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Changes in sleep, physical activity, and health behaviors among Nigerian fasting adults in Ramadan during the COVID-19 pandemic

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Abstract:

BACKGROUND: There is limited data on sleep, physical activity, and health-related behaviors among the general public during Ramadan, particularly during the COVID-19 pandemic. This study aimed to assess the factors associated with sleep and physical activity changes among Nigerian Muslims during Ramadan fasting.

MATERIALS AND METHODS: A nationwide web-based cross-sectional study was conducted among Nigerians aged ≥ 18 years who performed diurnal fasting during Ramadan. The target sample size was obtained using Fisher's formula, and snowball sampling was employed. Adapted versions of the International Physical Activity Questionnaire Short Form and Copenhagen Psychosocial Questionnaire II were used to evaluate sleep and physical activity. Correlates of change in physical activity and sleep quality were assessed using logistic regression analysis.

RESULTS: Seven hundred and seventy individuals participated in the study. During Ramadan, 39.1% (95% confidence interval (CI): 35.6%–42.6%) reported decreased physical activity, and 56.6% (95% CI: 53.0%–60.2%) stated having self-reported good sleep. The independent correlates of physical activity were female sex (adjusted odds ratio (aOR):0.5, 95% CI: 0.4–0.8), having very good sleep (aOR: 0.4, 95% CI: 0.2–0.7), and obesity (aOR: 2.0, 95% CI: 1.1–3.7). In addition, factors associated with improved self-reported sleep quality were perceived good health state (aOR: 8.8, 95% CI: 1.1–72.4), sleeping 7–9 h per day (aOR: 5.5, 95% CI: 2.6–10.3), and sleeping for over 9 h per day (aOR: 4.6, 95% CI: 2.1–14.1).

CONCLUSIONS: Although physical activity decreased by about a third, over half of the respondents lost weight and slept well during Ramadan. Strategies to include intermittent fasting in positive lifestyle changes could improve the health and well-being of the population.

Keywords:

Health behaviors, intermittent fasting, Islam, pandemic, physical activity, sleep

Introduction

Ramadan is the ninth month in the Islamic (lunar) calendar, during which healthy adult Muslims worldwide refrain from food, drink, smoking, and sexual activities from dawn to sunset over 29–30 days.^[1–3] The fasting period ranges

from 12 to 20 h, depending on the season and geographical location.^[1,4] Lifestyle modifications during this month have been shown to affect physical activity, sleep, and other health behaviors.^[5–9] The role of physical activity in improving health and well-being is well-established across the globe, from decreasing the risk of chronic

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diseases to lowering the rate of mood disorders and improving emotional and overall well-being.^[10] Despite physical activity being recognized as a core determinant of health, 27.5% of adults worldwide do not meet the recommended levels of physical activity.^[11] Globally, physical inactivity is reported to be the fourth leading risk factor with the highest epidemiological impact on population health worldwide and is a phenomenon of substantial public health importance.^[12]

Sleep plays a pivotal role as a determinant of health and is closely connected to well-being and quality of life. The relationship between sleep and health is purported to be bidirectional.^[5] Insufficient sleep has a negative impact on physical and mental health, quality of life, and social outcomes, such as poor school/workplace performance, traffic accidents, industrial accidents, medical errors, and more.^[13-15] Sleep deprivation has also been linked to reduced quality of life,^[16,17] increased risk for cardiovascular diseases,^[18] and high odds for depression and anxiety.^[19] According to the National Sleep Foundation, 7–9 h of sleep are recommended for young adults, and 7–8 h are suggested for older adults.^[20] The sleep pattern is typically distorted during Ramadan, with individuals waking up to eat before dawn and or performing some religious rites. Later nightlife activities and social and family demands are sometimes more common during Ramadan.^[21] Some of these changes associated with Ramadan intermittent fasting may impact sleep patterns, circadian rhythms, and the biological clock.^[21,22]

While a significant change in sleep pattern was noticed in many Islamic countries during Ramadan,^[23-25] conflicting results regarding sleep duration were reported during the same month, with some reporting reductions in night-time sleep duration,^[24,25] and others reporting insignificant changes in the duration of night time sleep.^[7] Similarly, divergent findings on the level of physical activity during Ramadan have been reported. Two studies reported a reduction in physical activity during Ramadan,^[26,27] while another study reported no change in physical activity levels between fasting and nonfasting state.^[28] Certain health-related behaviors like smoking and alcohol consumption are also noted to change during Ramadan.^[29-31] With Ramadan happening during the COVID-19 pandemic, these consequences may be confounded by the psychological and emotional disturbances associated with the pandemic and the resultant lockdown.

The prevalence of sleep problems and mental disorders has increased globally since the start of the pandemic.^[32-34] For example, close to a fifth of the general population in China experienced poor sleep quality during the COVID-19 pandemic.^[35] Similar

trends were noticed among the general population in Europe.^[36,37] Both sleep duration and quality have been altered due to the pandemic.^[33] An increase in the prevalence of insomnia and poor mental health outcomes such as anxiety and depression among the general population has been reported.^[37] In Nigeria, 20.8% of males and 32% of females studied had subthreshold insomnia, 8.2% of males and 13.4% of females had moderate insomnia, while 5.9% of males and 3.6% of females had insomnia.^[38] Another study reported that 80% of healthcare workers from a Nigerian hospital had extended sleep onset latency, 70% had both duration problems and daytime dysfunction, while roughly one in three had poor sleep quality and reported using sleep-enhancing drugs.^[39] Contrary to this finding, a cohort study of 396 Nigerian university students found that more than half of the participants had increased sleep duration, and at least eight hours of sleep/day, while around eight in ten had reduced physical activity and poor dietary intake.^[40]

The novelty of our study lies in its unique exploration of the intersection between Ramadan fasting, sleep and physical activity changes, and the COVID-19 pandemic among Nigerian Muslims. While previous research has examined the impact of Ramadan fasting on sleep and physical activity, and separate studies have investigated the effects of the COVID-19 pandemic on these aspects, our study is the first to examine these factors concurrently. This provides a unique perspective on how these significant lifestyle and global health factors interact and influence each other.

Materials and Methods

Study design and setting

The conceptual framework of our study is based on the hypothesis that Ramadan fasting and the COVID-19 pandemic would have a significant impact on sleep and physical activity among Nigerian Muslims. Over the course of four weeks between 9th May 2021 (27th of Ramadan) and 4th June 2021, we conducted a web-based cross-sectional survey among Nigerian adults who fasted during Ramadan. Nigerians fasted from dawn until sunset during Ramadan, which lasted approximately 12–14 h depending on where they lived. We evaluated sleep and physical activity using adapted versions of the International Physical Activity Questionnaire Short Form (IPAQ-SF)^[41] and Copenhagen Psychosocial Questionnaire II (COPSOQ-II).^[42] We then assessed the correlates of change in physical activity and sleep quality using logistic regression analysis. This framework allowed us to systematically examine the factors associated with sleep and physical activity changes during Ramadan fasting in the context of the COVID-19 pandemic.

Study participants and sampling

Participants were part of the Nigerian Ramadan study.^[43] Adult Nigerian Muslims (18 years old and above) residing in the country during the survey period were invited to participate. Nonprobability snowball sampling technique was used. The target sample size for the survey was obtained using Fisher's formula,^[44] using a prevalence of 30% of individuals who were satisfied with their sleep by the end of the third week of Ramadan,^[45] 95% confidence level, and 5% margin of error. The minimum sample size ($n = 323$) was increased by 10% to account for nonresponse and rounded to 356.

Data collection tool and technique

Data were collected anonymously to exclude any identifying information using pretested, self-administered, online questionnaires (assessing physical activity, screen time, and sleep) adapted to suit the study objectives.^[41,42] The questions were prepared on Google forms (docs.google.com/forms). The survey was conducted in the English language as English is the main language in Nigeria. Collaborators from different parts of the country were issued a unique Google Form link to help distribute the link and maximize recruitment to family, friends, relatives, colleagues, and other contacts through social media platforms like WhatsApp, Facebook, Twitter, and Instagram. Responses submitted by all the survey participants have been collected automatically into a single Google spreadsheet to create the final data set. The survey questionnaire elicited information from the respondents about sociodemographic characteristics, medical history, physical activity (before and during Ramadan), screen time, and sleep (before and during Ramadan).

Survey participants were asked about their age, sex, marital status, place of permanent domicile (rural or urban), the highest level of educational attainment (tertiary, undergraduate, secondary, primary), occupational status (employed or unemployed), level of education of father and mother (none/nonformal, primary, secondary, tertiary), and total household income with reference to the country's minimum household expenditure of NGN137,600 (USD 354) for families.^[46]

Participants were asked to self-report their body weight (kg) and height (cm). These were later used to calculate the corresponding body mass index (BMI, kg/m²) of the study subjects during analysis, and classified into four categories: underweight (<18.5), normal (18.5–24.9), overweight (25.0–29.9) and obese (>30).^[47] Respondents were also asked about their personal or immediate family history of diabetes mellitus, hypertension, and heart disease. In addition, participants were asked if they had a family history of obesity or overweight (yes/no).

Participants were asked to report the number of cigarettes smoked per day and the number of days shisha was smoked within 30 days before Ramadan and during Ramadan. Perceived mental health state (in the English language) three months before and during Ramadan was assessed on a five-point Likert scale (poor, fair, good, very good, excellent). Questions adapted from the IPAQ-SF were used to assess physical activity before and during Ramadan.^[41]

Questions assessing time routine and sleep were adapted from the COPSOQ-II.^[42] Data were analyzed using STATA version 15.0 (StataCorp LLC, College Station, TX, USA). Mean and standard deviation (SD) were used to summarize the age of the respondents. Frequencies and percentages were obtained for categorical variables. The frequencies of health behavior before and during Ramadan were compared using Pearson's Chi-square or Fisher's exact test. Type I error was fixed at 5% for all tests. Multinomial logistic regression models were developed for changes in physical activity, and sleep quality and crude odds ratios were reported. Maintained or no change was used as the reference category for physical activity, while poor sleep was used for sleep quality. All models considered age, sex, and health state as *a priori* confounding variables. Independent variables with $P < 0.10$ at the bivariate level were included in the multivariate analysis. Adjusted odds ratios and their 95% confidence intervals (CIs) were used to measure the strength and direction of the effect of factors associated with the dependent variables. A backward stepwise regression was used, and the P values reported were from the likelihood ratio test.

Ethical considerations

This study was conducted in accordance with the Helsinki Declaration and was approved by the research ethics committee of the Yobe State University Teaching Hospital, Damaturu, Nigeria (YSUTH/MAC/EC/02), and the Social Sciences Research Ethics Committee (REC) of the United Arab Emirates University (Approval Number ERS_2021_7308).

Results

The reliability of the study was measured by calculating Cronbach's alpha for each of the scales assessing physical activity and sleep. The scales were found to be reliable, with a Cronbach's alpha of ≥ 0.80 . There were 770 participants within the age range of 15–60 years. Over half (61.8%, $n = 476$) were 21–30 years, and their mean age and SD were 27.7 ± 6.4 years. Appendix 1 summarizes the sociodemographic characteristics of the respondents.

Medical history

Approximately a third of the respondents (35.2%, $n = 271$) had a normal BMI, 5.8% ($n = 45$) were diabetic,

and 8.7% ($n = 67$) were hypertensive. Appendix 2 depicts the medical history of the respondents.

Weight change and perceived health state during Ramadan

Most respondents (97.3%, $n = 749$) said they had good health during Ramadan, and 54.6% ($n = 420$) lost weight. About a third of the respondents (32.1%, $n = 247$) lost between 1.1 and 3 kg; however, 3.4% ($n = 26$) gained between 0.1 and 1.0 kg.

Health behaviors before and during Ramadan

Table 1 depicts the health behaviors before and during Ramadan, as reported by the respondents. The perceived health state of the respondents significantly improved during Ramadan compared to the pre-Ramadan state (51.3% vs. 43.5%). Approximately a fifth of the respondents (21.8%, 95% CI: 18.9%–24.9%) increased their physical activity during Ramadan. However, a much higher proportion, 39.1% (95% CI: 35.6%–42.6%), decreased their physical activity during the same period [Figure 1].

Rest and sleep before and during Ramadan

Figure 1 shows that more than half of the respondents had good sleep quality during Ramadan (56.6%, 95% CI: 53.0%–60.2%), and about one in five had poor sleep quality during Ramadan (19.1%, 95% CI: 16.4%–22.1%).

Table 2 depicts changes in rest and sleep status, as reported by the respondents. Time spent on the computer or television screen was significantly reduced during Ramadan ($P < 0.001$) compared to pre-Ramadan. Sleep duration during Ramadan was significantly lower. A much lower proportion of the respondents reported poor sleep quality before Ramadan versus during Ramadan (10.3% vs. 19.1%). However, sleep disturbances were significantly higher before than during Ramadan ($P = 0.02$). Moreover, energy levels were reported as higher before Ramadan compared to during Ramadan.

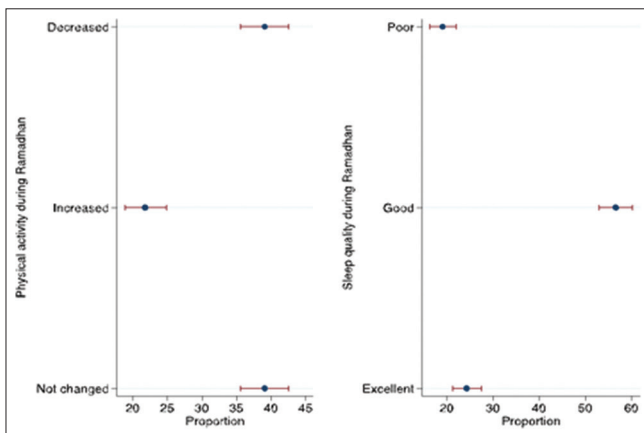


Figure 1: Change in physical activity and sleep quality during Ramadan

Factors associated with physical activity

Table 3 shows the multinomial logistic regression analysis for independent correlates of physical activity changes during Ramadan. Multinomial regression analysis was conducted using three categories of changes in physical activity: no change, increase, or decrease. The reference category used in the analysis was “no change”.

Factors associated with sleep quality

Table 4 shows the multinomial logistic regression analysis of factors associated with a change in sleep quality during Ramadan. The perceived health state of the respondents, number of hours slept, energy level, and sleep disturbances during Ramadan remained independently associated with sleep quality during Ramadan after adjusting for other covariates.

Discussion

This study explored changes in sleep, physical activity, and other health behaviors among fasting adults during

Table 1: Health behaviors before and during Ramadan

Behavior	Before Ramadan	During Ramadan	P
Cigarettes smoked per day			
0	759 (98.6)	761 (98.8)	0.21
1–5	5 (0.7)	8 (1.0)	
6–10	2 (0.5)	0 (0)	
11–20	4 (0.3)	1 (0.1)	
Number of days shisha was smoked			
0	758 (98.4)	763 (99.1)	0.84
1–5	6 (0.8)	4 (0.5)	
6–10	2 (0.3)	1 (0.1)	
11–20	2 (0.3)	1 (0.1)	
All 30 days	2 (0.3)	1 (0.1)	
Perceived health state			
Excellent	335 (43.5)	395 (51.3)	0.02
Fair	24 (3.1)	19 (2.5)	
Good	150 (19.5)	114 (14.8)	
Poor	3 (0.4)	2 (0.3)	
Very good	258 (33.5)	240 (31.2)	
Any exercise done for at least 10 min			
3 times	339 (44.0)	223 (29.0)	<0.001
>3 times	85 (11.0)	58 (7.5)	
None	346 (44.9)	489 (63.5)	
Heavy lifting, digging, aerobics, or fast cycling for at least 10 min			
1–3 times	151 (19.6)	118 (15.3)	0.02
>3 times	39 (5.1)	27 (3.5)	
None	580 (75.3)	625 (81.2)	
Jogging, bike riding, brisk walking, or swimming for at least 10 min			
1–3 times	307 (39.9)	224 (29.1)	<0.001
>3 times	109 (14.2)	72 (9.4)	

Table 2: Rest and sleep during Ramadan

Activity	Before Ramadan	During Ramadan	P
Time spent daily on the computer for work or study			
None	104 (13.5)	140 (18.2)	<0.001
<30 min	105 (13.6)	152 (19.7)	
1–2 h	198 (25.7)	223 (29.0)	
3–5 h	206 (26.8)	148 (19.2)	
Six or more hours	157 (20.4)	107 (13.9)	
Time spent daily on TV, computer, and social media for entertainment			
None	51 (6.6)	79 (10.3)	<0.001
<30 min	90 (11.7)	202 (26.2)	
1–2 h	213 (27.7)	270 (35.1)	
3–5 h	256 (33.3)	158 (20.5)	
Six or more hours	160 (20.8)	61 (7.9)	
Time spent with family on average			
None	79 (10.3)	86 (11.2)	0.11
<30 min	77 (10.0)	100 (13.0)	
1–2 h	171 (22.2)	148 (19.2)	
3–5 h	206 (26.8)	179 (23.3)	
Six or more hours	237 (30.8)	257 (33.4)	
Sleep hours per night			
<7 h	363 (47.1)	594 (77.1)	<0.001
7–9 h	350 (45.5)	146 (19.0)	
>9 h	57 (7.4)	30 (3.9)	
Quality of sleep			<0.001
Poor	79 (10.3)	148 (19.1)	<0.001
Good	417 (54.2)	436 (56.6)	
Excellent	274 (35.6)	187 (24.3)	
Energy Level			<0.001
Energized	335 (43.5)	218 (28.3)	<0.001
Lazy	27 (3.5)	74 (9.6)	
Neutral	408 (53.0)	478 (62.1)	
Experienced any of the following sleep disturbances			
Hard to go to sleep	125 (16.2)	103 (13.4)	0.02
No sleep disturbance	357 (46.4)	340 (44.2)	
Slept badly and restlessly	114 (14.8)	97 (12.6)	
Woken up several times and found it difficult to get back to sleep	52 (6.8)	67 (8.7)	<0.001
Woken up too early and have not been able to get back to sleep	122 (15.8)	163 (21.2)	

Ramadan and the COVID-19 pandemic in Nigeria. Within this period, approximately 4 out of 10 respondents decreased their physical activity; half reported weight loss, and almost 6 out of 10 had a good sleep.

The decline in the frequency of physical activity during Ramadan seen in this study is akin to findings from fasting Muslims in Malaysia,^[48] Qatar,^[26] and among fasting young males in Turkey.^[9] Additionally, a lower physical activity profile has been reported among trained Muslim soccer players who were fasting.^[49] During Ramadan, physical activity may be reduced due to lower energy levels caused by decreased food and fluid intake. Muslims wake up early to eat before the fast and break their fast at sunset. This disrupts their usual sleep patterns and routines, making it challenging to find time for exercise. Additionally, community gatherings, such as iftar dinners, and

spiritual reflection take up more time and energy during Ramadan. Cultural perceptions that physical activity is inappropriate, concerns about becoming dehydrated, and a preference for less strenuous activities can also contribute to a reluctance to engage in physical activity during Ramadan. Further, a compensatory slower basal metabolic rate found among people fasting may explain the weakness and fatigue associated with lower physical activities during Ramadan.^[50] To support this finding, this study demonstrated that sex, energy levels, and BMI were associated with physical activity. Furthermore, literature shows that weight and sex are related to the metabolism of individuals and, therefore, could affect physical activity in the fasting state.^[51,52]

In addition, considering Ramadan coincided with the COVID-19 pandemic, the restrictions of the period and

Table 3: Multinomial logistic regression showing factors associated with a change in physical activity during Ramadan

Covariate	Crude OR (95% Confidence Interval)		P	*Adjusted OR (95% Confidence Interval)		P
	Decreased Physical activity	Increased physical activity		Decreased physical activity	Increased physical activity	
Age (in years)						
≤20	Reference		0.005			0.16
21–30	2.2 (1.2–3.9)	1.5 (0.8–2.8)		1.7 (0.9–3.3)	1.6 (0.8–3.6)	
31–40	2.6 (1.4–4.9)	1.1 (0.5–2.1)		1.6 (0.7–3.7)	1.1 (0.4–2.9)	
41–50	2.8 (1.0–7.8)	0.8 (0.2–3.3)		1.5 (0.4–5.3)	0.6 (0.1–3.8)	
Sex						
Male	Reference	Reference	<0.001			0.02
Female	0.5 (0.4–0.7)	0.6 (0.4–0.9)		0.5 (0.4–0.8)	0.6 (0.4–0.9)	
Perceived health state during Ramadan						
Good	Reference			Reference		
Poor	0.6 (0.2–1.7)	0.7 (0.2–2.2)	0.58	0.7 (0.4–1.6)	0.9 (0.4–2.3)	0.61
Highest educational status						
Tertiary or higher	Reference	Reference	0.06	Reference	Reference	0.26
Undergraduate	0.9 (0.6–1.3)	1.6 (0.9–2.6)		1.2 (0.7–1.9)	1.6 (0.9–3.0)	
Secondary	1.3 (0.7–2.3)	2.2 (1.1–4.4)		1.6 (0.7–3.3)	1.5 (0.6–3.5)	
Occupation						
Unemployed	Reference	Reference				
Employed	1.3 (0.9–1.8)	0.8 (0.5–1.1)	0.05	0.9 (0.6–1.4)	1.1 (0.7–1.8)	0.71
BMI (kg/m ²)						
Normal	Reference	Reference	0.02			0.03
Underweight	1.2 (0.7–2.0)	0.9 (0.5–1.8)		0.9 (0.5–1.5)	1.1 (0.4–2.1)	
Overweight	1.3 (0.8–2.2)	0.9 (0.5–1.7)		1.3 (0.7–2.4)	1.1 (0.5–2.4)	
Obese	2.1 (1.4–3.3)	1.9 (1.1–3.1)		2.0 (1.1–3.7)	2.1 (1.1–4.3)	
History of DM						
No	Reference	Reference	0.01	Reference	Reference	0.26
Yes	1.5 (0.7–3.2)	3.2 (1.5–6.9)		1.2 (0.5–2.9)	2.1 (0.8–5.1)	
Sleep quality during Ramadan						
Poor	Reference	Reference	0.07	Reference	Reference	0.03
Good	0.7 (0.5–1.2)	0.7 (0.4–1.1)		0.8 (0.4–1.1)	0.6 (0.4–1.1)	
Excellent	0.5 (0.3–0.9)	0.7 (0.4–1.3)		0.4 (0.2–0.7)	0.5 (0.3–1.1)	
Time spent daily on the computer for work or study						
None	Reference	Reference	0.02	Reference	Reference	0.04
<30 min	1.5 (0.9–2.6)	0.9 (0.5–1.7)		1.6 (0.8–2.6)	0.8 (0.7–1.7)	
1–2 h	1.4 (0.9–2.3)	0.7 (0.4–1.3)		1.4 (0.8–2.3)	0.9 (0.5–1.6)	
3–5 h	1.1 (0.6–1.9)	0.6 (0.3–1.1)		1.4 (0.6–2.3)	0.6 (0.3–1.1)	
6 or more hours	0.6 (0.4–1.2)	0.4 (0.3–0.8)		0.8 (0.6–1.4)	0.4 (0.3–0.9)	
Time spent daily on TV, computer, and social media for entertainment						
None	Reference	Reference		Reference	Reference	
<30 min	0.1 (0.5–1.8)	1.1 (0.6–2.2)	0.08	0.3 (0.8–2.3)	1.3 (0.6–2.2)	
1–2 h	0.8 (0.4–1.4)	0.7 (0.3–1.3)		1.0 (0.6–1.9)	0.8 (0.5–2.3)	
3–5 h	0.7 (0.4–1.2)	0.4 (0.2–1.0)		0.9 (0.4–2.4)	0.4 (0.2–1.0)	0.10
6 or more hours	0.5 (0.2–1.2)	0.5 (0.2–1.3)		0.5 (0.6–1.9)	0.5 (0.4–1.1)	
Energy Level						
Neutral	Reference	Reference	<0.001	Reference	Reference	0.02
Lazy	1.9 (1.1–3.3)	0.8 (0.4–1.7)		2.1 (1.4–3.9)	0.8 (0.5–1.8)	
Energized	0.7 (0.4–1.0)	1.8 (1.3–2.7)		0.7 (0.3–1.0)	2.4 (1.6–3.9)	

*Adjusted for age, sex, educational status, health state, BMI, occupation, history of DM, sleep quality, time spent on TV for entertainment, and energy level during Ramadan

the public's fear of the disease could have prevented individuals from leaving their homes and engaging in

any form of exercise.^[53] From Iran, it has been reported that COVID-19 restrictions affected physical activity,

Table 4: Multinomial logistic regression showing factors associated with a change in sleep quality during Ramadan

Covariate	Crude OR (95% Confidence Interval)		P	*Adjusted OR (95% Confidence Interval)		P
	Good Sleep	Excellent sleep		Good sleep	Excellent sleep	
Age (in years)						
≤20	Reference	Reference		Reference	Reference	
21–30	1.4 (0.8–2.6)	1.7 (0.8–3.6)	0.81	1.3 (0.7–2.4)	1.6 (0.8–3.4)	0.64
31–40	1.3 (0.7–2.6)	1.7 (0.8–3.8)		1.2 (0.6–2.4)	1.5 (0.7–3.5)	
41–50	1.3 (0.4–4.0)	1.3 (0.4–4.0)		1.2 (0.4–3.8)	1.2 (0.3–5.0)	
51–60	0.9 (0.1–10.6)	--		0.9 (0.1–10.3)	--	
Sex						
Male	Reference	Reference	0.48	Reference	Reference	0.68
Female	0.8 (0.5–1.2)	0.8 (1.1–1.8)		0.8 (0.5–1.2)	0.9 (0.5–1.4)	
Perceived health state during Ramadan						
Poor	Reference	Reference	0.03	Reference	Reference	0.04
Good	1.6 (0.6–4.2)	9.3 (1.1–76.5)		1.6 (0.6–4.0)	8.8 (1.1–72.4)	
Energy Level						
Neutral	Reference		<0.001	Reference	Reference	0.01
Lazy	1.3 (0.7–3.1)	1.3 (0.6–2.5)		1.5 (0.6–3.3)	1.3 (0.6–2.5)	
Energized	2.7 (1.4–5.4)	4.2 (2.0–9.1)		2.9 (1.4–5.5)	5.0 (2.6–11.1)	
Sleep hours per night						
<7 h	Reference	Reference	<0.001	Reference	Reference	0.01
7–9 h	2.5 (1.3–4.7)	5.2 (2.6–10.1)		2.6 (1.2–4.7)	5.5 (2.6–10.3)	
>9 h	1.3 (0.2–3.3)	4.5 (1.5–13.9)		1.1 (0.5–3.6)	4.6 (2.1–14.1)	
Experienced any of the following sleep disturbances						
No sleep disturbance	Reference	Reference	<0.001	Reference	Reference	0.02
Hard to go to sleep	0.2 (0.1–0.4)	0.2 (0.1–0.3)		0.2 (0.1–0.5)	0.2 (0.1–0.3)	
Slept badly and restlessly	0.3 (0.2–0.5)	0.2 (0.1–0.5)		0.4 (0.2–0.6)	0.2 (0.1–0.6)	
Woken up several times and found it difficult to get back to sleep	0.3 (0.2–0.6)	0.3 (0.2–0.6)		0.3 (0.2–0.8)	0.3 (0.2–0.8)	
Woken up too early and have not been able to get back to sleep	0.2 (0.1–0.4)	0.2 (0.1–0.4)		0.2 (0.1–0.5)	0.2 (0.1–0.4)	

*Adjusted for age, sex, perceived health state, sleep hours, energy level, and sleep disturbance during Ramadan

with 33.7% of the sample engaging in less physical activity during Ramadan.^[54]

The proportion of respondents who lost weight in this study is comparable to findings from fasting adolescents in neighboring Ghana,^[55] and among Muslims in the United Kingdom, where 46% of participants lost >1 kg at the end of Ramadan compared to their pre-Ramadan weight.^[56] Multiple studies have shown the impact of Ramadan fasting on weight and other metabolic markers.^[8,57,58] Weight loss during Ramadan may not be unrelated to the reduction in feeding frequency and dietary diversity during the period. A change toward the consumption of a healthier diet consisting mainly of fruits and vegetables may explain this change. Across different cultures, fasting adults have been seen to deviate from consuming cereal and cereal-based products, classical confectioneries, and fats and oils.^[55,59] Intermittent fasting has also been linked to an increase in the oxidation of fat with improvements in insulin sensitivity and effective obesity management.^[60]

The role of sleep in health cannot be overemphasized. More than half of the respondents in this study attested to having a good sleep during Ramadan compared to a much lower value from the pre-Ramadan period. Initially, this appears as though respondents' sleep quality improved during Ramadan; however, on a closer look, the proportion of respondents with better sleep quality was increased because a significant portion of those who had excellent sleep quality before Ramadan later stepped down to a have a lower category of "good quality" of sleep during Ramadan. This finding is unsurprising considering higher frequencies of respondents slept for shorter hours, woke up several times during the night, and more of them woke up too early. Analogous to our findings, sleep duration, and the pattern were altered during Ramadan in different parts of the world.^[27] A comparable study that assessed sleep architecture across different time points before, during, and after Ramadan also demonstrated no significant alterations to sleep, except for a decline in rapid eye movement sleep.^[61] Despite these studies highlighting insufficient evidence to support changes in sleep,

physical activity, or energy expenditure, a recent review suggested that these lifestyle alterations are common during Ramadan intermittent fasting rituals.^[57,62]

Factors reported to contribute to the growing sleep deficiency include longer work hours and commute times, shift work, as well as social and family demands.^[63] Outside of Ramadan, evidence shows that sleep duration and quality are closely connected, as documented in a recent review.^[64] Therefore, it is unsurprising that sleep duration significantly correlated with subjective sleep quality during Ramadan after adjusting for potential confounders in our study. Within the context of Ramadan, challenges to the circadian system are presented in terms of sleep-wake and meal timings.^[23,65] The typical dietary practice during Ramadan involves consuming one large meal after sunset (Iftar) and another meal before dawn (Suhoor). This is likely to have downstream consequences on sleep and physical activity levels, given the extensive evidence pertaining to sleep and feeding behavior.^[66-68] Some Muslims take an additional meal just before sleeping, which modifies circadian rhythms and affects sleep onset latency and quality.^[69] Typically, the core body temperature peaks in the late afternoon or evening hours and reaches its nadir in the latter part of the night.^[70] This decline in temperature before and during sleep promotes sleep onset and duration, respectively.^[45] Frequent nocturnal meals during Ramadan increase core body temperature at night, promoting wakefulness.^[65,71]

The circadian timing system is also responsible for daily variations in many physiologic mechanisms.^[69,71] Melatonin, a hormone produced by the pineal gland, which is mainly secreted at night, further consolidates circadian rhythms with specific direct effects on sleep.^[72,73] The alteration in circadian rhythms results in wakefulness, delayed sleep-wake cycle, decreased deep sleep, and poorer alertness during the day.^[5] Other lifestyle changes like delays to starting times for schools and work, increased activity until late at night, broadcasting popular programs on TV channels until dawn, observing night prayers, and social gatherings until late at night have also been proposed as potential causes of altered circadian rhythms during Ramadan.^[59,74] However, our study showed that a much lower proportion of respondents spent long hours on the television and computer.

Sleep deprivation and an altered sleep-wake cycle during the previous Ramadan (which overlapped with the COVID-19 pandemic period) may have been further worsened by the consequent lifestyle changes of the ongoing pandemic. Since its emergence, the pandemic has, in many ways, affected sleep and mental health.^[33,75,76] Several studies have shown that infectious

disease outbreaks like SARS-CoV-2 are associated with disturbed sleep and psychological distress, mainly due to fear and anxiety of potentially contracting the infection, physical illness, mental health history, environmental stressors, social isolation, and other measures put in place to control such outbreaks.^[77-79]

Smoking cigarettes and shisha was also practiced by fewer respondents. In addition to the restriction on smoking during the Ramadan period, the month is considered a holy one, where unnecessary habits are deviated from, a reason why individuals who are fasting may desist from unhealthy exposures like smoking.^[31] As a result, a reduction in cigarette consumption during Ramadan was reported by 285 (80.5%).

Our study is among the earliest to assess the contributing factors to alterations in physical activity, sleep, and other health behaviors among fasting adult Nigerians during the holy month of Ramadan, concurrent with the COVID-19 pandemic. The study benefited from a relatively large sample size and accrued data during and after Ramadan, and the COVID-19 pandemic for comparison purposes. However, we also acknowledge several study limitations. First, associations between the exposures of interest and the primary outcomes (changes in physical activity and sleep, respectively) do not denote causality and, therefore, should be interpreted accordingly. Second, as with any survey-based design, biases may be present, including social desirability and recall, thus affecting the overall findings; however, being limited to a specific study time (Ramadan month) and the need for a large sample hindered the use of objective assessment. Third, the use of self-reported assessment of sleep quality is another limitation of the current work. Therefore, future studies should consider utilizing objective measures whenever feasible for the outcomes of interest. Finally, although reliable instruments were administered, these were adapted for our study. The medium through which the study was conducted (online) and the sampling technique (snowball) make it subject to selection bias. For example, only participants with access to the internet could participate.

Conclusion

In conclusion, alterations to physical activity level and sleep quality were evident in our large sample of Nigerian fasting adults during Ramadan. We identified several significant associations for these lifestyle behavior changes, including being female, self-rated health status, multiple sleep quality features, BMI status, and energy level. Additional studies need to be conducted among other fasting Muslims across different geographical regions and cultures to confirm or refute these findings.

These findings can then be later utilized in formulating health policy guiding campaigns to raise awareness at a population level to promote better health practices during the holy month of Ramadan, which could further enhance the well-documented health benefits of intermittent fasting.

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Conflicts of interest

There are no conflicts of interest.

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Appendix 1: Sociodemographic characteristics of the respondents

Variable <i>n</i> =770	Frequency (%)
Age (Years)	
≤20	76 (9.9)
21–30	476 (61.8)
31–40	191 (24.8)
41–50	24 (3.1)
51–60	3 (0.4)
Marital status	
Single	510 (66.2)
Married	249 (32.3)
Divorced	8 (1.0)
Widowed	3 (0.4)
Place of permanent domicile	
Urban	562 (73.0)
Rural	208 (27.0)
Sex	
Male	286 (37.1)
Female	484 (62.9)
Highest Educational status	
Tertiary or higher	164 (21.3)
Undergraduate	508 (66.0)
Secondary	95 (12.3)
Primary	3 (0.4)
Occupation	
Employed	371 (48.2)
Unemployed	399 (51.8)
Father's highest education	
None/Nonformal	64 (8.3)
Primary	84 (10.9)
Secondary	164 (21.3)
Tertiary	458 (59.5)
Mother's highest education	
None/Nonformal	115 (14.9)
Primary	131 (17.0)
Secondary	203 (26.4)
Tertiary	321 (41.7)
Household income relative to the national average	
Lowest	73 (9.5)
Lower 20%	121 (15.7)
Middle 20%	435 (56.5)
Upper 20%	123 (16.0)
Top 20%	18 (2.3)

Appendix 2: Medical history of the respondents

Variable <i>N</i> =770	Frequency (%)
BMI (kg/m ²)	
Underweight (<18)	271 (35.2)
Normal (18.0–24.9)	78 (10.1)
Overweight (25–29.9)	113 (14.77)
Obese (>30)	186 (24.2)
Do not know	122 (15.8)
History of diabetes	45 (5.8)
History of hypertension	67 (8.7)
History of heart disease	24 (3.1)
Family history of overweight or obesity	117 (15.2)
Family history of hypertension	385 (50.0)
Family history of diabetes	261 (33.9)
Family history of heart disease	82 (10.7)