Ann Ig. 2023 Nov-Dec; 35(6): 683-694 doi: 10.7416/ai.2023.2574

How do chronotype and sleep patterns impact young athletes' aerobic performance during Ramadan intermittent fasting?

A. El-Jaziz[1], S. Lotfi[1]

Key words: Chronotype, sleep, VO_{2peak}, Ramadan, intermittent fasting, public health
Parole chiave: Cronotipo, sonno, VO_{2peak}, Ramadan, digiuno intermittente, sanità pubblica

Abstract

Background. *Ramadan observance has been practiced by many faith groups and cultures worldwide. Moreover, recently, it has been adopted as a natural alternative to promote public health. During Ramadan, our circadian rhythm can be altered. This study investigates how athletes' chronotype and sleep patterns impact aerobic fitness during Ramadan intermittent fasting.*
Study design. *A prospective cohort design with repeated measurements was adopted. We measured the chronotype, maximal Oxygen Uptake as a measure of aerobic performance, and sleep patterns before and during Ramadan intermittent fasting. Then we explored the correlation among these variables.*
Methods. *50 amateur athletes (Mean age = 17.22 years SD = 1.15) from Morocco participated in this study.*
The maximal Oxygen Uptake was measured with the 20-m shuttle-run test. The chronotype was assessed by the Morningness-Eveningness Questionnaire. The sleep timing was assessed by Sleep Timing Questionnaire. We also assessed sleep quality with the Pittsburgh Sleep Quality Index. We examined the difference between variable means before and during Ramadan, also considering chronotype and sleep patterns of participants.
Results. *The results showed a significant decrease in sleep quality and maximal Oxygen Uptake during the Ramadan Intermittent Fasting. Also, we found a significant correlation between the chronotype, time in bed and time spent asleep. However, chronotype and sleep quality did not affect maximal Oxygen Uptake during the Ramadan intermittent fasting.*
Conclusions. *Sleep and chronotype do not influence physical performance during Ramadan Intermittent Fasting. More research is needed to identify the leading cause of the drop in aerobic performance.*

[1] *Multidisciplinary Laboratory in Education Sciences and Training Engineering (LMSEIF), Sport Science Assessment and Physical Activity Didactic, Normal Higher School (ENS-C), Hassan II University of Casablanca, BP 50069, Morocco*

Annali di Igiene : Medicina Preventiva e di Comunità (Ann Ig)
ISSN 1120-9135 https://www.annali-igiene.it

Introduction

The observance of Ramadan has been a ritual practiced by many faith groups and cultures worldwide for several centuries (1). Moreover, recently, it has been adopted as a health and fitness trend. In Islam, fasting during Ramadan is an indispensable activity for people. Ramadan takes 29 or 30 days in duration. During this month, Muslim athletes stop eating, drinking, smoking and sexual activity from sunrise to sunset (2). The average fasting time varies according to the season and the geographical location (3).

Nevertheless, the fast length generally changes depending on sunrise and sunset. It is around 12-18 hours. In effect, Ramadan and associated rituals may impact sleep duration, daytime sleepiness and physical performance in ordinary healthy people (including athletes).

Also, troubled feeding times and delay of social activities until night impact the normal circadian rhythms of individuals (4, 5). Indeed, previous studies confirmed that the quality of sleep during Ramadan is impaired when athletes wake up early for the pre-dawn meal (Sohour), take a late evening dinner, and sleep on a full stomach (6, 7) and not waiting enough time to digest (3-3.5 hours) (8-10).

Therefore, during these four weeks of fasting, athletes face acute shortages of food and fluids, sleep deprivation (11-13) and more changes in psychological and social behaviours that alter the rhythmic pattern of many biological variables (14-16). Thus, it can negatively affect physical performance (17-19).

Earlier research has indicated that a shortage of liquids in the human body during Ramadan intermittent fasting (RIF) has a negative impact on aerobic exercise (20-22) but not on anaerobic activity (23, 24). In addition, the sleep restriction during Ramadan did not impact the anaerobic performance, whereas it affected the endurance performance. But other recent reviews have concluded that sleep does not influence physical exercise (25, 26).

In front of inconsistent results and non-coherent, Muslim athletes who train and participate in competitions, use multiple coping strategies (27). Sometimes they choose not to fast and play during athletic competition just based on their self-convictions and not based on a scientific approach. Therefore, this study aimed to investigate how athletes' chronotype and sleep quality impact aerobic fitness during RIF. There has been much concern about the possible effects of circadian preferences on athletic performance during Ramadan. However, the results still need to be debated, and no model was developed to predict these effects. The hypothesis was that chronotype and sleep patterns affect aerobic performance during RIF.

Materials and methods

Participants

Fifty amateur athletes (age: 17.22 ± 1.15 years; weight: 60.4 ± 12.7 kg; height: 168.3 ± 9.1 cm) from Moroccan scholars' teams volunteered to participate in this study. They practiced physical activity consistently for at least 5 hours per week, in addition to the training hours with their sporting clubs.

This engagement time was not altered in volume or timing during Ramadan. All subjects were practicing Muslims and therefore were fasting during Ramadan. In 2022, Ramadan started on the 3rd of April and finished on the 2nd of May. The temperature reached up to 21°. The minimum seasonal temperature is 14°. The average fasting duration was 15h30mn.

All participants were nonsmokers, did not consume alcohol, and did not report diseases. Subjects were unaware that the influence of Ramadan was being examined. The study was conducted following the Declaration of Helsinki and IJSM ethical standards. The experimental protocol was approved by the Clinical Research Ethics Committee of the Higher Normal School, Hassan II University of Casablanca.

Experimental design

A prospective cohort design with repeated measurements was adopted. Players performed a 20-m shuttle run test (SRT) at three separate times: the first before one week of Ramadan month (BR), the second during the 1st week of Ramadan (DR1), and the third occasion during the 3rd week of Ramadan (DR2). All sessions were completed in the morning. The researchers used the Morningness-Eveningness Questionnaire (MEQ) before the completion of the experiment to prevent any possible impact of diurnal RIF on circadian typology. Then the participants completed the Sleep Timing Questionnaire (STQ) and the Pittsburgh Sleep Quality Index (PSQI) at two moments; one-week before Ramadan (baseline) and during 3rd week of Ramadan (Figure 1).

20-m shuttle run test (SRT)

It is an endurance test that determines aerobic capacity and estimates VO_{2peak}. The protocol consisted of running progressively between 2 lines of 20m and following the recorded beeps, which increased progressively as the participant changed direction each time a beep was made. The participant's score indicated the level and number of shuttles (20m) reached before he/she could no longer follow the recording. The calculation of VO_{2peak} (in ml/kg/min) was performed according to the standard table or by using this formula $Y = 14.49 - 2.143\,x + 0.00324\,x^2$.

Morningness-Eveningness Questionnaire (MEQ)

It is a tool frequently used for approximating circadian typology. It is a questionnaire with 19 items that assess diurnal preferences by asking participants about several activities. Each item has a series of closed alternative responses that calculate a total score ranging from 16 to 86. The research team divided participants

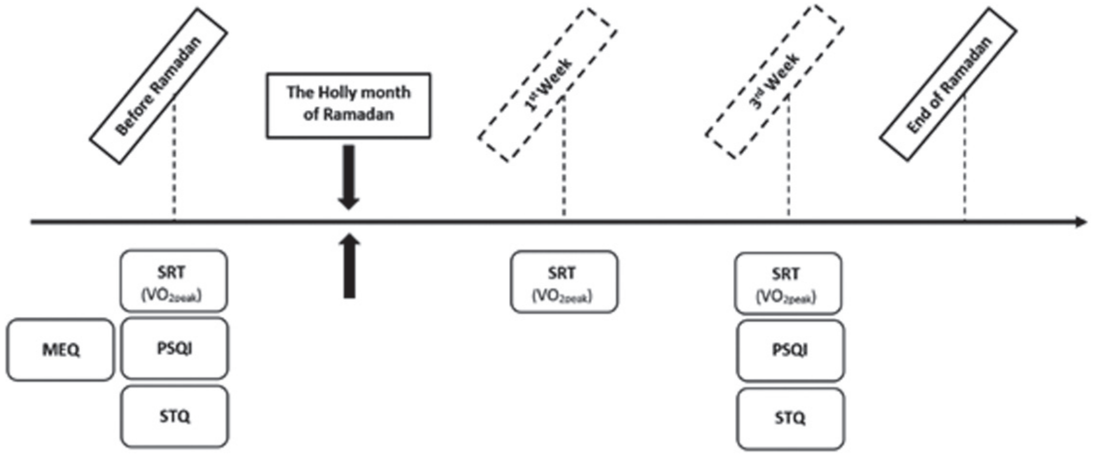

Figure 1 - Schematic explanation of the experimental protocol. MEQ: Morningness-Eveningness Questionnaire, SRT: 20-m shuttle run test, VO2peak: Maximal oxygen uptake, PSQI: Pittsburgh Sleep Quality Index, STQ: Sleep Timing Questionnaire.

into three types based on the MEQ score. Thus, athletes with a score of more than 59 represent a morning lark chronotype (M-type). Athletes with scores under 41 represent an evening owl chronotype (E-type). Then athletes with scores between 41 and 59 represent neither type (N-type).

Sleep Timing Questionnaire (STQ)

The questionnaire is composed of 18 items. The questions include bedtime and wake-up time, number and duration of awakenings during the night, and sleep schedule stability. These were recorded for weekdays, off days, mornings, and evenings. By using the STQ we derived five variables. The overall time spent in bed (TIB) was computed as ([5 × weekday TIB + 2 × weekend TIB]/7). The sleep latency (SL) was calculated as the average time to fall asleep. The time awake after falling asleep (WASO) was calculated as the average number of minutes awake after falling asleep. The time spent asleep (TSA) was estimated as TIB - SL - WASO. The overall sleep efficiency (SE) was calculated as 100 × TSA/TIB. Generally, the STQ was developed to get an accurate sleep schedule and to be aware of the individual's sleep patterns and habits.

The Pittsburgh Sleep Quality Index (PSQI)

It is a pertinent instrument for assessing youth and adult sleep patterns. By examining seven factors - subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disruption, use of sleeping medicines, and daytime dysfunction over the previous month - it provides two classifications of sleep quality (Poor or good). A scale from 0 to 3, where 3 represents the extreme negative on the Likert scale, has been employed to rate the responses. A "Poor" sleeper gets a "5" or above.

Statistical analyses

Statistical analyses were performed using SPSS software (IBM, version 25) for all statistical analyses. The descriptive statistics were presented as mean ± SD for key variables. The normality of data distribution was first verified by the Shapiro–Wilk test and the level of statistical significance was set at $p < 0.05$. Most data were not normally distributed, so we used nonparametric tests, including Friedman, Kruskal-Wallis, Mann-Whitney U and Wilcoxon Signed Ranks, with post hoc comparisons using the Bonferroni test. When the data were normally distributed, we used parametric tests. Finally, we used Pearson's or Spearman's correlation index to check the correlation between parameters. Furthermore, we judged significance when $p < 0.05$.

Results

The main characteristics of the sample are shown in Table 1. Nearly 66 percent of participants in this study were female athletes, and 34 percent were male. Also, 54 percent of the participants were "N-type", 40 percent were "M-type", and the rest of the sample was E-type. Finally, examining sleep quality, 58 percent of respondents indicated they were "poor sleepers" before Ramadan, and this percent increased to 88 during Ramadan.

Friedman Test showed that VO_{2peak} differed significantly across three-times $\chi^2(2) = 45.860$, $p = 0.001$. A post hoc pairwise comparison showed a decreased VO_{2peak} between the initial assessment and follow-up assessment on the 1st week of Ramadan (46.82 vs 41.86, respectively), which was statistically significant ($p = 0.008$). In addition, the increase in VO_{2peak} score did reach significance when comparing the initial assessment to a second follow-up assessment taken the third measure in Ramadan (46.82 vs 39.15; $p < 0.001$). Therefore, we can conclude that the results of the Friedman test indicate a negative effect of RIF on

Table 1- Descriptive statistics for variables

Participant characteristics	Categories (%)
Age $_{(year)}$, mean ±SD	17.22 ± 1.148
Gender, n (%)	
Female	33 (66)
Male	17 (34)
Chronotype n (%)	
M-type	20 (40)
N-type	27 (54)
E-type	3 (6)
PSQI	
Before Ramadan	
Poor Sleep Quality	29 (58)
Good Sleep Quality	21 (42)
During Ramadan	
Poor Sleep Quality	44 (88)
Good Sleep Quality	6 (12)
STQ	
Before Ramadan	
$TIB_{(h)}$, mean ±SD	8.65 ± 1.20
$SL_{(min)}$, mean ±SD	25.56 ± 22.58
$WASO_{(min)}$, mean ±SD	16.66 ± 21.19
$TSA_{(h)}$, mean ±SD	7.95 ± 1.30
$SE_{(\%)}$, mean ±SD	91.81 ± 6.64
During Ramadan	
$TIB_{(h)}$, mean ±SD	7.92 ± 1.57
$SL_{(min)}$, mean ±SD	25.30 ± 21.62
$WASO_{(min)}$, mean ±SD	19.87 ± 24.53
$TSA_{(h)}$, mean ±SD	7.17 ± 1.68
$SE_{(\%)}$, mean ±SD	90.11 ± 9.32
$VO_{2peak(ml/kg/min)}$ mean ±SD	
1week before Ramadan	46.82 ± 9.810
1st week of Ramadan	41.86 ± 9.670
3rd week of Ramadan	39.15 ± 7.918

LEGENDA: n: Frequency; SD: Standard deviation, PSQI = Pittsburgh Sleep Quality Index; STQ = Sleep Timing Questionnaire; TIB = time in bed; SL = sleep latency; WASO = Wake after sleep onset; TSA = Time spent asleep.; SE = Sleep efficiency; VO2peak: Maximal oxygen uptake; (h): Hour; (min): Minute

aerobic performance. The Kruskal-Wallis test was conducted to determine the effect of the chronotype (E-type, M-type, N-types) on VO_{2peak} in the three-time points. The results confirmed no difference in VO_{2peak} (BR, DR1& DR2 respectively) between the different circadian preferences, $\chi^2(2)_{BR} = 4.884$, $p = 0.089$, $\chi^2(2)_{DR1} = 0.596$, $p = 0.742$, $\chi^2(2)_{DR2} = 1.720$, $p = 0.423$. As evident in Table 2 that illustrates correlations between variables, a strong positive correlation was found between $VO_{2peak\ BR}$ and $VO_{2peak\ DR1}$ or $VO_{2peak\ DR2}$ ($r = 0.601$, $r = 0.648$, $p < 0.001$), indicating that participants with higher $VO_{2peakBR}$ tended to have higher VO_{2peak} during Ramadan. Nevertheless, there was no significant correlation between MEQ score and the three measures of VO2peak (BR: $r = 0.215$, $p = 0.225$; DR1: $r = 0.014$, $p = 0.306$; DR2: $r = 0.050$, $p = 0.868$).

Table 3 illustrated the sleep patterns differences before and during Ramadan. Wilcoxon Signed Ranks Test was performed and showed a significant difference between $PSQI_{BR}/PSQI_{DR2}$, TIB_{BR}/TIB_{DR2} and TSA_{BR}/TSA_{DR2}. However, there was no significant difference between SE, SL and WASO before and during Ramadan. We, therefore, conclude that there is a negative effect of RIF on PSQI, TIB, and TSA and no effect on SE, SL, and WASO scores. The Kruskal-Wallis test was performed to investigate the effect of chronotype on sleep patterns during Ramadan. The findings reveal a substantial difference between TSA and TIB [$F(2.47) = 10.125$, $p = 0.006$; $F(2.47) = 9.703$, $p = 0.008$]. Mann-Whitney U Test found that the mean value of TSA and SE was significantly different between M-type and N-type ($Z = -2.270$, $p = 0.023$; $Z = -2.077$, $p = 0.038$), between M-type and E-type ($Z = -2.282$, $p = 0.022$; $Z = -2.191$, $p = 0.028$) and between E-type and N-type ($Z = -2.248$, $p = 0.025$; $Z = -2.249$, $p = 0.013$). Again, Mann-Whitney U Test was conducted to determine whether there is a difference in VO_{2peak} (in three-point time) between sleep quality levels (poor, good). The results indicate no significant difference between groups $Z_{BR} = -0.030$, $p = 0.976$, $Z_{DR1} = -0.531$, $p = 0.596$, and $Z_{DR2} = -0.333$, $p = 0.739$. The correlation between variables showed a significant positive correlation between sleep quality before Ramadan and during Ramadan ($r = 0.507$, $p < 0.005$), indicating that athletes with

Table 2- Correlations between chronotype, sleep and aerobic performance variables

	1	2	3	4	5
1- $PSQI_{BR}$	-				
2- $PSQI_{DR}$	0.507**				
3- MEQ	-0.348*	-0.177			
4- VO_{2maxBR}	-0.013	-0.156	0.215		
5- $VO_{2maxDR1}$	-0.062	-0.114	0.014	0.601**	
6- $VO_{2maxDR2}$	-0.033	-0.107	0.050	0.648**	0.941**
7- TIB_{BR}	-0.193	-0.087	0.442**	-0.037	0.054
8- TIB_{DR2}	0.026	-0.192	0.361**	0.064	-0.164
9- TSA_{BR}	-0.370**	-0.159	0.472**	0.079	0.063
10- TSA_{DR}	-0.149	-0.279*	0.479**	0.127	0.026
11- SE_{BR}	-0.291*	-0.230	0.124	0.204	-0.034
12- SE_{DR}	-0.034	-0.159	0.156	0.129	-0.036
13- $WASO_{BR}$	0.101	0.086	0.052	-0.039	0.106
14- $WASO_{DR}$	-0.009	0.017	0.011	0.016	0.091
15- SL_{BR}	0.318*	0.240	-0.216	-0.242	-0.040
16- SL_{DR}	0.082	0.141	-0.193	-0.181	-0.097

LEGENDA: *p < 0.05, **p < 0.01; PSQI = Pittsburgh Sleep Quality Index; MEQ = Morningness-Eveningness Questionnaire; Vo_{2peak}: Maximal Oxygen Uptake; TIB = Time in bed; TSA = Time spent asleep; SE = Sleep efficiency; WASO = Wake after sleep onset; SL = Ramadan; DR1 = During the 1st week of Ramadan; DR2 = During the 2nd week of Ramadan.

poor sleep quality tended to have higher decreases. A bivariate correlation analysis was conducted to examine the relationship between chronotype and TIB before and during Ramadan, revealing a moderate and positive correlation respectively ($r = 0.442$, $p < 0.001$, $r = 0.361$, $p < 0.001$), suggesting that participants who reported a higher score of MEQ (morning lark chronotype) tended to have a better TIB. In addition, to evaluate the relationship between chronotype and TSA, the point-biserial correlation coefficient was calculated, revealing a moderate but statistically significant positive correlation between before and during Ramadan respectively ($r = 0.472$, $p< 0.001$; $r = 0.479$, $p< 0.001$) and suggesting that participants who reported higher levels of MEQ score tended to have higher TSA. Afterward, to explore the relationship between SE, WASO, SL and chronotype before and during Ramadan, a point-biserial correlation coefficient was calculated, and showed no significant correlation respectively (Table 2).

Discussion and conclusions

Our findings indicated that aerobic capacity decreased during RIF. These findings are consistent with those obtained by other researchers. They found that the mean value of VO_{2peak} significantly decreased during RIF, indicating a considerable decline in both aerobic capacity and cardiorespiratory fitness (1, 26, 28, 29).

Also, we noted that more results showed lower DR than BR. However, the differences between the two were not statistically

Table 3 - Sleep patterns differences before and during the intermittent fasting of Ramadan (Wilcoxon Signed Ranks Test)

	BR		DR_3		Z	Sig.
	Mean	SD	Mean	SD		
1-PSQI						
Subjective sleep quality (U)	0.90	0.71	1.80	1.01	-4.49**	0.000
Sleep latency (U)	0.90	0.74	1.02	0.87	-0.94	0.348
Sleep duration (U)	1.02	0.91	1.54	0.77	-2.81*	0.005
Sleep efficiency (U)	0.55	0.96	0.66	0.94	-0.39	0.695
Sleep disturbance (U)	1.16	0.79	1.14	0.78	-0.07	0.941
Use of sleeping medication (U)	0.46	0.99	0.34	0.85	-0.85	0.394
Daytime dysfunction sleep (U)	1.20	0.78	1.88	0.80	-4.19**	0.000
Global score PSQI (U)	5.46	2.94	7.66	3.07	-4.50**	0.000
2-STQ						
Sleep latency (min)	25.56	22.58	25.30	21.62	-0.52	0.602
WASO (min)	16.66	21.19	19.87	24.53	-1.95	0.051
TIB week days (h)	8.69	1.54	7.66	1.84	-3.79**	0.000
TIB weekends (h)	9.55	1.70	9.61	4.05	-1.26	0.210
TIB Overall weekly (h)	8.65	1.20	7.92	1.57	-3.91**	0.000
TSA weekday (h)	7.99	1.62	6.91	2.02	-3.63**	0.000
TSA weekend (h)	8.85	1.78	8.86	4.10	-1.21	0.226
TSA overall (h)	7.95	1.30	7.17	1.68	-3.46*	0.001
SE weekday (%)	91.68	6.91	89.39	10.07	-1.29	0.198
SE weekend (%)	92.48	6.32	91.51	7.60	-0.22	0.828
SE Overall (%)	91.81	6.64	90.11	9.32	-0.54	0.589

LEGENDA: $**p < 0.001$; $*p < 0.05$; PSQI = Pittsburgh Sleep Quality Index; STQ = Sleep Timing Questionnaire; WASO = Wake after sleep onset; TIB = time in bed; TSA = time spent asleep.; SE = Sleep efficiency; BR = before Ramadan; DR_3 = During the 3^{rd} week of Ramadan; (h): hour, (u): unit, (min): minute

significant (30). One potential factor that could have contributed to the results is that dehydration associated with RIF may have decreased blood volume, optimum cardiac output, and muscle glycogen reserves, which may have affected Oxygen uptake (1). Data analysis revealed no significant effect of chronotype on VO_{2peak} during RIF. Our results are consistent with previous studies (31-33) showing that fasting did not affect circadian rhythms, while other research confirms this effect (34). Indeed, many studies reported a significant effect of chronotype on aerobic performance (35-38). Generally, the performance is at its best in the early evening and declines in the late afternoon (39). Moreover, disturbances of the circadian system have a considerable impact on physical performance (40). Then, to preserve circadian rhythms and promote healthy aging, scheduled exercise is a highly effective method (41, 42). Ensuring optimal functioning is crucial, and any circadian disruptions could negatively impact health and physical and mental performance (43, 44). The results support the hypothesis that sleep quality did not affect aerobic performance during RIF. Our results confirm earlier studies that sleep had little to no effect on physical performance metrics during RIF, such as strength, aerobic capacity, jump height, and fatigue. However, it impacts sprint performance (28). These results are not in line with previous research that showed that RIF impacts athletes' physical performance and sleep quality, but those with higher sleep quality had significantly superior performance (45-46). Two possible explanations for these findings are the accommodation of late-evening food intake and the lifestyle of Ramadan. As practical applications, athletic trainers, educators, and competitors must develop training, dieting, and competition schedules that deal with those challenges during RIF. We recommend that professionals consider sleep patterns when organizing training sessions during Ramadan, such as avoiding the evening meal, taking a nap, and going to bed as early as possible.

The study's outcome confirmed no significant effect of RIF on the PSQI score. Our findings replicate the results of previous research indicating that sleep duration was adequately maintained during RIF, which could explain the absence of significant changes in brain functioning (32, 47). Our findings, however, do not contradict past studies that claimed a significant increase in perceived sleep quality during Ramadan compared with before (48). In addition, other research showed that the sleep quality score was higher during Ramadan than before (4). Indeed, Ramadan's effect on sleep patterns varies significantly between scientific papers. Generally, athletes presented worse physical performance during rather than before Ramadan. Bogdan and his team explained the findings, noting that the amounts of food ingested late at night during Ramadan frequently cause disturbing bedtime sleep and also make sleep duration shorter (49). Our research indicates no effect of RIF on SE, SL, and WASO scores. These findings are consistent with previous research that has suggested no changes in sleep metrics (50-52). In this context, interesting research (53) explained the result, stating that maybe the population was already getting sufficient sleep (> seven hours per night). Thus, this lack of effect is not surprising. Future research should prioritize using more sophistical devices for a more robust sleep assessment. Also, it is crucial to consider daytime naps when assessing sleep duration during RIF (10).

In conclusion, it has been hypothesized that circadian preferences and sleep patterns influence aerobic performance during RIF. This research has demonstrated that fasting during Ramadan has a negative effect on aerobic capacity and sleep quality. However, the chronotype did not affect these two variables. Finally, no significant effect of RIF on SE, SL, and WASO scores was observed. Overall, further research is needed to fully understand the complexities of circadian preferences and their implications for improving our physical performance during Ramadan.

Limitations

By using the RIF, we did not just intend to research the effect of avoiding food in general but also the effect of all the changes that fasting brings to daily routines, physical activity, and eating habits. However, we recognize that there was no control group in this study because it was conducted among athletes who were religious practitioners. It was not possible to ask athletes not to observe Ramadan. Also, we did not control variables such as normal lifestyle, training program, and daily intake. Future studies are welcome to focus primarily on standardizing the conditions of the circadian study. The small sample size of the evening type is one significant threat to our study. Despite our efforts to select a wide range of volunteers, our final sample only contained three participants with E-type. So, our results might only apply to some populations. While our study offers insightful information about how chronotype and sleep patterns affect physical performance during Ramadan, we neglected that menstruating Muslim women are excused from the Ramadan fast. So, the effects of RIF may vary. Another area for improvement is that we used self-reported data, which may be biased or inaccurate, to measure the quantity and quality of sleep. Our study only examined circadian rhythm over one week, which might have yet to capture this biological process's intricacy adequately.

Declaration of interest
The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

Acknowledgments
The authors would like to thank participant and the Educational Staff who enthusiastically supported the study by allowing access to participants for the intervention.

Riassunto

In che modo il cronotipo e i modelli di sonno influiscono sulle prestazioni aerobiche dei giovani atleti durante il digiuno intermittente del Ramadan?

Premessa. L'osservanza del Ramadan è stata praticata da molti gruppi religiosi e culture in tutto il mondo. Inoltre, recentemente, è stato adottato come alternativa naturale per promuovere la salute pubblica. Durante il Ramadan, il nostro ritmo circadiano può essere alterato. Questo studio indaga su come il cronotipo e i modelli di sonno degli atleti influiscono sulla forma fisica aerobica durante il digiuno intermittente.

Progettazione dello studio. È stato adottato un disegno di coorte prospettico con misurazioni ripetute. Abbiamo misurato il cronotipo, il massimo consumo di ossigeno come misura delle prestazioni aerobiche e i modelli di sonno prima e durante il digiuno intermittente del Ramadan. Quindi abbiamo esplorato la correlazione tra queste variabili.

Metodi. Hanno partecipato a questo studio 50 atleti dilettanti (età media = 17,22 anni DS = 1,15) provenienti dal Marocco. Il massimo consumo di ossigeno è stato misurato con il test della corsa dello shuttle di 20 m. Il cronotipo è stato valutato dal Morningness-Eveningness Questionnaire. La tempistica del sonno è stata valutata mediante il Sleep Timing Questionnaire. Abbiamo anche valutato la qualità del sonno con il Pittsburgh Sleep Quality Index. Abbiamo esaminato la differenza tra medie variabili prima e durante il Ramadan, considerando anche cronotipo e schemi di sonno dei partecipanti.

Risultati. I risultati hanno mostrato una significativa diminuzione della qualità del sonno e del massimo consumo di ossigeno durante il Ramadan. Inoltre, abbiamo trovato una correlazione significativa tra il cronotipo, il tempo trascorso a letto e il tempo trascorso a dormire. Tuttavia, il cronotipo e la qualità del sonno non hanno influenzato il massimo consumo di ossigeno durante il digiuno intermittente del Ramadan.

Conclusioni. Il sonno e il cronotipo non influenzano le prestazioni fisiche durante il Ramadan. Sono necessarie ulteriori ricerche per identificare la causa principale del calo delle prestazioni aerobiche durante il digiuno intermittente del Ramadan.

References

1. Roy AS, Bandyopadhyay A. Effect of Ramadan intermittent fasting on selective fitness profile parameters in young untrained Muslim men. BMJ Open Sport Exerc Med. 2015 Sep 30; **1**(1): e000020. doi: 10.1136/bmjsem-2015-000020.
2. Patterson RE, Laughlin GA, LaCroix AZ, et al. Intermittent Fasting and Human Metabolic Health. J Acad Nutr Diet. 2015 Aug; **115**(8): 1203-12. doi: 10.1016/j.jand.2015.02.018. Epub 2015 Apr 6.
3. Chamari K, Roussi M, Bragazzi NL, Chaouachi A, Abdul RA. Optimizing training and competition during the month of Ramadan: Recommendations for a holistic and personalized approach for the fasting athletes. Tunis Med. 2019 Oct 17; **97**(10): 1095-103.
4. Boukhris O, Trabelsi K, Shephard RJ, et al. Sleep Patterns, Alertness, Dietary Intake, Muscle Soreness, Fatigue, and Mental Stress Recorded before, during and after Ramadan Observance. Sports (Basel, Switzerland). 2019 May; **7**(5): 118. doi: 10.3390/sports7050118.
5. Faris MeA-IE, Jahrami HA, Alhayki FA, et al. Effect of diurnal fasting on sleep during Ramadan: a systematic review and meta-analysis. Sleep Breath. 2020 Jun; **24**(2): 771-82. doi: 10.1007/s11325-019-01986-1. Epub 2019 Dec 12.
6. Nakajima K. Unhealthy eating habits around sleep and sleep duration: To eat or fast? World J Diabetes. 2018 Nov 15; **9**(11): 190-4. doi: 10.4239/wjd.v9.i11.190.
7. Roky R, Chapotot F, Hakkou F, Benchekroun MT, Buguet A. Sleep during Ramadan intermittent fasting. J Sleep Res. 2001 Dec; **10**(4): 319-27. doi: 10.1046/j.1365-2869.2001.00269.x.
8. Bahammam AS, Almushailhi K, Pandi-Perumal SR, Sharif MM. Intermittent fasting during Ramadan: does it affect sleep? J Sleep Res. 2014 Feb; **23**(1): 35-43. doi: 10.1111/jsr.12076. Epub 2013 Aug 12.
9. Bahammam A. Effect of fasting during Ramadan on sleep architecture, daytime sleepiness and sleep pattern. Sleep Biol Rhythms. 2004; **2**(2): 135-43. https://doi.org/10.1111/j.1479-8425.2004.00135.

10. Bahammam A. Does Ramadan fasting affect sleep? Int J Clin Pract. 2006 Dec; **60**(12): 1631-7. doi: 10.1111/j.1742-1241.2005.00811.x. Epub 2006 May 2.
11. Reilly T, Piercy M. The effect of partial sleep deprivation on weight-lifting performance. Ergonomics. 1994 Jan; **37**(1): 107-15. doi: 10.1080/00140139408963628.
12. Abedelmalek S, Souissi N, Chtourou H, et al. Effects of Partial Sleep Deprivation on Proinflammatory Cytokines, Growth Hormone, and Steroid Hormone Concentrations During Repeated Brief Sprint Interval Exercise. Chronobiol Int. 2013 May; **30**(4): 502-9. doi: 10.3109/07420528.2012.742102. Epub 2013 Jan 2.
13. Souissi N, Chtourou H, Aloui A, et al. Effects of time-of-day and partial sleep deprivation on short-term peakimal performances of judo competitors. J Strength Cond Res. 2013 Sep; **27**(9): 2473-80. doi: 10.1519/JSC.0b013e31827f4792.
14. Chaouachi A, Coutts AJ, Chamari K, Wong del P, Chaouachi M, Chtara M, et al. Effect of Ramadan intermittent fasting on aerobic and anaerobic performance and perception of fatigue in male elite judo athletes. J Strength Cond Res. 2009 Dec; **23**(9): 2702-9. doi: 10.1519/JSC.0b013e3181bc17fc.
15. Aziz AR, Wahid MF, Png W, Jesuvadian CV. Effects of Ramadan fasting on 60 min of endurance running performance in moderately trained men. Br J Sports Med. 2010 Jun; **44**(7): 516-21. doi: 10.1136/bjsm.2009.070425.
16. Gueldich H, Zghal F, Borji R, Chtourou H, Sahli S, Rebai H. The effects of Ramadan intermittent fasting on the underlying mechanisms of force production capacity during peakimal isometric voluntary contraction. Chronobiol Int. 2019 May; **36**(5): 698-708. doi: 10.1080/07420528.2019.1592183. Epub 2019 Mar 20.
17. Andrade A, Bevilacqua GG, Coimbra DR, Pereira FS, Brandt R. Sleep Quality, Mood and Performance: A Study of Elite Brazilian Volleyball Athletes. J Spots Sci Med. 2016 Dec 1; **15**(4): 601-5.
18. Brandt R, Bevilacqua GG, Andrade A. Perceived Sleep Quality, Mood States, and Their Relationship With Performance Among Brazilian Elite Athletes During a Competitive Period. J Strength Cond Res. 2017 Apr; **31**(4): 1033-9. doi: 10.1519/JSC.0000000000001551.
19. Juliff LE, Halson SL, Hebert JJ, Forsyth PL, Peiffer JJ. Longer Sleep Durations Are Positively Associated With Finishing Place During a National Multiday Netball Competition. J Strength Cond Res. 2018 Jan; **32**(1):189-94. doi: 10.1519/JSC.0000000000001793.
20. Watson G, Judelson DA, Armstrong LE, Yeargin SW, Casa DJ, Maresh CM. Influence of diuretic-induced dehydration on competitive sprint and power performance. Med Science Sports Exerc. 2005; **37**(7): 1168-74. doi: 10.1249/01.mss.0000170100.93279.be.
21. Cheuvront SN, Carter R 3rd, Sawka MN. Fluid balance and endurance exercise performance. Curr Sports Med Rep. 2003 Aug; **2**(4): 202-8. doi: 10.1249/00149619-200308000-00006.
22. Edwards AM, Mann ME, Marfell-Jones MJ, Rankin DM, Noakes TD, Shillington DP. Influence of moderate dehydration on soccer performance: physiological responses to 45 min of outdoor match-play and the immediate subsequent performance of sport-specific and mental concentration tests. Br J Sports Med. 2007 Jun; **41**(6): 385-91. doi: 10.1136/bjsm.2006.033860. Epub 2007 Feb 1.
23. Hoffman JR, Stavsky H, Falk B. The effect of water restriction on anaerobic power and vertical jumping height in basketball players. Int J Sports Med. 1995 May; **16**(4): 214-8. doi: 10.1055/s-2007-972994.
24. Cheuvront S, Carter R, Haymes E, Sawka M. No Effect of Moderate Hypohydration or Hyperthermia on Anaerobic Exercise Performance. Med Sci Sports Exerc. 2006 Jun; **38**: 1093-7. doi: 10.1249/01.mss.0000222838.74015.15.
25. Chaouachi A, Leiper JB, Chtourou H, Aziz AR, Chamari K. The effects of Ramadan intermittent fasting on athletic performance: recommendations for the maintenance of physical fitness. J Sports Sci. 2012; **30**(Suppl 1): S53-73. doi: 10.1080/02640414.2012.698297. Epub 2012 Jun 27.
26. Correia JM, Santos I, Pezarat-Correia P, Minderico C, Mendonca GV. Effects of Intermittent Fasting on Specific Exercise Performance Outcomes: A Systematic Review Including Meta-Analysis. 2020 May 12; **12**(5): 1390. doi: 10.3390/nu12051390.
27. Roy J, Hwa OC, Singh R, Aziz AR, Jin CW. Self-generated coping strategies among muslim athletes during ramadan fasting. J Sports Sci

Med. 2011 Mar 1; **10**(1): 137-44.

28. Abaïdia A-E, Daab W, Bouzid MA. Effects of Ramadan Fasting on Physical Performance: A Systematic Review with Meta-analysis. Sports Med. 2020 May; **50**(5): 1009-26. doi: 10.1007/s40279-020-01257-0.
29. Lipert A, Kozłowski R, Rasmus P, et al. Sleep Quality and Performance in Professional Athletes Fasting during the Month of Ramadan. Int J Environ Research Public health. 2021 Jun 27; **18**(13): 6890. doi: 10.3390/ijerph18136890.
30. Miladi A, Ben Fraj S, Latiri I, Ben Saad H. Does Ramadan Observance Affect Cardiorespiratory Capacity of Healthy Boys? 2020; Am J Mens Health. 2020 May-Jun; **14**(3): 1557988320917587. doi: 10.1177/1557988320917587.
31. Qasrawi SQ, Albarrak AM, Alharbi AS, et al. Narcolepsy in Saudi patients before and after the 2009 H1N1 vaccination. The experience of 2 referral centers. Saudi Medical J. 2017 Dec; **38**(12): 1196-200. doi: 10.15537/smj.2017.12.21046.
32. Chamari K, Briki W, Farooq A, Patrick T, Belfekih T, Herrera CP. Impact of Ramadan intermittent fasting on cognitive function in trained cyclists: a pilot study. Biol Sport. 2016 May; **33**(1): 49-56. doi: 10.5604/20831862.1185888. Epub 2015 Dec 30.
33. Lotfi S, Madani M, Abassi A, Tazi A, Boumahmaza M, Talbi M. CNS Activation, Reaction Time, Blood Pressure and Heart Rate Variation During Ramadan Intermittent Fasting and Exercise. World J Sport Sci. 2010; **3**(1). Available on: http://idosi.org/wjss/3(1)10/7.pdf [Last accessed: 2023 Marc 13].
34. BaHammam AS, Almeneessier AS. Recent Evidence on the Impact of Ramadan Diurnal Intermittent Fasting, Mealtime, and Circadian Rhythm on Cardiometabolic Risk: A Review. Front Nutr. 2020 Mar 11; **7**: 28. doi: 10.3389/fnut.2020.00028.
35. Henst RH, Jaspers RT, Roden LC, Rae DE. A chronotype comparison of South African and Dutch marathon runners: The role of scheduled race start times and effects on performance. Chronobiol Int. 2015; **32**(6): 858-68. doi: 10.3109/07420528.2015.1048870. Epub 2015 Jun 23.
36. Anderson A, Murray G, Herlihy M, et al. Circadian Effects on Performance and Effort in Collegiate Swimmers. J Circadian Rhythms. 2018 Aug 3; **16**: 8. doi: 10.5334/jcr.165.
37. Lim S-T, Kim D-Y, Kwon H-T, Lee E. Sleep quality and athletic performance according to chronotype. BMC Sports Sci Med Rehabil. 2021 Jan 7; **13**(1): 2. doi: 10.1186/s13102-020-00228-2.
38. Mirizio GG, Nunes RSM, Vargas DA, Foster C, Vieira E. Time-of-Day Effects on Short-Duration Peakimal Exercise Performance. Sci Rep. 2020 Jun 11; **10**(1): 9485. doi: 10.1038/s41598-020-66342-w.
39. Schmidt C, Collette F, Cajochen C, Peigneux P. A time to think: circadian rhythms in human cognition. Cogn Neuropsychology. 2007 Oct; **24**(7): 755-89. doi: 10.1080/02643290701754158.
40. Samuels C. Sleep, recovery, and performance: the new frontier in high-performance athletics. Neurol Clin. 2008 Feb; **26**(1): 169-80; ix-x. doi: 10.1016/j.ncl.2007.11.012.
41. de Souza Teixeira AA, Lira FS, Rosa-Neto JC. Aging with rhythmicity. Is it possible? Physical exercise as a pacemaker. Life Sci. 2020 Nov 15; **261**: 118453. doi: 10.1016/j.lfs.2020.118453. Epub 2020 Sep 18.
42. Gubin DG, Weinert D, Bolotnova TV. Age-Dependent Changes of the Temporal Order--Causes and Treatment. Curr Aging Sci. 2016; **9**(1): 14-25. doi: 10.2174/1874609809666151130215824.
43. Smolensky MH, Hermida RC, Reinberg A, Sackett-Lundeen L, Portaluppi F. Circadian disruption: New clinical perspective of disease pathology and basis for chronotherapeutic intervention. Chronobiol Int. 2016; **33**(8): 1101-19. doi: 10.1080/07420528.2016.1184678. Epub 2016 Jun 16.
44. Weinert D, Schöttner K, Müller L, Wienke A. Intensive voluntary wheel running may restore circadian activity rhythms and improves the impaired cognitive performance of arrhythmic Djungarian hamsters. Chronobiol Int. 2016; **33**(9): 1161-70. doi: 10.1080/07420528.2016.1205083. Epub 2016 Jul 26.
45. Trabelsi K, Bragazzi N, Zlitni S, et al. Observing Ramadan and sleep-wake patterns in athletes: a systematic review, meta-analysis and meta-regression. Br J Sports Med. 2020 Jun; **54**(11): 674-80. doi: 10.1136/bjsports-2018-099898. Epub 2019 Jun 1.
46. Herrera CP. Total sleep time in Muslim football players is reduced during Ramadan: a pilot study on the standardized assessment

of subjective sleep-wake patterns in athletes. J Sports Sci. 2012; **30** Suppl 1: S85-91. doi: 10.1080/02640414.2012.676666. Epub 2012 Apr 10.

47. Boulhlel H, Latiri I, Zarrouk N, et al. Effect of Ramadan observance and exercise on simple and choice reaction times in trained men. Sci Sports. 2014 Jun; **29**(3): 131-7. https://doi.org/10.1016/j.scispo.2014.02.002.
48. Hsouna H, Boukhris O, Trabelsi K, et al. A Thirty-Five-Minute Nap Improves Performance and Attention in the 5-m Shuttle Run Test during and Outside Ramadan Observance. Sports (Basel, Switzerland). 2020 Jul 11; **8**(7): 98. doi: 10.3390/sports8070098.
49. Bogdan A, Bouchareb B, Touitou Y. Ramadan fasting alters endocrine and neuroendocrine circadian patterns. Meal-time as a synchronizer in humans? Life Sci. 2001 Feb 23; **68**(14): 1607-15. doi: 10.1016/s0024-3205(01)00966-3.
50. Hutchison AT, Regmi P, Manoogian ENC, et al. Time-Restricted Feeding Improves Glucose Tolerance in Men at Risk for Type 2 Diabetes: A Randomized Crossover Trial. Obesity (Silver Spring). 2019 May; **27**(5): 724-32. doi: 10.1002/oby.22449. Epub 2019 Apr 19.
51. Gabel K, Hoddy KK, Burgess HJ, Varady KA. Effect of 8-h time-restricted feeding on sleep quality and duration in adults with obesity. Appl Physiol Nutr Metab 2019 Aug; **44**(8): 903-6. doi: 10.1139/apnm-2019-0032. Epub 2019 Feb 25.
52. Kesztyüs D, Fuchs M, Cermak P, Kesztyüs T. Associations of time-restricted eating with health-related quality of life and sleep in adults: a secondary analysis of two pre-post pilot studies. BMC Nutr. 2020 Dec 17; **6**(1): 76. doi: 10.1186/s40795-020-00402-2.
53. McStay M, Gabel K, Cienfuegos S, Ezpeleta M, Lin S, Varady KA. Intermittent Fasting and Sleep: A Review of Human Trials. Nutrients. 2021 Oct 1; **13**(10): 3489. doi: 10.3390/nu13103489.

Corresponding author: Anas El-Jaziz, Multidisciplinary Laboratory In Education Sciences and Training Engineering (LMSEIF), Sport Science Assessment and Physical Activity Didactic, Normal Higher School (ENS-C), Hassan II University of Casablanca, BP 50069, Morocco
e-mail: anas.eljaziz@enscasa.ma