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Ramadan fasting as an intermittent fasting method: effects on sleep patterns and exercise in diabetic and non-diabetic adults in Tabuk, Saudi Arabia – a cross-sectional study

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Abstract
Ramadan is among the five major pillars of Islam, during which adults abstain from eating and drinking from dawn to sunset. Some individuals with diabetes mellitus are exempt from fasting due to potential health risks. However, many choose to fast. We investigated Ramadan fasting practices, lifestyle factors, sleep patterns, and fasting-related risk among patients with diabetes and those without diabetes. This cross-sectional study was conducted among 204 participants with and without diabetes in Tabuk, Saudi Arabia, from March to April 2025. A structured questionnaire evaluating demographic factors, the International Diabetes Federation risk score (IDFRS) for fasting risk, sleep patterns, and exercise was used. Among the 204 participants, 65.7% were women, the mean age was 33.69±11.94 years, 25.5% had diabetes, and 59.8% reported sleeping <6 hours per night during Ramadan. Among participants with diabetes, 65.4% reported hypoglycemia, 15.4% reported hospital admission during Ramadan, and 73.2% were classified as having moderate/high fasting risk according to the IDFRS. Participants with diabetes were older than those without diabetes (38.2±15.2 *vs*. 32.5±10.3 years, p=0.034). Multivariable logistic regression assessing factors associated with fasting showed that older age (adjusted OR 0.93, 95% CI 0.87-0.99; p=0.034) and obesity (adjusted odds ratio 0.19, 95% confidence interval 0.04-0.95; p=0.043) were associated with lower odds of Ramadan fasting. Individuals with diabetes experienced fasting-related risks, including hypoglycemia and hospital admission. These findings highlight the importance of individualized assessment, education, and risk-based guidance for people with diabetes who choose to fast during Ramadan.

Introduction

Diabetes mellitus is a chronic progressive metabolic disease with increasing mortality from both microvascular and macrovascular complications. Currently, more than 450 million people worldwide live with diabetes, and this number is projected to increase substantially over the coming decades.[1] In the Kingdom of Saudi Arabia, the prevalence of type 2 diabetes is estimated at 17.7%, affecting approximately 4.27 million adults.[2] Ramadan fasting is a form of intermittent fasting that is practiced by millions of Muslims for a lunar month every year. Unlike conventional intermittent fasting protocols, Ramadan fasting involves complete abstinence from food and fluids from dawn until sunset, followed by unrestricted eating during nighttime hours. In addition to meal change, Ramadan is accompanied by changes in physical activity, circadian rhythm, and hormonal changes.[3] Although some individuals with diabetes are exempt from fasting, many patients choose to observe Ramadan fasting despite the potential risk of acute complications, including hypoglycemia, dehydration, thrombosis, hyperglycemia, and diabetic ketoacidosis.[4] Pre-Ramadan risk assessment tools are available to stratify patients according to their risk of fasting-related complications and guide decisions regarding fasting eligibility. Drug adjustments and education are vital to reduce the risk of complications. Close monitoring of glucose levels and early management of complications are recommended throughout Ramadan.[5] Many glucose-lowering medications can be continued with appropriate timing adjustments; however, insulin and sulfonylureas often require dose modification to reduce the risk of hypoglycemia.[6]

Ramadan fasting, one of the five Pillars of Islam, can be challenging for individuals with diabetes and healthcare providers. Appropriate counseling, glucose monitoring, medication adjustment, and optimization of glycemic control are essential to support safe fasting.[5] In addition, increased physical activity after sunset, including Taraweeh prayers, may influence glucose levels, particularly among patients using insulin or sulfonylureas, and should be considered during diabetes management.[7] The effects of Ramadan fasting on glycemic control were discussed controversially with some showing improvement in glycemic control,[8,9] some showing deterioration,[10] while others showed no effects.[11] Previous studies from Saudi Arabia reported that only 10% of patients with diabetes monitored their blood glucose daily during fasting and nearly half experienced hypoglycemia.[12] To the best of my knowledge, no researchers have assessed the pattern of Ramadan fasting among Saudis in Tabuk City, Saudi Arabia. To our knowledge, limited data are available regarding Ramadan fasting practices and associated lifestyle changes among individuals with diabetes in Tabuk City, Saudi Arabia. In addition, we compared patients with and without diabetes regarding lifestyle, comorbidities, and sleep pattern.

Materials and Methods

This cross-sectional study was conducted among adults residing in Tabuk City, Saudi Arabia, during March and April 2025. Adults with and without diabetes were eligible for inclusion, regardless of whether they observed Ramadan fasting. A web-based questionnaire was distributed to Saudi adults in Tabuk City and children below 18 years were excluded. A multistage sampling approach was applied. Three shopping malls and three primary healthcare centers were randomly selected as recruitment sites. Adults who met the eligibility criteria and agreed to participate were invited to complete the questionnaire.

Sample size calculation

The calculation of sample size is done by using the Raosoft Sample Size Calculator based on a 95% confidence level, 5% margin of error, 50% response distribution, and the estimated adult population of Tabuk. The minimum required sample size was 204 participants.

Inclusion criteria
Age >18 years
Patients with diabetes and non-diabetics fasting and non-fasting

Exclusion criteria
Individuals younger than 18 years, those with psychiatric disorders, other endocrine or metabolic disorders that could affect sleep or metabolic status, active malignancy, diagnosed sleep disorders, or medications affecting sleep were excluded.

Data collection tool
A structured questionnaire was used to collect demographic factors, glycemic status, medications used, the time of meals, and if skipping meals. Sleep duration during weekends and weekdays and timing of sleep during the weekdays and weekends were reported. The level of exercise, smoking, and medication adherence were recorded in addition to the glycated hemoglobin, hypoglycemia, hyperglycemia, and ketoacidosis. The weight and height were measured to estimate the body mass index. The questionnaire was adapted from previous studies. [7-10]

The risk score for fasting eligibility for patients with diabetes
Inquire about: Multiple daily mixed insulin injections, basal-bolus/insulin pump once-daily mixed insulin, basal insulin, Glibenclamide use, Gliclazide MR or glimepiride or repaglinide, and other therapy not including SU or insulin. In addition to self-monitoring of blood glucose use, frequency of ketoacidosis or hyperosmolar hyperglycemic syndrome, renal complications/comorbidities, and macrovascular cardiovascular disease. The risk score was developed by the International Diabetes Federation with scores of 1-3 mild, 3.5-6 moderate, and >6 severe risk.[5,6]

Dietary modification during Ramadan
Dietary modification during Ramadan was assessed by asking the participants if they intentionally modify food choices, meal composition, or eating patterns with three choices (yes, no, and not applicable). Ramadan fasting itself was not considered a dietary modification; only intentional changes in food choices, meal composition, or eating patterns were classified as dietary modification.

Ethical issues
Ethical approval was obtained from the ethical committee of the University of Tabuk to get the data with the protection of patient confidentiality. Participation was voluntary, and electronic informed consent was obtained from all participants before completing the questionnaire. The first question of the web-based survey asked participants to confirm their willingness to participate; those who selected “disagree” were automatically prevented from proceeding to the questionnaire. All information was kept confidential within the confines of the first author and the co-authors. The patient's privacy was restored and no name or identity was reported. The investigators strictly adhere to the Helsinki Declaration. The participants were assured that the information collected would be used for this research.

Data analysis
The Statistical Package for Social Sciences (SPSS, IBM, Version 20, New York) was used for data analysis. Continuous variables are presented as mean ± standard deviation, while categorical variables are presented as frequencies and percentages. The chi-square test and independent-samples t-test were used for comparisons between categorical and continuous variables, respectively. Binary logistic regression analysis was performed to identify independent factors associated with Ramadan fasting

(fasting versus non-fasting), including age, sex, diabetes status, obesity, sleep duration. Odds ratios (ORs) with 95% confidence intervals (CI) were calculated. A two-sided P value <0.05 was considered statistically significant.

Results

Among the 204 participants, 65.7% were female. The mean age was 33.69±11.94 years (range: 18-69 years)., their ages ranged from 18-69 with a mean of 33.69±11.94 years, 25.5% had diabetes, while 13.7% were diagnosed with impaired glucose tolerance. In this study the blood glucose ranged from 124.46±34.94 to 152.74±34.40 mg/dL, dyslipidemia was found in 14.7% and hypertension was reported in 16.7%, the majority(66.7%) of patients had $HbA1_c$ less than 7.

Hypoglycemia was reported in 65.4%, and 13.7% were admitted for hyperglycemia, and 53.8% were checking their blood glucose regularly. Regarding the lifestyle during Ramadan, the majority used to sleep less than 6 hours (59.8%), 32.4% of sleeping hours ranged from 6-8 hours per night, and 6.9% changed their meal pattern. Interestingly 50% of the participant did not change their exercise level, 20.6% increased their exercise level and 29.4% decreased their level of exercise.

Participants reported marked alterations in sleep habits during Ramadan. Mean nocturnal sleep duration was 4.65±2.34 hours, with 59.8% sleeping fewer than six hours per night. Average bedtime occurred at 8.31±6.70 hours on weekdays and 7.96±5.51 hours on weekends, while wake-up times were 8.62±3.10 hours and 9.65±4.38 hours, respectively, suggesting delayed sleep timing and circadian rhythm disruption during Ramadan (Table 1).

The risk stratification of patients with diabetes who observed fasting Ramadhan in Tabuk City, Saudi Arabia was 0-3 in 26.9%, 3.5-5 in 38.5%, and >6 in 34.7% (Table 2).

Comparison of participants with and without diabetes

No significant difference was evident between patients with and without diabetes regarding gender (OR=1.275, 95% CI: 0.506-3.211, p=0.606), breakfast skipping (OR=0.724, 95% CI: 0.259-2.020, p=0.536), shift work (OR=0.727, 95% CI: 0.188-2.820, p=0.644), and changes in exercise (p=0.947). Hypoglycemia was commoner in patients with diabetes than their counterparts without diabetes (OR=6.51, 95% CI: 2.46-17.19, p<0.001). Likewise, a lower proportion of patients with diabetes fasted during Ramadan (OR=0.102, 95% CI: 0.010-1.03, p=0.020). A significant association was also observed between comorbidities and diabetes status (p<0.001). Hypertension, dyslipidemia, and the coexistence of hypertension and dyslipidemia were more common among participants with diabetes than among those without diabetes. Table 3 depicted the comparison between patients with and without diabetes

Participants with diabetes were older than those without diabetes with significant statistical difference (38.23±15.24 *vs*. 32.50±10.30 years; mean difference = 5.73 years, 95% CI: 0.44-11.01, p=0.034), and sleep time during weekends was longer in patients with diabetes than their counterparts without diabetes (8.81±5.39 *vs*. 6.30±3.37 hours; mean difference = 2.50 hours, 95% CI: 0.71-4.29, p=0.007). No significant statistical differences were found regarding BMI (p=0.236), sleep duration (p=0.476), wake-up time during working days (p=0.236), wake-up time during weekends (p=0.543), or sleep time during working days (p=0.257) (Table 4).

In multivariable logistic regression analysis, older age (adjusted OR=0.932, 95% CI: 0.873-0.995, p=0.034) and obesity (adjusted OR=0.190, 95% CI: 0.038-0.952, p=0.043) were independently associated with lower odds of Ramadan fasting. No significant associations were observed between Ramadan fasting status and gender (adjusted OR=1.004, 95% CI: 0.248-4.10, p=0.995), diabetes status (adjusted OR=1.013, 95% CI: 0.162-6.32, p=0.989), or sleep duration (adjusted OR=1.266, 95% CI: 0.309-5.18, p=0.743) (Table 5). Regarding diabetes treatment 50% were on oral hypoglycemic medication, 30% were on basal bolus and 20% were on lifestyle (Figure 1).

Discussion

Ramadan fasting involves substantial changes in the daily routines (physical activity, meal timing, and sleep pattern). These changes may result from changes in sleep pattern and physical activity, and altered food intake.[13] In addition, the changes in social schedule (reduced working hours, and delay in the starting time for work and school) can lead to shifts in sleep–wake patterns and contribute to circadian misalignment.[14]

Avoiding circadian misalignment and maintaining a regular sleep–wake cycle are increasingly recognized as important factors in preventing adverse cardiometabolic outcomes.[15] Ramadan-related changes in meal schedules, daily routines, and sleep timing may disrupt the synchronization between environmental cues and the circadian system, potentially affecting metabolic regulation.[16]

In the current study, we assessed fasting practice, characteristics, and lifestyle of adults during Ramadan with especial focus on patients with diabetes. Approximately one in four of participants had diabetes, while 13.7% prediabetes. Hypoglycemia was reported in nearly two-thirds (65.4%), and 13.7% were admitted for hyperglycemia. Half of the patients with diabetes were receiving oral hypoglycemic agents, while smaller proportions were managed with basal-bolus insulin or lifestyle modification alone.

A notable lifestyle changes were observed in Ramadan, most participants slept fewer than six hours per night, and showed delayed bedtimes and wake-up times suggesting disruption of circadian rhythms. While, only a small proportion modified their meal patterns and half maintained their usual physical activity.

Patients with diabetes were less likely to fast during Ramadan, significantly older, experienced hypoglycemia symptoms more frequently, had a higher prevalence of comorbidities including hypertension and dyslipidemia. Weekend sleep duration was significantly longer among participants with diabetes, no significant differences were observed in BMI, total sleep duration, weekday sleep timing, and changes in physical activity.

In the present study, 34.7% of participants were classified as high risk for Ramadan fasting according to diabetes risk stratification, highlighting the importance of individualized pre-Ramadan assessment and counseling. Fasting during Ramadan was positively associated with dietary modification, whereas older age and higher body mass index were independently associated with a lower likelihood of fasting. No significant association was observed between fasting and gender.

Previous studies have reported inconsistent effects of Ramadan fasting on body mass index (BMI. A large meta-analysis of 70 studies involving 2947 participants reported a reduction in BMI after Ramadan, likely due to decreases in muscle mass, body water, or energy intake,[17] These findings were supported by a subsequent systematic review and meta-analysis of 85 studies involving 4,176 participants.[18] Similarly, Urooj *et al*. on the other hand some reported no significant changes.[19] Gender differences could explain the discrepancy because the latter studies were conducted in women.[20-22] In this study, changes in body weight were not assessed; however, a higher BMI was independently associated with a lower likelihood of fasting. The relationship between Ramadan fasting and body weight is likely influenced by energy balance, meal timing, chronotype, and physical activity.[23]

Fasting and sleep

Substantial changes in sleep patterns were observed in Ramadan inparticular in Saudi population, where many individuals stay awake late for worship and social activities and compensate with daytime sleep.[24] Faris *et al*. conducted a meta-analysis and reported an approximately one-hour reduction in total sleep duration during Ramadan, consistent with the present findings, in which nearly two-thirds of participants slept fewer than six hours per night.[25] Delayed bedtimes and wake-up times further suggested circadian rhythm disruption.

No significant statistical difference were evident between participants with and without diabetes regarding sleep duration and weekday sleep schedules, although those with diabetes had significantly later weekend bedtimes. While the clinical significance of this finding is uncertain, delayed sleep timing has been associated with circadian disruption, impaired glucose metabolism, and poorer glycemic control.[26] The delayed bedtime and wake-up time observed on weekends may also represent compensation for accumulated sleep debt during the workweek.

Several mechanisms may contribute to Ramadan-related sleep disturbances. Evening consumption of high-fat and high-sugar meals, social, and environmental factors during Ramadan may affect the suprachiasmatic nucleus and peripheral circadian clocks, leading to circadian misalignment.[27,28]

Short sleep duration and circadian misalignment have been linked to increased catecholamine and cortisol secretion, impaired glucose metabolism, insulin resistance, and higher cardiovascular risk.[29] Our findings are consistent with previous reports of persistent sleep disturbances during Ramadan.[27,30] Although a cause and effect cannot be concluded because of the cross-sectional design, the high prevalence of short sleep duration and delayed sleep timing highlights the importance of promoting healthy sleep habits during Ramadan, particularly among individuals with diabetes.

Although some patients with diabetes are exempt from fasting during Ramadan when it poses a health risk, many still observe fasting and may modify or discontinue medications without medical advice, increasing the risk of acute diabetes complications including hypoglycemia, hyperglycemia, and diabetic ketoacidosis.[31,32] In the present study, nearly two-thirds of participants with diabetes reported hypoglycemia. However, the true prevalence may have been underestimated because only about half regularly monitored their blood glucose. Furthermore, approximately 15% of participants with diabetes required hospitalization because of hypoglycemia, highlighting the potential severity of fasting-related complications.

The greater prevalence of cardiovascular risk factors including hypertension and dyslipidemia, and the higher rate of hypoglycemia observed among participants with diabetes, underscores the importance of pre-Ramadan risk assessment and individualized counseling.[31] Although we recorded the treatment categories in this study, medication dose adjustments were not assessed. Future studies should focus on the impact of specific treatment regimens and dose modifications on fasting-related outcomes. Shared decision-making, appropriate adjustment of insulin and sulfonylurea therapy, and education on diet, hydration, physical activity, and glucose monitoring remain essential for safe Ramadan fasting.[32,33]

Comparison between participants with and without diabetes

Patient with diabetes were older and had higher rates of cardiovascular risk factors including hypertension, dyslipidemia than those without diabetes, consistent with the known association between aging, type 2 diabetes, and cardiometabolic risk. These comorbidities reflect the combined effects of endothelial dysfunction, insulin resistance, inflammation, and chronic hyperglycemia.

The greater burden of comorbidities (dyslipidemia and hypertension) is particularly relevant during Ramadan, as fasting may affect fluid balance, medication use, glycemic variability, and cardiovascular stress. Therefore, pre-Ramadan assessment should extend beyond glycemic target to include lipid profile, body weight, blood pressure control, renal function, and diabetes complications in line with the Ramadan Practical Guidelines.[32,33]

Despite higher rates of hypoglycemia and cardiovascular comorbidities among participants with diabetes, lifestyle-related factors, including changes in physical activity, shift work, and breakfast skipping, did not differ significantly between groups. These findings suggest that metabolic characteristics, rather than behavioral changes, were the primary factors distinguishing participants with diabetes during Ramadan.

Physical activity during Ramadan

The effects of Ramadan fasting on the level of exercise remain inconsistent across studies. Some studies reported reduced activity,[30] others found no significant changes.[34] Altered meal timing, sleep patterns, and daily routines may influence exercise behavior.

In the present study, half of the participants reported no change in physical activity, whereas 29.4% decreased and 20.6% increased their activity. These findings suggest considerable individual variation in adaptation to Ramadan. Changes in physical activity did not differ significantly between patients with and without diabetes, indicating that physical activity was not influenced by diabetes status.

Maintaining appropriate exercise is important, particularly for patients with diabetes, as inactivity may worsen metabolic control and insulin resistance. Exercise recommendations should be individualized according to diabetes type, diabetes treatment, meal and medication timing, and hypoglycemia risk. Healthcare providers should include safe exercise guidance as part of pre-Ramadan diabetes education.[35]

Factors associated with Ramadan fasting

In this study, age, BMI, and dietary modification were independently associated with fasting. Increasing age and higher BMI were associated with lower odds of fasting, possibly reflecting adherence to medical advice, and an increasing awareness of fasting-related risks. In contrast, dietary modification was positively associated with fasting, likely reflecting adaptation of meal timing and food choices during Ramadan. Increasing the awareness of, adequate hydration, balanced carbohydrate intake during non-fasting hours, and limiting high-fat and high-sugar foods are highly recommended for safe fasting.

The above findings are in line with the IDF-DAR Practical Guidelines, which recommend individualized pre-Ramadan education, and risk assessment .[33] The observed lower rate of fasting in older individuals and those with higher BMI may represent appropriate risk-based decision-making. In this study, gender was not independently associated with fasting, suggesting that clinical factors were more influential than sex.

Risk stratification and implications for Ramadan care

Pre-Ramadan risk stratification is essential because fasting may increase the risk of hypoglycemia, hyperglycemia, dehydration, and acute metabolic complications.29 In this study, most participants with diabetes were classified as moderate (38.5%) or high risk (34.7%) according to the IDF-DAR system. Many participants classified as moderate or high risk had characteristics such as insulin therapy, poor glycemic control, or inadequate glucose monitoring, consistent with the IDF-DAR risk classification.

Despite these risks, many individuals with diabetes continued to fast, highlighting the need for structured pre-Ramadan education and shared decision-making. Counseling should include assessment of fasting suitability, medication review and adjustment, recognition and management of hypoglycemia, glucose monitoring, dietary advice, hydration, physical activity, and sleep.

The high proportion of moderate- and high-risk participants emphasizes the need to strengthen pre-Ramadan diabetes education. Early identification of high-risk individuals may facilitate treatment optimization, address misconceptions, and support safer fasting decisions. Ramadan may also provide physical and psychological benefits, including opportunities for smoking cessation, improved self-discipline, and spiritual well-being. Nevertheless, these benefits should be balanced against the potential metabolic risks among individuals with diabetes.

Study strength

Unlike previous studies focusing exclusively on patients with diabetes, this study also included non-diabetic adults, we compared lifestyle changes fasting behavior, sleep characteristics, physical activity, dietary changes, and diabetes-related fasting risk within the same community-based population.

Importantly, nearly two-thirds of the study population were female, sex differences in glycemic responses, sleep, physical activity, and hormonal regulation could influence our findings. Although sex was not independently associated with fasting in logistic regression. However, residual confounding cannot be excluded.

Study limitations

The study have several limitations: First lifestyle variables including physical activity, dietary habit, and sleep duration were collected by a self-administered questionnaire which is more prone to recall and social desirability bias may influence the accuracy of the reported information. Second, the cross-sectional nature of the study limits the ability to establish causal relationships between the studied variables. Third, the small number of participants with diabetes may have limited the precision of subgroup comparisons. Finally, the small number of participants who did not observe Ramadan fasting may have reduced the statistical power and stability of the regression analysis. Therefore, the observed associations should be interpreted with caution and require confirmation in larger prospective studies.

Conclusions

This study demonstrates that Ramadan fasting among individuals with diabetes in Tabuk City is associated with important clinical and lifestyle considerations. A substantial proportion of participants were classified as moderate or high risk according to the IDF-DAR risk stratification system, and hypoglycemia was common despite suboptimal blood glucose monitoring.

Ramadan was also associated with short nocturnal sleep duration and delayed sleep timing, suggesting circadian disruption, whereas changes in physical activity varied between individuals. Older age and higher BMI were associated with a lower likelihood of fasting, while dietary modification was positively associated with fasting.

These findings highlight the importance of individualized pre-Ramadan assessment, structured diabetes education, medication review, and counseling on glucose monitoring, diet, physical activity, and sleep to support safer fasting practices and reduce fasting-related complications.

References

1. Ralbovsky NM, Lednev IK. Vibrational spectroscopy for detection of diabetes: a review. Appl Spectrosc 2021;75:929-46.
2. IDF Diabetes Atlas, 10th edition. 2021. Available from https://idf.org/news-and-resources/resources/idf-diabetes-atlas-2021/.
3. Lessan N, Ali T. Energy metabolism and intermittent fasting: the ramadan perspective. Nutrients 2019;11:1192.
4. Hassanein MM, Hanif W, Malek R, et al. Changes in fasting patterns during Ramadan, and associated clinical outcomes in adults with type 2 diabetes: A narrative review of epidemiological studies over the last 20 years. Diabetes Res Clin Pract 2021;172:108584.
5. Zainudin SB, Yeoh E. Preparing muslims with diabetes mellitus for Ramadan fasting in Singapore: a clinical approach and review of current practice. Singapore Med J 2022;63:633-40.
6. Loh HH, Kamaruddin NA. Treatment options for patients with type 2 diabetes mellitus during the fasting month of Ramadan. Ann Acad Med Singap 2020;49:468-76
7. Shaltout I, Zakaria A, Abdelwahab AM, et al. Culturally based pre-Ramadan education increased benefits and reduced hazards of Ramadan fasting for type 2 diabetic patients. J Diabetes Metab Disord 2020;19:179-86.

8. Syed F, Arif MA, Ramzan A, et al. DAR-GRACE: diabetes and Ramadan: glycaemic control, physician counselling and patient practices -experience from a tertiary care hospital in Pakistan. J Pak Med Assoc 2020;70:1990-5.
9. Bener A, A Al-Hamaq AOA, Öztürk M, et al. Effect of ramadan fasting on glycemic control and other essential variables in diabetic patients. Ann Afr Med 2018;17:196-202.
10. Shafras MS, Monaragala LM, Samarakkody IS, et al. Comparison of glycaemic control and anthropometric parameters before and after Ramadan fasting in a selected cohort of patients with type 2 diabetes mellitus in Sri Lanka. Ceylon Med J 2020;65:79-85.
11. Lessan N, Hannoun Z, Hasan H, et al. Glucose excursions and glycaemic control during Ramadan fasting in diabetic patients: insights from continuous glucose monitoring (CGM). Diabetes Metab 2015;41:28-36.
12. Mansouri D, Khayat E, Khayat M, et al. Self-monitoring of blood glucose and hypoglycemia association during fasting in Ramadan among patients with diabetes. Diabetes Metab Syndr Obes 2020;13:1035-41.
13. Ongsara S, Boonpol S, Prompalad N, et al. The effect of Ramadan fasting on biochemical parameters in healthy Thai subjects. J Clin Diagn Res 2017;11:BC14-8.
14. Bahammam A. Does Ramadan fasting affect sleep? Int J Clin Pract 2006;60:1631-7.
15. de Cabo R, Mattson MP. Effects of intermittent fasting on health, aging, and disease. N Engl J Med 2019;381:2541-51. Erratum in: N Engl J Med 2020;382:298. Erratum in: N Engl J Med 2020;382:978.
16. Bahammam AS, Pirzada AR. Delaying school and office timings during Ramadhan: boon or bane? Ann Thorac Med 2021;16:1-3.
17. Fernando HA, Zibellini J, Harris RA, et al. Effect of Ramadan fasting on weight and body composition in healthy non-athlete adults: a systematic review and meta-analysis. Nutrients 2019;11:478.
18. Jahrami HA, Alsibai J, Clark CCT, et al. A systematic review, meta-analysis, and meta-regression of the impact of diurnal intermittent fasting during Ramadan on body weight in healthy subjects aged 16 years and above. Eur J Nutr 2020;59:2291-316.
19. Urooj A, Pai Kotebagilu N, Shivanna LM, et al. Effect of Ramadan fasting on body composition, biochemical profile, and antioxidant status in a sample of healthy individuals. Int J Endocrinol Metab 2020;18:e107641.
20. Attarzadeh Hosseini SR, Sardar MA, Hejazi K, Farahati S. The effect of ramadan fasting and physical activity on body composition, serum osmolarity levels and some parameters of electrolytes in females. Int J Endocrinol Metab 2013;11:88-94.
21. Savas E, Öztürk ZA, Tanrıverdi D, et al. Do Ramadan fasting restrictions alter eating behaviours in obese women? J Relig Health 2014;53:135-40.
22. Yeoh EC, Zainudin SB, Loh WN, et al. Fasting during Ramadan and associated changes in glycaemia, caloric intake and body composition with gender differences in Singapore. Ann Acad Med Singap 2015;44:202-6.
23. Alzhrani A, Alhussain MH, BaHammam AS. Changes in dietary intake, chronotype and sleep pattern upon Ramadan among healthy adults in Jeddah, Saudi Arabia: a prospective study. Front Nutr 2022;9:966861.
24. Al Harbi KM, Alsaleem LS, Alsaidan AI, et al. Quality of sleep in the Saudi population during the holy month of Ramadan. Cureus 2023;15:e50897.
25. Faris MAE, Jahrami HA, Alhayki FA, et al. Effect of diurnal fasting on sleep during Ramadan: a systematic review and meta-analysis. Sleep Breath 2020;24:771-82.

26. Koren D, Knutson KL, Burke BK, et al; TODAY Study Group. The association of self-reported sleep and circadian measures with glycemic control and diabetes complications among young adults with type 2 diabetes. Am J Physiol Heart Circ Physiol 2024;326:H1386-95.
27. Qasrawi SO, Pandi-Perumal SR, BaHammam AS. The effect of intermittent fasting during Ramadan on sleep, sleepiness, cognitive function, and circadian rhythm. Sleep Breath 2017;21:577-86.
28. BaHammam A. Assessment of sleep patterns, daytime sleepiness, and chronotype during Ramadan in fasting and nonfasting individuals. Saudi Med J 2005;26:616-22.
29. Greenlund IM, Carter JR. Sympathetic neural responses to sleep disorders and insufficiencies. Am J Physiol Heart Circ Physiol 2022;322:H337-49.
30. Alghamdi AS, Alghamdi KA, Jenkins RO, et al. Impact of Ramadan on physical activity and sleeping patterns in individuals with type 2 diabetes: the first study using fitbit device. Diabetes Ther 2020;11:1331-46.
31. Almulhem M, Susarla R, Alabdulaali L, et al. The effect of Ramadan fasting on cardiovascular events and risk factors in patients with type 2 diabetes: a systematic review. Diabetes Res Clin Pract 2020;159:107918.
32. Hassanein M, Al-Arouj M, Hamdy O, et al. Diabetes and Ramadan: practical guidelines. Diabetes Res Clin Pract 2017;126:303-16.
33. Hassanein M, Afandi B, Yakoob Ahmedani M, et al. Diabetes and Ramadan: practical guidelines 2021. Diabetes Res Clin Pract 2022;185:109185.
34. Geok SK, Yusof A, Abdullah NSM, et al. Comparing physical activity of Malaysian Malay men and women before, during, after Ramadan. Pertanika J Soc Sci Human 2013;21:569-78.
35. BaHammam AS, Alghannam AF, Aljaloud KS, et al. Joint consensus statement of the Saudi Public Health Authority on the recommended amount of physical activity, sedentary behavior, and sleep duration for healthy Saudis: Background, methodology, and discussion. Ann Thorac Med 2021;16:225-38.

Table 1. Basic characteristics of the study group.

Character	No %
Gender	
Males	70 (34.3%)
Females	134 (65.7%)
Age (18-69 years)	33.69±11.94
Glycemic status	
Diabetes	52 (25.5%)
Prediabetes	28 (13.7%)
No diabetes	124
Blood glucose range	
Lower (range, 97,126 mg/dl)	124.46±34.94
Upper (range, 126,240 mg/dl)	152.74±34.40
Comorbidities	
Dyslipidemia	30 (14.7%)
Hypertension	34 (16.7%)
HbA1c	
<6	68 (40.5%)
6-7	44 (26.2%)
7-8	22 (13.1%)
8-10	16 (9.5%)
10-12	12 (7.2%)
>12	06 (3.6%)
Diabetes	
Type 1	24 (11.8%)
Type 2	28 (13.7%)
Prediabetes	22 (10.8%)
Gestational	04 (2%)
Pregnant	06 (2.9%)
Fasting	
Hypoglycemia (N=26 patients)	
Yes	34 (65.4%)
Sometimes	28 (13.7%)
Hypoglycemia frequency	
Once per week	20 (38.5%)
More than once per week	20 (38.5%)
Less than once per week	08 (15.4%)
Hospital admission	08 (15.4%)
Regular check of blood glucose	
Regular	28 (53.8%)
Irregular	24 (46.2%)
Regular breakfast and Sahour	158 (77.5%)
Exercise during Ramadhan	
Increase	42 (20.6%)
Stable	102 (50%)
Less	60 (29.4%)
Sleep duration	
< 6 hours	122 (59.8%)
6-8 hours	66 (32.4%)
>8 hours	16 (7.9%)
Shift workers	30 (14.7%)
Dietary modifications during Ramadan	14 (6.9%)
Sleep duration in hours (Mean± SD)	4.65±2.34
Sleep timing during weekdays	8.31±6.7
Sleep timing during weekends	7.96±5.51
Awakening time during weekdays	8.62±3.1
Awakening time during weekends	9.65±4.38

Table 2. Risk stratification of patients with diabetes who observed fasting Ramadan in Tabuk City, Saudi Arabia according to the International Diabetes Federation.

Risk score	No %
0-3	14 (26.9%)
3.5-6	20 (38.5%)
>6	18 (34.7%)

Table 3. Comparison of demographic, clinical, and lifestyle characteristics between participants with and without diabetes in Tabuk City, Saudi Arabia.

Character	Diabetes	No diabetes	Odds ratio (95% CI)	p
Gender				
Males	20 (28.6%)	50 (71.4%)	1.28 (0.51-3.21)	0.606
Females	32 (23.9%)	102 (76.1%)		
Hypoglycemia	32 (61.5%)	30 (19. 7%)	6.51 (2.46-17.19)	<0.001
Breakfast skipping	38 (24.1%)	120 (75.9%)	0.72 (0.26-2.02)	0.536
Shift work	6 (20%)	44 (80%)	0.73 (0.19-2.82)	0.644
Ramadhan fasting	46 (88.5%)	150 (98.7%)	0.10 (0.01-1.03)	0.02
Exercise change				
Increased	10 (23.8%)	32 (76.2%)		
The same	26 (25.4%)	76 (74.6%)		
Decreased	16 (26.7%)	44 (72.3%)		0.947
Comorbidities				
Hypertension	16 (30.7%)	10 (6.6%)		
Dyslipidemia	6 (11.5%)	4 (2.6%)		< 0.01
Hypertension and dyslipidemia	8 (15.4%)	4 (2.6%)		

Chi-square test or Fisher's exact test, as appropriate.

Table 4. Comparison of demographic characteristics, body mass index, and sleep patterns between participants with and without diabetes in Tabuk City, Saudi Arabia.

Character	Diabetes (mean±SD)	No diabetes (mean±SD)	Mean difference (95% CI)	p
Age/years	38.23±15.24	32.50 ± 10.30	5.73 (0.44 to 11.01)	0.034
BMI (kg/m^2)	27.63±6.87	29.29± 5.89	−1.66 (−4.43 to 1.11)	0.236
Sleep duration (hours/night)	4.38±2.37	4.77± 2.37	−0.38 (−1.45 to 0.68)	0.476
Wake-up time on workdays (hours after midnight)	10.25±3.91	9.44± 2.62	0.81 (−0.53 to 2.16)	0.236
Wake-up time on weekends	10.92±4.20	10.31± 4.32	0.60 (−1.36 to 2.57)	0.543
Bedtime on workdays (hours after midnight)	8.56±6.81	7.10± 5.25	1.47 (−1.09 to 4.03)	0.257
Bedtime on weekends	8.81±5.39	6.30± 3.37	2.50 (0.71 to 4.29)	0.007

Independent-samples t-test.

Table 5. Factors associated with Ramadan fasting status among adults in Tabuk City, Saudi Arabia: binary logistic regression analysis.

Variable	B	Adjusted OR (95% CI)	p
Gender	0.004	1.004 (0.248-4.1)	0.995
Age	-0.070	0.932 (0.873-0.995)	0.034
Diabetes status	0.013	1.013 (0.162-6.32)	0.989
Obesity	-1.66	0.190 (0.038-0.952)	0.043
Sleep duration (hours/night)	0.236	1.266 (0.309-5.18)	0.743
Constant	0.949		0.674

Binary Logistic regression.

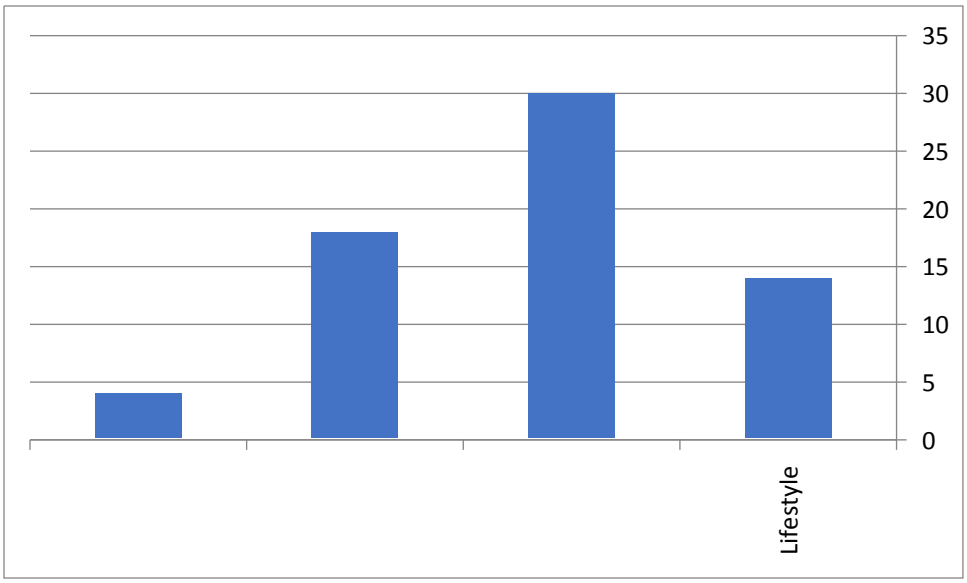


Figure 1. Diabetes management.