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Wearable AI Reveals the Impact of Intermittent Fasting on Stress Levels in School Children During Ramadan

Arfan AHMED[a,1], Sarah AZIZ[a], Alaa Abd-Alrazaq[a], Uvais QIDWAI[b], Faisal FAROOQ[c] and Javaid SHEIKH[a]

[a] *AI Center for Precision Health, Weill Cornell Medicine-Qatar, Doha, Qatar*
[b] *Department of Computer Science and Engineering, Qatar University, Qatar*
[c] *Center for Digital Health and Precision Medicine, Qatar Computing Research Institute, Doha, QA*

Abstract. Intermittent fasting has been practiced for centuries across many cultures globally. Recently many studies have reported intermittent fasting for its lifestyle benefits, the major shift in eating habits and patterns is associated with several changes in hormones and circadian rhythms. Whether there are accompanying changes in stress levels is not widely reported especially in school children. The objective of this study is to examine the impact of intermittent fasting during Ramadan on stress levels in school children as measured using wearable artificial intelligence (AI). Twenty-nine school children (aged 13-17 years and 12M / 17F ratio) were given Fitbit devices and their stress, activity and sleep patterns analyzed 2 weeks before, 4 weeks during Ramadan fasting and 2 weeks after. This study revealed no statistically significant difference on stress scores during fasting, despite changes in stress levels being observed for 12 of the participants. Our study may imply intermittent fasting during Ramadan poses no direct risks in terms of stress, suggesting rather it may be linked to dietary habits, furthermore as stress score calculations are based on heart rate variability, this study implies fasting does not interfere the cardiac autonomic nervous system.

Keywords. Intermittent fasting, Ramadan, circadian, stress, wearable devices, artificial intelligence, fitbit, School children

1. Introduction

Over the past decade, there has been an increased focus on the benefits of intermittent fasting. Both Intermittent and regular fasting lead to advantages that span from disease prevention to improved disease management [1]. Intermittent fasting has been a common practice across various cultures for centuries, from the ancient Greeks to the Chinese. However, one of the most well-known examples of intermittent fasting is observed by over 1.6 billion Muslims worldwide during the Islamic month of Ramadan each year, where Muslims fast from dawn to sunset for the entire month, and it has unchanged for over 1400 years [2]. During Ramadan, intermittent fasting involves abstaining from eating and drinking between dawn and sunset for a lunar month (29-30 days), which

[1] Corresponding Author: Arfan AHMED. AI Center for Precision Health, Weill Cornell Medicine-Qatar, Doha, Qatar. Email: ara4013@qatar-med.cornell.edu.

disrupts established routines and eating patterns [3]. Meals are timed differently, with an early breakfast before dawn and the omission of lunch, and the fast is broken at sunset with the main meal. Changes in sleeping patterns are also necessary to accommodate the morning meal before dawn [4]. Skipping lunch and the long intervals between meals can affect appetite [5], hormonal responses to food, and energy and glucose metabolism. The longer gaps between meals during Ramadan can have significant physiological effects. Brief fasting in children revealed it negatively impacted problem-solving accuracy but had a positive impact on immediate retrieval in short-term memory [6]. A meta-analysis of 11 studies (1436 participants) examining the effectiveness of intermittent fasting reported a positive effect of Ramadan on stress, anxiety and depression, with post-Ramadan scores for all three lower compared to those before Ramadan [7].

Wearable devices such as smart watches and smart bands with sensors like photoplethysmography and accelerometers can monitor vital health stats like heart rate, activity, and sleep. These devices rely on AI to analyze the collected data and provide personalized insights. Stress monitoring can also be done using these devices. Investigating changes in stress levels, which devices are normally calculating based on heart rate variability in the context of Ramadan could provide better evidence for managing patient stress levels. Whilst many previous studies have investigated the association between intermittent fasting and dietary changes in various populations, there has been little attempt to quantify different aspects of stress during Ramadan[8][9]. Furthermore, previous studies on this topic assessed stress using subjective measures (e.g., questionnaires or interviews) rather than objective measures such as wearable AI. Thus, this study aims to examine the impact of intermittent fasting on stress levels in school children as measured using wearable AI.

2. Materials and Methods

Data were collected from 12 healthy adolescents (mean age 15.7, SD 1.31) aged 13 to 17 at one time point, covering 2 weeks before and after Ramadan, and 4 weeks during Ramadan. Whilst we initially recruited 29 participants, only data from 12 students from two private high schools in Doha were appropriate for analysis due to synchronization and device usage issues. The sample included 3 boys and 9 girls. Inclusion criteria required good general health, high school age (11-17 years), no known skin allergies, and possession of a smart mobile phone with internet access. The study followed the Declaration of Helsinki and was approved by the Institutional Review Board (IRB), Weill Cornell Medicine-Qatar (WCM-Q, Study No.: 21-00025). Written assent and informed consent were obtained from all participants and their parents.

The schools enlisted participants who showed a willingness to volunteer for the study. The participants were provided with a Fitbit Charge 5 wristband [10] and were instructed to wear it on either wrist for the entire study period, including during sleep, but they could remove it briefly for charging or other necessary reasons. The wristbands were worn continuously throughout the study (8 weeks). The study was conducted in March 2022, daily stress score and heart rate variability was collected along with other digital data such as sleep patterns and activity levels.

One-way ANOVA (Analysis of Variance) test a statistical analysis technique used to compare means of a dependent variable measured across the different time points or conditions for a single group of participants, is the type of analysis that was carried out. The ANOVA test calculates an F-statistic and p-value. F-statistic is the ratio of the variance between the groups to the variance within the groups. The F-value represents the significance of the differences between the means of the group at different points of time. The p-value in the ANOVA test represents the probability of obtaining the observed F-value or a more extreme F-value if the null hypothesis (i.e., the means of the groups are equal) is true. A p-value of less than α =0.05 was deemed statistically significant. We determine that at least one group mean is significantly different from the mean if the F-value is high and the corresponding p-value is low (i.e., less than the significance threshold). The analysis was performed using Python programming language, version 3.8.10 with packages including NumPy, pandas, skLearn (Scikit-learn), seaborn, and Matplotlib. The tests were executed on a computer running the Windows 11 Pro operating system with Intel(R) processor 11th generation i9 with 8 cores @ 2.60GHz and 64 GB RAM.

3. Results

The on-route Anova results for the corresponding several weeks of observation are presented in Table 1. In and Out Ramadan denotes the whole four weeks of Ramadan and the four weeks out of it (which are two weeks before and two weeks after). The differences between In and Out of Ramadan were not statistically significant, indicating that both groups were same regardless of how they were classified (p-value >0.05). Also, individual scores of matching individuals In and Out of Ramadan is shown visually in Appendix A. These results demonstrate a modest difference in each participant's score regardless of the time zone, but no such pattern was seen in the students' stress scores. Appendix B further illustrates the participant split by weeks and the scores.
Appendix Files are available on GitHub[2].

Table 1. Participants Stress score corresponding to different Points of time

Category	F-value	P-value
In and Out Ramadan	3.14	0.09
Ramadan WK1 vs Ramadan WK2	2.40	0.14
Ramadan WK2 vs Ramadan WK3	0.23	0.63
Ramadan WK3 vs Ramadan WK4	0.02	0.89
Ramadan WK1 vs Ramadan WK4	1.94	0.18

4. Discussion

We observed changes in stress levels for 12 of the participants, initially a common trend was noted highlighting stress levels were changing during fasting in Ramadan. Upon analyzing the p-values none of the values were reported <0.05 suggesting no statistically significant differences in the stress level changes were observed. Appendix A highlights that these changes were in fact stress levels “switching” i.e., sometimes high sometimes low for a given participant. One reason could be that the changes observed in the stress levels are not linked directly to fasting in Ramadan, there are also other factors to consider such as our sample size, which was very small. Future work would involve analyzing the stress and heart rate variability values against sleep as we know during

[2] https://github.com/SarahAzizAhmed/Wearable-AI-impact-on-Intermittent-Fasting-

Ramadan sleep patterns are disrupted, this could be compared with data from outside Ramadan for correlation between different sleep habits and effect on stress and/or HRV. We did some preliminary analysis not reported in this paper on activity levels during Ramadan and outside of Ramadan but again found no significantly different changes, this could be due to activity levels in this population were deemed low for this age group as reported in our previous study within the same cohort [11], therefore remained just as low during Ramadan, which goes against previous studies concluding Ramadan is associated with reduced physical activity [12].

5. Conclusions

In conclusion, our study implies for school children in the 2 Qatari schools during intermittent fasting in Ramadan pose no direct risks in terms of stress, in line with previous studies [13], suggesting rather it may be linked to dietary habits. Furthermore, as stress score calculations are based on heart rate variability, this study implies fasting during Ramadan does not interfere with the cardiac autonomic nervous system. Finally, larger studies involving more schools are needed in order to establish if this is a trend across school aged population in this region.

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