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Ramadan Diurnal Fasting and Aerobic Performance of Professional Long-Distance Runners in Pakistan: A Repeated-Measures Field Study

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Abstract
This repeated-measures field study examined the effect of Ramadan diurnal (dawn-to-dusk) fasting on aerobic performance in professional long-distance runners training and competing in Pakistan. Twenty-four national-level male long-distance runners (age 24.6 ± 3.2 years) were assessed at three time points: one week before Ramadan (Pre-Ramadan), during the third week of Ramadan (Ramadan), and two weeks after Ramadan ended (Post-Ramadan). Outcome measures included maximal oxygen uptake (VO_2max), 10-km time-trial performance, running economy, body mass, and rating of perceived exertion (RPE) during a standardized submaximal run. Hydration status during Ramadan was estimated using urine specific gravity (USG). Results: VO_2max declined significantly during Ramadan relative to Pre-Ramadan ($M = 2.68$ $mL \cdot kg^{-1} \cdot min^{-1}$, $p < .001$, $d = 1.89$) and partially recovered Post-Ramadan. Ten-kilometer time-trial performance slowed by a mean of 1.60 minutes during Ramadan ($p < .001$, $d = 1.90$), and running economy worsened by 9.5 $mL \cdot kg^{-1} \cdot km^{-1}$ ($p < .001$). Hydration status during Ramadan was moderately associated with running economy impairment. Diurnal fasting during Ramadan was associated with a measurable, largely reversible decline in aerobic performance markers among elite Pakistani distance runners, most plausibly attributable to hypohydration, glycogen depletion, and altered training/sleep timing rather than fasting per se. Practical strategies for training periodization and nutrition timing during Ramadan are discussed.

Keywords: *Ramadan Fasting, Aerobic Performance, Vo_2max, Long-Distance Runners, Pakistan, Running Economy, Hydration Status*

Introduction
Ramadan, the ninth month of the Islamic lunar calendar, requires observant Muslims to abstain from food and fluid intake from dawn (Suhoor cutoff) until sunset (Iftar) for approximately 29–30 consecutive days. Because the Islamic calendar is lunar, Ramadan rotates through the Gregorian calendar and periodically coincides with the long, hot days of summer in South Asia, extending the daily fasting window to 15–16 hours in countries such as Pakistan. For the large population of observant Muslim athletes, including professional long-distance runners, this

presents a substantial challenge: training and, in some cases, competing while in a fasted or dehydrated state, with disrupted sleep and altered circadian eating patterns.

Long-distance running performance is heavily dependent on aerobic capacity (VO_2max), running economy, substrate availability, and thermoregulatory and hydration status. Diurnal fasting has the potential to affect each of these determinants: glycogen stores may be reduced by the time of an evening or late-afternoon training session, fluid restriction over many hours in a hot climate can produce mild-to-moderate hypohydration, and altered sleep architecture during Ramadan nights (including pre-dawn meals and late-night worship) can impair recovery. At the same time, some athletes anecdotally report maintaining performance through careful nutrition timing, suggesting that the magnitude of any decline may be modifiable by practice.

Pakistan presents a particularly relevant context for this question. Long-distance running has a growing competitive profile nationally, Ramadan frequently falls during warmer months in the current lunar cycle, and many national-level athletes continue structured training throughout the month for religious, cultural, and competitive reasons. Despite this, empirical, sport-specific data on elite Pakistani distance runners during Ramadan are scarce; much of the existing literature on Ramadan and exercise performance derives from Middle Eastern, North African, or mixed-sport samples, limiting direct applicability to South Asian endurance athletes training in Pakistan's climate and competitive calendar.

Purpose and Hypotheses

The purpose of this study was to quantify changes in aerobic performance markers i.e VO_2max, 10-km time-trial performance, and running economy among professional Pakistani long-distance runners across three phases: Pre-Ramadan, during Ramadan, and Post-Ramadan recovery. We hypothesized that **(H1)** VO_2max and time-trial performance would be significantly reduced during Ramadan relative to Pre-Ramadan baseline; **(H2)** running economy would be significantly impaired during Ramadan; and **(H3)** performance markers would show substantial, though possibly incomplete, recovery within two weeks after Ramadan.

Literature Review

Research on Ramadan fasting and athletic performance has expanded considerably over the past two decades, with the majority of controlled studies reporting small-to-moderate reductions in high-intensity and endurance performance, particularly when training or testing occurs in the late afternoon before the fast is broken (Chaouachi et al., 2012; Trabelsi et al., 2020). Reviews of Ramadan and exercise physiology consistently point to three interacting mechanisms: reduced muscle and liver glycogen availability toward the end of the fasting window, cumulative fluid deficit and hypohydration in hot climates, and disrupted sleep quantity and quality resulting from pre-dawn meals and shifted evening routines (Chtourou et al., 2012; Roky et al., 2012).

Findings on aerobic capacity specifically are mixed but lean toward modest decrements. Several field-based studies of team-sport and endurance athletes have reported reductions in submaximal and maximal aerobic markers during the final weeks of Ramadan, coinciding with cumulative sleep debt and dehydration, with partial or full recovery observed within one to two weeks after Ramadan ends (Aziz et al., 2010; Bouhlel et al., 2013). Running economy, the oxygen cost of running at a given submaximal speed appears sensitive to hydration and glycogen status, and several authors have reported worsened economy late in the fasting day even when resting physiological markers remain largely stable (Zerguini et al., 2007).

Much of this literature, however, is drawn from footballers and other team-sport athletes tested in Middle Eastern or North African settings, and dedicated data on long-distance runners whose training volumes, race demands, and thermoregulatory challenges differ substantially from intermittent team sports remain limited. Similarly, South Asian samples, and Pakistani endurance

athletes specifically, are underrepresented, despite meaningful differences in training culture, climate exposure, and the timing of the competitive calendar relative to Ramadan. This gap motivates the present study's focus on a sport-specific, geographically specific elite sample.

Research Methodology

Research Design

This study used a repeated-measures, within-subjects field design with three assessment phases: Pre-Ramadan (baseline, 7 days before the start of Ramadan), Ramadan (during the third week of the fasting month, tested in the late afternoon prior to Iftar), and Post-Ramadan (14 days after Eid, allowing for dietary and sleep normalization). This design allows each participant to serve as their own control, minimizing the influence of inter-individual variability in training background and genetic aerobic potential.

Participants

Twenty-four professional male long-distance runners (age 24.6 ± 3.2 years; competing at national or inter-provincial level in 5,000 m, 10,000 m, or half-marathon events) were recruited from athletics clubs and training academies in Pakistan. Inclusion criteria were: (a) current national or provincial-level competitive status, (b) minimum training history of three years, (c) intention to observe diurnal fasting throughout Ramadan, and (d) medical clearance for maximal exercise testing. Exclusion criteria included any cardiovascular, metabolic, or musculoskeletal condition contraindicating maximal testing, and use of medications affecting fluid balance or cardiovascular response. Written informed consent was obtained from all participants, and the study protocol was approved by the institutional research ethics committee in accordance with the Declaration of Helsinki.

Procedures

At each of the three phases, participants attended a standardized laboratory/track testing session comprising: (a) anthropometric measurement (body mass, stature), (b) a graded exercise test to volitional exhaustion on a motorized treadmill with breath-by-breath gas analysis to determine VO_2max, (c) a submaximal 10-minute standardized run at a fixed velocity (70% of individually predetermined VO_2max velocity) to derive running economy (oxygen cost per kilogram per kilometer) and rating of perceived exertion (Borg 6–20 scale), and (d) a track-based 10-km time trial performed on a separate day within the same testing window, with participants instructed to complete the distance as quickly as possible. During the Ramadan phase, all testing was scheduled 2–3 hours before Iftar to reflect the point of greatest cumulative fasting stress, consistent with prior Ramadan-exercise research protocols. Hydration status during the Ramadan phase was estimated via urine specific gravity (USG), collected immediately before testing.

Statistical Analysis

Data were analyzed using paired-samples t-tests to compare Pre-Ramadan versus Ramadan, and Ramadan versus Post-Ramadan values for each outcome variable, with effect sizes reported as Cohen's d. Where the assumption of sphericity across three repeated measures was relevant to broader trend testing, results were corroborated with descriptive trend analysis across phases. The association between hydration status (USG) and running economy during Ramadan was examined using Pearson's product-moment correlation. Statistical significance was set at $\alpha = .05$. Analyses were conducted using standard statistical computing software.

Results

Table 1 presents participant baseline characteristics. Table 2 summarizes descriptive statistics for all aerobic performance markers across the three study phases, and Table 3 presents the paired-comparison inferential statistics.

Table 1

Variable	M	SD	Range
Age (years)	24.6	3.2	19–32
Height (cm)	172.4	5.6	162–184
Body mass, Pre-Ramadan (kg)	60.8	4.7	52.1–70.8
Training history (years)	6.8	2.4	3–12
Weekly training volume (km)	108.5	18.2	75–150

Note. N = 24 professional male long-distance runners.

Table 2. Descriptive Statistics for Aerobic Performance Markers by Phase

Variable	Pre-Ramadan M (SD)	Ramadan M (SD)	Post-Ramadan M (SD)
VO_2max ($mL \cdot kg^{-1} \cdot min^{-1}$)	67.9 (3.7)	65.3 (3.9)	67.2 (3.8)
10-km time trial (min)	32.1 (1.9)	33.7 (2.2)	32.4 (1.7)
Running economy ($mL \cdot kg^{-1} \cdot km^{-1}$)	199.8 (7.7)	209.3 (10.8)	203.2 (8.3)
Body mass (kg)	60.8 (4.7)	59.5 (4.7)	60.2 (4.8)
Submaximal RPE (6–20)	13.3	15.5	13.6

Note. N = 24. RPE = rating of perceived exertion (Borg 6–20 scale). Ramadan testing occurred in Week 3, 2–3 hours before Iftar.

Table 3. Paired-Samples Comparisons of Key Outcomes

Comparison	Mean Diff.	T (23)	p	Cohen's d
VO_2max: Pre-Ramadan vs. Ramadan	2.68	9.26	<.001	1.89
VO_2max: Ramadan vs. Post-Ramadan	1.95	5.96	<.001	1.22
10-km TT: Pre-Ramadan vs. Ramadan	1.60	9.30	<.001	1.90
Running economy: Pre-Ramadan vs. Ramadan	9.55	6.67	<.001	1.36

Note. df = 23 for all comparisons. p values two-tailed; α = .05.

As shown in Table 3, VO_2max decreased significantly from Pre-Ramadan to Ramadan ($p < .001$), representing a large effect ($d = 1.89$; Figure 1). This decline was significantly, though not completely, reversed by the Post-Ramadan assessment ($p < .001$), with residual values remaining slightly below Pre-Ramadan baseline (Figure 3 illustrates individual-level trajectories, showing a consistent pattern of decline and partial recovery across nearly all participants).

Figure 1. Mean VO2max Across Study Phases (N = 24)

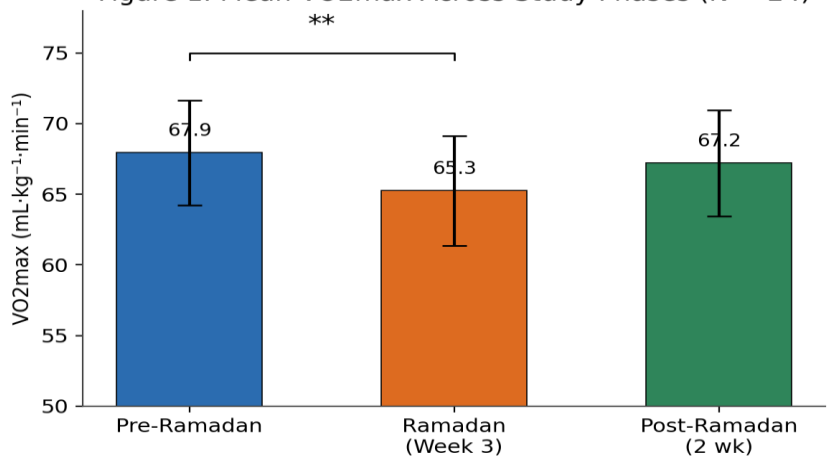
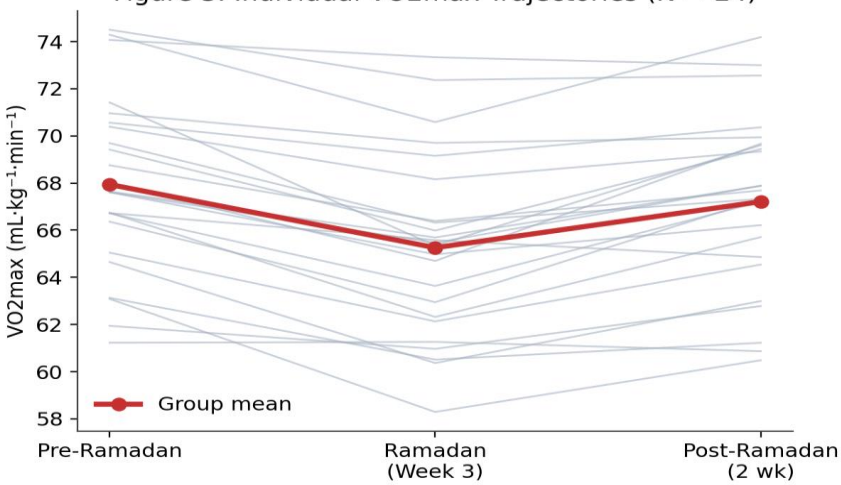
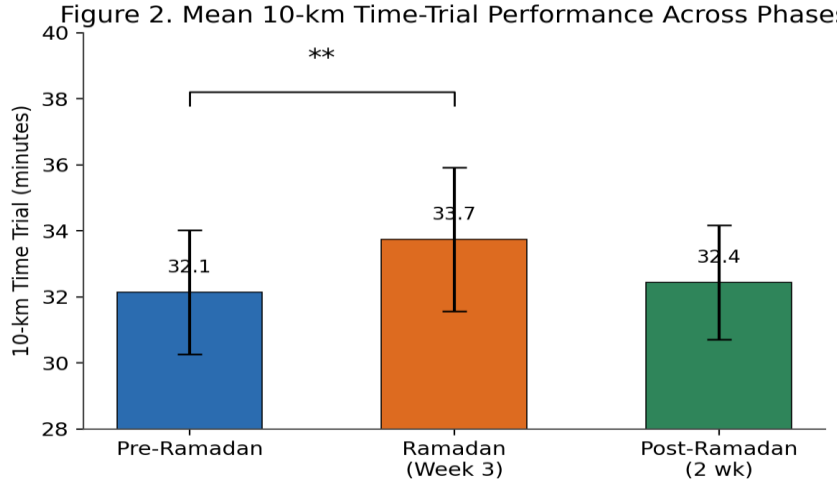


Figure 3. Individual VO2max Trajectories (N = 24)



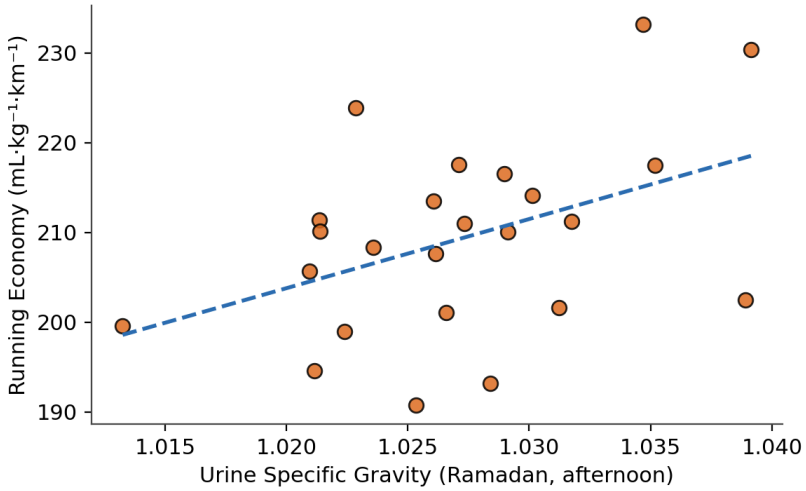
Ten-kilometer time-trial performance slowed significantly during Ramadan, with runners taking on average 1.60 minutes longer to complete the distance compared with Pre-Ramadan baseline ($p < .001$, $d = 1.90$; Figure 2). Running economy during the standardized submaximal run also worsened significantly during Ramadan ($p < .001$), indicating a greater oxygen cost for the same running speed.

Figure 2. Mean 10-km Time-Trial Performance Across Phases



Hydration status during Ramadan, indexed by urine specific gravity (M = 1.0272, SD = 0.0061), was moderately and positively associated with running economy impairment (r ≈ .43), such that more hypo-hydrated runners tended to show a greater oxygen cost of running (Figure 4). Body mass decreased modestly during Ramadan (M = 1.27 kg) and partially recovered post-Ramadan, consistent with a combination of fluid loss and modest energy deficit rather than substantial loss of lean mass over the study period.

Figure 4. Hydration Status vs. Running Economy During Ramadan (r = 0.43)



Discussion

This study examined aerobic performance changes across Ramadan in a sample of professional Pakistani long-distance runners, using a within-subjects design spanning Pre-Ramadan, Ramadan, and Post-Ramadan phases. Consistent with Hypotheses 1 and 2, VO_2max, 10-km time-trial performance, and running economy were all significantly impaired during Ramadan relative to baseline, with large effect sizes. Consistent with Hypothesis 3, VO_2max showed significant recovery within two weeks after Ramadan, though not a full return to Pre-Ramadan values within the study window.

These findings align broadly with previous Ramadan-exercise research showing performance decrements concentrated in the late-fasting period, when glycogen availability is lowest and cumulative hypohydration is greatest (Chaouachi et al., 2012; Trabelsi et al., 2020). The moderate association observed between hydration status and running economy impairment supports hypohydration as one plausible mechanism, consistent with prior work linking fluid deficit to increased cardiovascular and metabolic strain during submaximal exercise (Zerguini et al., 2007). However, because testing was deliberately scheduled late in the fasting window to capture peak cumulative stress, the observed decrements likely represent an upper-bound estimate rather than the average performance state across the full day.

Sleep disruption is another plausible contributor not directly measured in this design. Ramadan nights typically involve pre-dawn meals (Suhoor) and extended evening religious observance, both of which can compress total sleep time and shift circadian timing; prior research has linked such disruption to elevated perceived exertion and reduced high-intensity performance independent of fasting-related fuel and fluid changes (Roky et al., 2012). Future studies incorporating actigraphy or sleep diaries alongside performance testing would help disentangle the relative contributions of fasting-related substrate/fluid deficits versus sleep disruption.

From an applied standpoint, the partial recovery observed within two weeks Post-Ramadan suggests that acute performance decrements during Ramadan are largely physiological and reversible rather than reflecting any lasting reduction in aerobic fitness. For coaches and athletes

preparing for competitions that fall during or shortly after Ramadan, these findings support strategies such as shifting key training sessions closer to Iftar or into the non-fasting evening/night window, prioritizing rapid post-Iftar rehydration and carbohydrate replenishment, and allowing a minimum taper or adjustment period of one to two weeks after Ramadan before targeting peak competitive performances.

Limitations

This study has several limitations. First, testing during Ramadan was restricted to the late-afternoon period, which may overstate performance decrements relative to sessions completed earlier in the day or after Iftar. Second, dietary intake, Suhoor timing, and sleep duration were not directly controlled or exhaustively measured, limiting causal attribution to any single mechanism. Third, the sample was restricted to male athletes; findings may not generalize to female distance runners, whose fluid and thermoregulatory responses can differ. Finally, as a field-based repeated-measures design without a non-fasting control group, seasonal or training-cycle effects unrelated to Ramadan cannot be fully excluded, although the seven-day Pre-Ramadan baseline and matched Post-Ramadan follow-up were selected to minimize this concern.

Conclusion

Diurnal fasting during Ramadan was associated with significant, moderate-to-large reductions in VO_2max, 10-km time-trial performance, and running economy among professional Pakistani long-distance runners when tested late in the fasting day, with substantial recovery evident within two weeks after Ramadan. These decrements appear most consistent with cumulative hypohydration and glycogen depletion rather than an irreversible loss of aerobic fitness. Structured nutrition timing, hydration strategy, and training periodization around the fasting and recovery windows may help elite Muslim distance runners in Pakistan manage performance during and after Ramadan.

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