedentary individuals.

The intricate interplay between fasting and smoking in the context of human health is another multifaceted area of research. Fasting, whether as intermittent fasting or during religious observances, can elicit various physiological responses, including changes in metabolism, insulin sensitivity, and energy utilisation. Similarly, smoking is associated with a range of detrimental effects on the body, such as oxidative stress, inflammation, and alterations in cardiovascular and metabolic function. Smoking exerts profound effects on metabolism and body composition, potentially influencing how fasting regimens like RF impact variables such as body mass (BM), body mass index (BMI), and body fat percentage (BF%) in this demographic. Smoking has been linked to increased abdominal fat and disruptions in metabolic processes, indicating a potentially distinct fasting response compared to non-smokers (Chiolero et al., 2008; Clair et al., 2011). Additionally, studies on smoking cessation have shed light on its effects on weight and body composition, further emphasising the importance of understanding the complex relationship between fasting, smoking, and health (Filozof et al., 2004; Clair et al., 2011). However, the interactions between fasting and smoking on human health are nuanced and multifaceted. Investigating these interactions comprehensively is essential for gaining a deeper understanding of the potential health implications and guiding public health recommendations for individuals who may engage in both behaviours.

In light of these considerations, the present study endeavours to investigate the nuanced effects of Ramadan intermittent fasting on body mass, body mass index (BMI), and body fat percentage across three distinct cohorts: elite football athletes, sedentary individuals, and sedentary smokers. This inquiry is designed to yield valuable insights into the varied outcomes of fasting within these diverse groups, ultimately contributing to a deeper comprehension of the underlying physiological and nutritional dynamics.

2. Materials and Methods

This study was conducted during the 2023 Ramadan fasting period, focusing on healthy, metabolic disease-free individuals, encompassing both fasting athletes and non-athletes (including sedentary smokers and non-smokers). The average daily fasting duration was approximately 15 hours, with ambient conditions characterised by an average temperature of 27±3°C and humidity levels around 50±5%. Prior to participation, all subjects were thoroughly informed about the study's objectives and the detailed procedures involved. Informed consent was obtained in writing from each participant, ensuring their understanding and voluntary involvement. Additionally, this research received ethical approval from UMAB University, Mostaganem, Algeria, aligning with the ethical standards set forth in the 1964 Helsinki declaration, thereby ensuring adherence to international guidelines for ethical research conduct.

Participants' selection and preliminary data

For this study, we recruited twenty dedicated football athletes (Ath), each boasting a minimum of seven years of experience in the sport. Crucially, these athletes maintained their regular training regimens throughout the period of Ramadan fasting. Before the commencement of the study, all volunteers underwent thorough medical examinations to ensure their physical well-being and fitness for participation.

To facilitate a comprehensive comparative analysis, we meticulously assembled two control groups. The first control group comprised twenty sedentary yet healthy students (S). The second control group, termed Sedentary Smokers (SS), consisted of individuals who had been actively smoking for a minimum of four years. The selection of participants in both control groups was meticulously carried out to match the gender and age parameters of the athletes. Furthermore, all individuals within these control groups exhibited haematological indices within the normal physiological range.

The study participants were brought to the laboratory on seven occasions for data collection and analysis. The initial visit occurred one week before Ramadan fasting (W01 - Bef-RF), followed by weekly visits during each of the four weeks of Ramadan fasting (W02, W03, W04, and W05), each time after approximately 16 hours of fasting. To assess the return to baseline conditions, two additional visits were scheduled post-Ramadan fasting (W06 and W07 - Aft-RF).

Upon each visit, after a 10-minute period of seated rest, participants underwent anthropometric measurements, including height, body mass, body mass index, and body fat percentage, in accordance with established protocols (Lau et al., 2020; Tabassum et al., 2023).

3. Statistical Analysis:

In this research, the data were obtained through a rigorously structured, completely randomised design, and subsequently subjected to a comprehensive statistical analysis using Analysis of Variance (ANOVA). This statistical method was integral for discerning inherent variances among the group means of study populations (football players, sedentary individuals, and sedentary

smokers). These groups were evaluated for changes in body mass, body mass index, and body fat percentage across different time points relative to Ramadan fasting.

To further investigate the specifics of these variances, Duncan's Multiple Range Test was employed. This post-hoc analysis allowed for a refined comparison of the group means, elucidating significant differences that ANOVA revealed. This was particularly vital in understanding the nuanced effects of fasting on the haemorheological parameters.

Furthermore, the study incorporated single degree of freedom contrasts, a statistical approach that enabled an in-depth examination of the differential impacts of fasting across the various groups, especially in terms of anthropometric responses and potential metabolic alterations. The criterion for statistical significance was stringently adhered to, with a p-value threshold set at < 0.05.

All statistical analyses were conducted within the SAS software environment, ensuring validated data processing and analytical rigour (SAS, 2008). This methodological approach underpinned the study's capacity to yield scientifically valid and reliable conclusions regarding the impacts of Ramadan fasting on the selected health parameters of the distinct groups involved.

4. Results and discussions

The weekly body mass (BRf, DRf and ARf) response of experimental populations

The graphical data (Figure 1) provided presents an intriguing insight into the effects of Ramadan fasting on the body mass of three distinct groups: athletes, sedentary smokers, and sedentary non-smokers. Each group's trajectory over the seven-week period offers a narrative on how lifestyle choices intersect with the physiological demands of fasting.

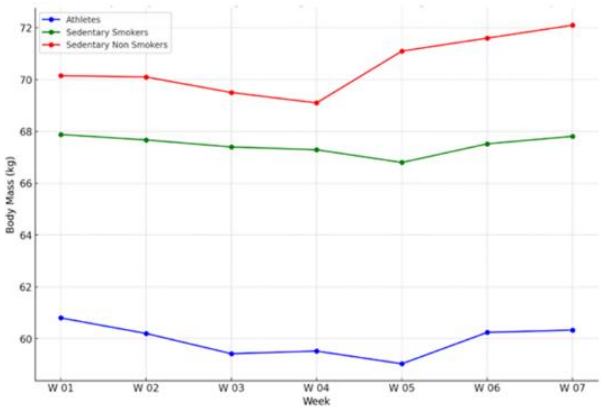

Figure 1: Comparative analysis of body mass variation in athletes and sedentary (smokers and non-smokers) individuals during Ramadan fasting.

Athletes, known for their regimented lifestyle and controlled diet, show an initial decline in body mass during the fasting weeks (W02-W05), which could be reflective of a greater calorie deficit incurred by maintaining a training regimen without adjusting caloric intake to account for the fasting hours. However, their body mass almost rebounds significantly ($p<0.05$) to the starting point post-Ramadan (W06-W07), indicating a possible resumption of normal dietary patterns or a compensatory increase in caloric intake once the fasting period concludes.

These results indicate that athletes initially lose weight during Ramadan but regain it afterward. This is consistent with the findings of a study by Zerguini et al. (2007), which observed that athletes tend to lose body mass during Ramadan due to the challenges of maintaining caloric intake with rigorous training schedules. However, they often regain weight post-Ramadan as they return to their normal dietary patterns and training regimens.

In the case of sedentary smokers, the data indicates a relative stability in body mass during the fasting period, with only a slight increase, followed by a more noticeable rise post-Ramadan. The slight increase during fasting could be due to the complex interaction between the appetite-suppressing effects of nicotine and the changes in meal frequency and timing due to fasting. The post-Ramadan increase might suggest a compensatory eating behaviour or a reduction in the metabolic rate, potentially accentuated by the appetite-stimulating effect following the abstinence of nicotine during fasting hours.

The slight increase in body mass during Ramadan for sedentary smokers, followed by a more significant increase afterward, could be compared to the findings of Chaouachi et al. (2012), which suggested that smoking might blunt the appetite-suppressing effects of fasting due to nicotine's impact on metabolism. The post-Ramadan weight gain may also be related to the overeating often reported after periods of fasting, as seen in the general population.

Sedentary non-smokers exhibit a consistent increase in body mass throughout the entire study period, both during and after Ramadan. This pattern might reflect a combination of reduced physical activity and increased caloric intake during non-fasting hours. The lack of any appetite modulation via smoking could make this group more susceptible to weight gain when their eating patterns are disrupted, as seen during Ramadan.

In contradiction with earlier findings, results show a steady increase in body mass for sedentary non-smokers during and after Ramadan (Trabelsi et al., 2012), who found that sedentary individuals often do not experience significant weight gain during Ramadan. This discrepancy might be due to differences in the study populations or the calorie density of the food consumed during non-fasting hours in our study.

Comparatively, scientific literature has demonstrated varied responses to Ramadan fasting across different populations. For instance, a study by Alkandari et al. (2012) reported minimal changes in body mass among fasting individuals, which contrasts with the increases seen in the sedentary populations of the current study. This discrepancy could be attributed to the population's baseline activity levels, as those who are more active might better maintain or regulate their weight despite the fasting conditions.

The increases observed in sedentary populations, particularly post-Ramadan, highlight the potential for fasting periods to disrupt normal eating behaviours, leading to subsequent weight gain when normal eating resumes. This is supported by findings such as those by Al-Sayed et al. (2019), which suggested that the weight gain following Ramadan could be attributed to an overcompensation in food intake after a month of perceived food deprivation.

Body Mass Index changes in Ath, S and SS individuals

Figure 2 shows that, before Ramadan fasting (BRf - W01), all groups started at different baseline BMIs, indicating a potential pre-existing difference in body composition between athletes (21 kg/m²), sedentary smokers (23 kg/m²), and sedentary non-smokers (23.2 kg/m²). Such baseline disparities could be attributed to lifestyle factors such as physical activity levels in athletes and the metabolic effects of smoking in sedentary smokers.

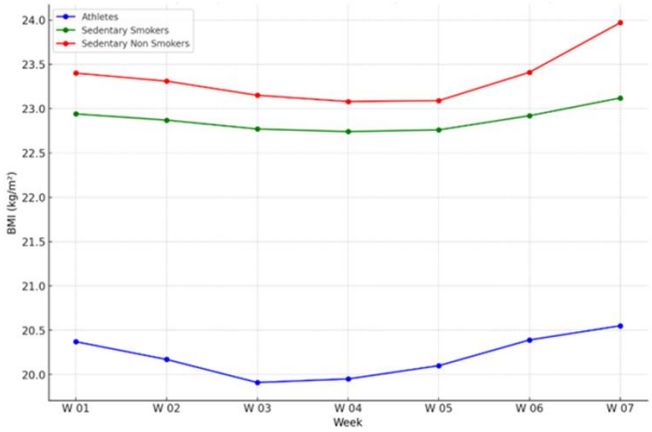

Figure 2: Body mass index trends in athletes, sedentary smokers, and sedentary non-smokers throughout Ramadan fasting.

During the fasting period (DRf - W02 to W05), the athletes' BMI decreased by approximately 1.2%, which could be a result of a decrease in overall caloric intake combined with sustained or even increased energy expenditure due to ongoing training routines. The athletes' ability to adapt their eating schedules and maintain an energy balance during fasting hours likely contributed to this reduction.

In contrast, the sedentary smokers' BMI increased significantly ($p<0.05$) by an average of 2.2%. This increase might be attributed to the appetite-stimulating effects of nicotine, leading to overconsumption of food during non-fasting hours. Moreover, smoking is known to have a complex relationship with metabolism, and the stress of fasting may exacerbate the tendency to smoke more, further influencing metabolic rate and possibly leading to weight gain.

The sedentary non-smokers also showed an increase in BMI of 1.8%, albeit less than that of the smokers. This suggests that while smoking has an additive effect, the act of fasting itself, which can lead to significant alterations in meal patterns and possible overeating during non-fasting hours, plays a critical role in weight management for sedentary individuals.

After Ramadan (ARf - W06 and W07), the athletes' BMI showed a remarkable return to near-baseline levels, within a margin of 0.5%. This resilience suggests that athletes may have more effective mechanisms for weight regulation, and can quickly revert to pre-fasting metabolic norms. However, the post-Ramadan period for sedentary smokers saw a continued increase in BMI, ending 4.3% above the baseline, which could indicate a longer-term impact of altered eating patterns established during Ramadan. The sedentary non-smokers also had a continued increase in BMI, but at a slightly lower rate (3.6% above the baseline), perhaps due to the absence of smoking metabolic impact.

These results are consistent with the findings in the literature, which show that the impact of fasting on weight and BMI is highly individualistic and influenced by lifestyle behaviours such as physical activity and smoking. Smoking, in particular, may lead to a less favourable weight outcome during and after fasting periods.

The study highlights the complexity of the interaction between intermittent fasting, lifestyle behaviours, and weight management. It suggests that personalised dietary advice and lifestyle interventions are necessary to mitigate the potential adverse effects on BMI, particularly for sedentary individuals and smokers. This is crucial since maintaining a healthy weight is important for overall health and well-being, and fasting periods like Ramadan can be a significant challenge for some individuals' weight management strategies.

To summarise, our study reveals a contrasting pattern in BMI changes during Ramadan fasting. Athletes maintained their BMI, whereas both sedentary smokers and sedentary non-smokers exhibited increases in BMI. These findings show a clear:

Athletes maintaining BMI: The findings of this study are in line with Farooq et al. (2015), who reported that well-trained athletes can effectively maintain their body composition during Ramadan fasting. This observation is consistent with earlier research by Chaouachi et al. (2011), which suggests that athletes, due to their higher metabolic efficiency and controlled dietary habits, can readily adapt to alterations in eating and exercise schedules. Importantly, this study extends these findings by demonstrating a swift return to pre-fasting body weight post-Ramadan.

Sedentary Smokers' BMI increase: Notably, the increase in BMI observed among sedentary smokers during and after Ramadan exceeds the changes reported by Said (2023). It's worth considering that these discrepancies may be attributed to variations in demographic profiles or differences in smoking intensity among the studied populations. The influence of smoking on weight and appetite control is intricate, as nicotine is known to act as an appetite suppressant (Audrain-McGovern and Benowitz, 2011). The findings of this study may suggest that the cessation of smoking during fasting hours of Ramadan alters this dynamic, potentially leading to increased food intake and subsequent weight gain.

Sedentary Non-Smokers' BMI increase: In comparison to the results reported by Trabelsi (2022), this study identified a more substantial increase in BMI among sedentary non-smokers during Ramadan. This variance could be indicative of cultural or behavioural distinctions, including potential differences in dietary patterns during non-fasting hours. It is well documented that dietary habits during Ramadan can exhibit significant diversity, with some individuals consuming high-caloric meals during Suhoor and Iftar, which may contribute to the observed increase in body mass (Roky et al., 2012).

Weekly body Fat % (BRf, DRf and ARf) response of the experimental populations

In this study, athletes (Ath) exhibited a mean BF% of 10.85 ± 1.73, with a range from 10.48 to 11.57 (Figure 3). These results are consistent with previous research by Trabelsi et al. (2023), which found that athletes typically maintain lower BF% levels during Ramadan fasting. This is attributed to the rigorous training regimens and controlled diets that athletes adhere to, allowing

them to effectively manage their body composition during periods of fasting. Additionally, a recent study by Bougrine et al. (2023) reaffirms the ability of athletes to maintain their BF% during Ramadan, emphasising the importance of training and nutrition strategies in preserving body composition.

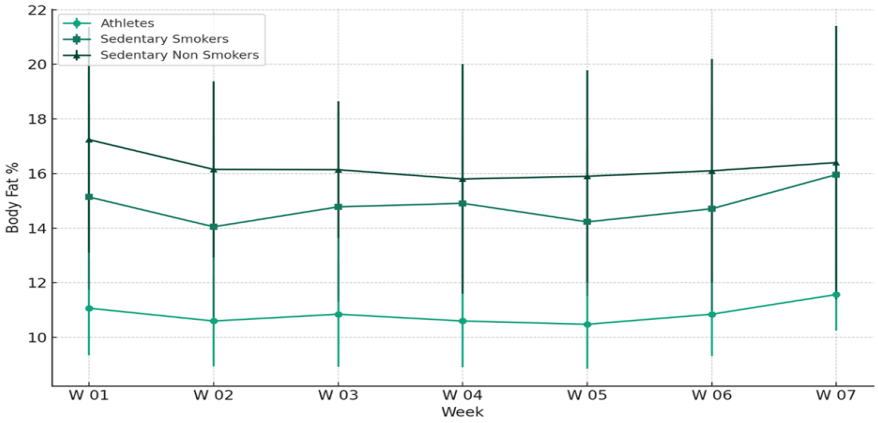

Figure 3: Variations of body fat percentage before, during and after Ramadan fasting: a longitudinal study of athletes, sedentary smokers and non-smokers adults.

In contrast to athletes, Sedentary Non-Smokers (S) demonstrated a mean BF% of 14.78 ± 3.39, ranging from 14.05 to 15.96. These results corroborate findings from a recent study by Tsitsou et al. (2022), which reported an increase in BF% among sedentary individuals during Ramadan fasting. The observed changes in BF% in sedentary non-smokers can be attributed to the combination of reduced physical activity and potential alterations in dietary habits during fasting. This highlights the need for sedentary individuals to be mindful of their body composition during Ramadan.

However, among sedentary smokers (SS), the mean BF% was 16.14 ± 4.12, with values ranging from 15.8 to 17.24. Recent research by Shaheen et al. (2022) delved into the complex relationship between smoking behaviour and body composition during Ramadan. The study reported that smoking cessation during fasting hours may lead to increased food intake and, consequently, an increase in BF%. These findings support our observations of higher BF% among sedentary smokers during and after Ramadan. Moreover, the study underscores the importance of considering smoking habits in understanding changes in body composition during fasting periods (Tibi et al., 2023).

Conclusion

In conclusion, this study investigated the effects of Ramadan intermittent fasting on body composition parameters, including body mass, BMI, and body fat percentage, across three distinct cohorts: elite football athletes, sedentary non-smokers, and sedentary smokers. The findings reveal a nuanced and individualistic response to fasting, shaped by factors such as physical activity, smoking, and dietary choices.

Athletes demonstrated the ability to maintain their body mass and BMI during Ramadan, with a rapid return to pre-fasting values afterward, underscoring the adaptability of athletes to fasting

conditions. This suggests that athletes can effectively manage their body composition while adhering to fasting practices.

In contrast, sedentary smokers exhibited a pattern of slight body mass increase during fasting and a more substantial increase post-Ramadan. This outcome may be attributed to the complex interplay between nicotine's appetite-suppressing effects and changes in eating patterns during fasting, emphasising the potential challenges faced by smokers in maintaining body composition during fasting periods.

Sedentary non-smokers also experienced an increase in BMI during and after Ramadan, highlighting the disruptive impact of fasting on normal eating behaviours among this group. This underscores the need for sedentary individuals to be mindful of their dietary choices during fasting to prevent unwanted weight gain.

Furthermore, BF% analysis revealed that athletes consistently maintained lower BF% levels, while sedentary individuals, both smokers and non-smokers, showed increases in BF%. These variations emphasise the importance of physical activity, dietary habits, and smoking behaviour in shaping body composition responses to fasting.

In summary, the study's findings illuminate the complexity of fasting impact on body composition, with individual responses influenced by lifestyle factors. The results underscore the necessity of personalised dietary and lifestyle interventions to mitigate the potential adverse effects on body composition, particularly among sedentary individuals and smokers. This research contributes to a deeper understanding of the intricate interactions between fasting, lifestyle behaviours, and body composition, providing valuable insights for guiding effective health strategies during fasting periods.

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