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ORIGINAL RESEARCH

Influence of daytime napping on hormonal and psychometric variables of professional male basketball players during increased game frequency period crossing Ramadan intermittent fasting: a crossover research design with repeated assessments

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Abstract

A diurnal nap during Ramadan intermittent fasting (RIF) could significantly reduce fatigue. This study aimed to assess the effects of a 45-min daytime nap on hormonal and psychometric variables during an increased basketball game frequency period that crosses RIF. 28 participants from two professional basketball clubs were selected. Participants were divided into two groups: a 45-min nap group (NAP, n = 14) and an active control group (CON, n = 14). Both groups experienced an increased game frequency when crossing the RIF. During week 1 and 4 of RIF, players were assessed for testosterone to cortisol ratio, body composition (body mass, body mass index and body fat percentage), sleep quality index survey results, well-being indices (sleep, fatigue, stress and delayed onset of muscle soreness (DOMS)), weekly internal training load (session rating of perceived exertion (RPE)), heart rate frequency, dietary intake and recovery state (Total Quality Recovery (TQR)). In this study, a group-by-time interaction ($p = 0.02$, effect size (ES) = 0.35, small) was observed for RPE, although NAP showed a lower value. Significant group-by-time interactions for TQR and DOMS ($p = 0.02$, ES = 0.38, small; $p = 0.04$, ES = 0.30, small; $p = 0.045$, ES = 0.28, small), with a better value of NAP. A 45-min nap during an increased game frequency period crossing RIF may improve professional basketball performance by providing a better way for recovery.

Keywords

Fatigue; Intermittent fasting; Performance; Sleeping; Team sport

1. Introduction

Basketball is a complex team sport with intermittent metabolic demands [1]. Sporting success in basketball influenced by technical, tactical and high-intensity actions, such as quick direction changes [1, 2]. Previous studies showed that overall basketball performance depends heavily on players' recovery state [3]. Incomplete recovery can lead to performance declines. Several factors, such as extended game frequency periods [4] and Ramadan intermittent fasting (RIF) [5, 6], may influence players' recovery state during the competitive season. During these periods, strength and conditioning coaches should adopt an efficient recovery strategy that optimizes performance and minimizes injury risks [4, 5]. For Muslim basketball players, increased game frequency periods during RIF resulted in increased stress and insufficient recovery [7–9]. Therefore, more research is required to identify recovery strategies for Muslim players during RIF.

Ramadan is a month-long fast during which Muslims abstain from food and fluid intake from dawn to sunset [10]. Sleep, lifestyle rhythms, body composition and biochemical variables may be affected significantly by Ramadan-related changes in eating patterns and time between meals, negatively affecting athletes' recovery [11–15]. Furthermore, requiring only overnight eating can alter sleep quality [16, 17] as well as meal timing and composition [18, 19]. RIF has been associated with disturbances in sleep quantity [20–22], quality [23, 24], and dietary intake [17, 25]. As a result of RIF alterations, Muslim athletes may need to reduce their training loads [10]. Other studies have shown that basketball players can perform well and continue training at a prescribed load during RIF [5, 8].

Based on improvements in physical and cognitive performance, researchers have reported that a diurnal nap during RIF could o reduce fatigue [26–29]. Taking a nap during the day improves endurance, short-term balance, speed, and power performance [30–33]. A nap may also lower fatigue effects and/or improve strength/energy, subjective alertness, objective vigilance, and cognitive performance in athletes [26, 28]. Recently, a systematic review examining daytime napping strategies effects on sports performance in physically active individuals with and without partial-sleep deprivation reported a significant improvement in sprint performance in favor of the napping groups [33]. According to a systematic review and a meta-analysis, a daytime nap between 30 and 60 min has a moderate-to-high effect on improving cognitive and physical performance and reducing perceived fatigue [34]. To achieve better performance, athletes may consider napping between 20 and 90 min and between 13:00 and 16:00 hours [35]. Recent studies have examined the effects of sleep extension and napping on basketball players [36, 37]. A 40-min nap or increased sleep duration reduced fatigue sensation in basketball players, while improving players' reaction time, linear sprint speed, shooting accuracy, free throw percentage, and three-point percentage [36, 37]. Therefore, it would be interesting to investigate the effects of nap duration $\geq$45 min during RIF on specific performances among professional basketball players.

Stress can be caused by elevated cortisol, which is a crucial to chronic psychological and physical stress responses [38, 39]. More specifically, RIF is characterized by increased stress in Muslim athletes and basketball players in particular due to changes in nutritional/hydration habits, disruption of the sleep-wake cycle, and increased fatigue [10–13]. Human psychological and physical responses are regulated by cortisol (C) and testosterone (T), which play a crucial role in the biological balance [11]. Testosterone-to-cortisol ratio (T/C) is often used as a marker of anabolic/catabolic activities, and it was previously used among professional basketball players during RIF [11]. During a period of increased basketball game frequency coinciding with RIF, no study examined the impact of a 45-min nap on T/C ratio, weekly internal training load, and psychometric variables.

A crossover experimental study with repeated assessments was designed to address the gaps in the literature by exploring how a 45-min daytime nap affected the T/C ratio, weekly internal training load, and psychometric variables during an increased basketball game frequency period crossing RIF. Based on prior studies [4, 5, 37], we hypothesized that a 45-min daytime nap would improve recovery and reduce fatigue variables during an extended basketball game period crossing RIF.

2. Methods

2.1 Study design and setting

This study aimed to investigate the impact of a 45-min nap on the T/C ratio, weekly internal training load, and psychometric variables during an increase in match frequency coinciding with RIF. Using a crossover research design with repeated assessments, we studied how a 45-minmidday sleep affects recovery state and fatigue characteristics in male professional basketball players. Participants were divided into two groups: a 45-min nap group (NAP, n = 14) and an active control group (CON, n = 14). Five weeks were covered in this study during the basketball season of 2021–2022. Starting with RIF (April 2022), the experimental period lasted until May 2022. The intervention period included around 15–16 h of fasting every day. Temperatures averaged 25.3 $\pm$ 3.4 °C and relative humidity 43.1 $\pm$ 9.8%. Training sessions were scheduled from 5 to 6.30 PM. Two games were played weekly (on Wednesdays and Saturdays) and four weekly workouts were conducted during RIF. NAP group slept for 45 min before training sessions and games during the intervention period, while CON group maintained their normal daily schedule and did not take naps. The only difference between the NAP and CON groups was that the NAP group took naps as part of their recovery plan. NAP participants went to bed at 1.45 PM in sleep-friendly settings (*i.e.*, quiet, dark and usually between 22 and 25 °C) after reporting their napping patterns to accountable strength and conditioning coaches [40]. During the trial, both groups were monitored by competent members of our research team to verify that NAP took their 45-min nap daily and the control group did not. NAP was subdivided into five comfortably warm, fully dark and quiet sleeping rooms. Over the experimental period, each room was monitored by a certified member of staff to ensure everybody took a 45-min nap and provided feedback about any breaks in the nap, and the same conditions were provided at night. Furthermore, players were encouraged to sleep well at night and woke up by 9 AM to provide enough time between waking up early and napping. During nap time, the CON did not take naps and instead engaged in other soft activities in their hotel rooms (reading books, watching TV, *etc.*) under strict team supervision.

2.2 Study participants

This study included 28 professional male basketball players from two clubs in the ProA Tunisian championship (Table 1). Both teams performed similarly during the experiment. Players' weekly practice load (8 h) and training experience (13.1 $\pm$ 1.2 years) were comparable. 3 guards, 3 shooting guards, 3 small forwards, 3 forwards and 2 centers made up each squad. The following requirements had to be met to participate in the study: (1) At least 90% attendance at training sessions. (2) Muslims who fasted throughout Ramadan. (3) Excellent health (no complaints of discomfort or injury). (4) Not taking any

TABLE 1. Anthropometric characteristics of the participating basketball players.

Groups	Age (yr)	Height (m)	BM (kg)	BMI (kg/m^2)
NAP (n = 14)	25.3 ± 2.3	1.98 ± 0.05	89.41 ± 5.77	22.86 ± 1.50
CON (n = 14)	25.7 ± 2.6	1.97 ± 0.06	89.64 ± 6.59	23.01 ± 0.68

Data are reported as means and standard deviations. NAP: 45-NAP group; CON: control group; BM: body mass; BMI: body mass index.

medications or other substances. This study was conducted during the in-season.

2.3 Study training and testing procedures

All testing procedures were explained to players before the experiment began. Training sessions were conducted at the same time every day, between 5 and 6.30 PM to mitigate the impact of daily fluctuations. During testing, players were requested to wear the same shoes. Testing began for both groups with a warm-up. We then moved to technical and tactical drills that targeted fundamental basketball movements. All training sessions lasted about 90 min each session (Table 2). During week 1 and 4 of RIF, players were assessed for their body composition (body mass, body mass index and body fat percentage), dietary intake, well-being indices (sleep, fatigue, stress and delayed onset of muscle soreness (DOMS)), recovery state (TQR), sleep quality index survey, weekly internal training load (session rating of perceived exertion (RPE)), heart rate frequency, and hormonal variations (Fig. 1).

2.3.1 Study anthropometric measurements

Using a routinely calibrated electronic balance, body mass was measured in kilograms with an accuracy of 0.1 kg. Players were asked to wear light attire without shoes. A portable stadiometer was used to measure height in centimeters with an accuracy of 0.1 centimeters. Body mass in kilograms (kg) was then divided by the height in meters squared (m^2) to calculate the body mass index. The four skin folds technique was applied with a Harpenden caliper to measure the thickness of the biceps, triceps, subscapular and suprailiac skin folds. Body density was computed using the following equation: (0.29288 × sum of all the skinfolds (mm)) − (0.0005 × sum of all the skinfolds squared) + (0.15845 × age (years)) − 5.76377. Body density can be used to estimate body fat percentage: (BF%) = (4.95/body density − 4.5) × 100 [41]. The International Society for the Advancement of Kinanthropometry's guidelines were followed for anthropometric measurements. A professional technician performed all these actions.

2.3.2 Dietary intake

Food and beverage types and quantities were recorded in a diary throughout the trial. Results were evaluated using the Bilnut application (S.C.D.A. NUTRISOFT-BILNUT, version 2.01, Cerelles, France) and the Tunisian National Institute of Statistics' dietary composition tables (1978).

2.3.3 Psychometric markers

Fifteen minutes before warm-up, each player was asked to complete ratings of well-being indices (quality of sleep, fatigue, stress and delayed onset muscle soreness (DOMS)) considering the timeline from the last (training/game) session until the moment of the upcoming session. A scale from 1 to 7 was used to rate each index: 1 indicated "very, very low" (fatigue, stress and DOMS) or "good" (quality of sleep) and 7 indicated "very, very high" (fatigue, stress and DOMS) or "bad" (quality of sleep) [42]. Calculate Hooper's Index (HI) by summing these four scores [42]. A higher HI score indicates a lower level of well-being. Intraclass Correlation Coefficient (ICC) ranged from 0.72 to 0.88 for these parameters in this study, indicating good reliability. Each player's recovery status was assessed before the daily training session using the Total Quality Recovery Scale (TQR) [43] was used to assess each player's recovery status before their daily training session. The question "What is your condition now?" was used. On the TQR scale, 6 indicates "very, very poor recovery", while 20 indicates "very, very good recovery". Earlier research has measured athletes' perceived recovery using this scale [43]. The ICC for TQR was 0.87.

2.3.4 Pittsburgh sleep quality index

Subjective sleep quality during the preceding month was assessed using the validated Arabic version of the Pittsburgh Sleep Quality Index [44, 45]. There are seven components (19 items) of sleep covered by such an index: length, quality, latency, efficiency, disruptions, dysfunction throughout the day, and sleeping pills use. Scores range from 0 to 21, where 0 indicates no difficulties and 21 indicates serious issues in all areas of sleep.

2.3.5 Internal training load

Every session, the rating of perceived exertion (RPE) score was taken to assess the individuals' global training load. Approximately half an hour after the training sessions, participants were asked to rate the overall intensity of workout and games using the category ratio-10 RPE scale according to Lupo *et al.* [46] guidelines. The length (measured in minutes) was multiplied by the session's RPE to determine. We calculated the daily training or gaming load by multiplying the length (measured in minutes) by the session's RPE. Each athlete's daily workload over a week was added up to determine the weekly load. The ICC for RPE was 0.86.

Heart rate (HR) was constantly measure using Heart rate monitors (Polar Team Sport System, Polar-Electro OY, Kempele, Finland) during training interventions and was captured every 5 s. Players were advised to frequently check their HR monitors throughout training sessions and games to reduce HR recording inaccuracies. Absolute heart rate (HR) and maximum heart rate percentage (HRmax%) were used to express heart rate data. Each participant's HR data was relativized using the Yo-Yo Intermittent Recovery Test—Level 1 maximal

TABLE 2. Weekly training program during the experimental period for the 45-NAP group (NAP) and the control (CON) group.

Days	Training program for NAP and CON
Monday	- Warm up, 15 min - Specific basketball fundamental training, 15 min - Moderate strength training (Upper/Lower), 20 min - Ball drill transition training, 15 min - Technical/Tactical training, 20 min
Tuesday	- Warm up, 15 min - Moderate intensity shooting exercises, 35 min - Tactical training, 20 min - Liveliness training, 10 min - Free throw shooting, 5 min
Wednesday	- Match of four 10 min quarters (FIBA)
Thursday	- Warm up, 15 min - Stretching (dynamic/static), 5 min - Free throw shooting, 10 min - Moderate intensity shooting exercises, 30 min - Technical/Tactical training, 25 min
Friday	- Warm up, 15 min - Low intensity 3 pts shooting exercises, 30 min - Tactical training, 20 min - Liveliness training, 10 min - Free throw shooting, 10 min
Saturday	- Match of four 10 min quarters (FIBA)
Sunday	- Recovery

FIBA: International Basketball Federation.

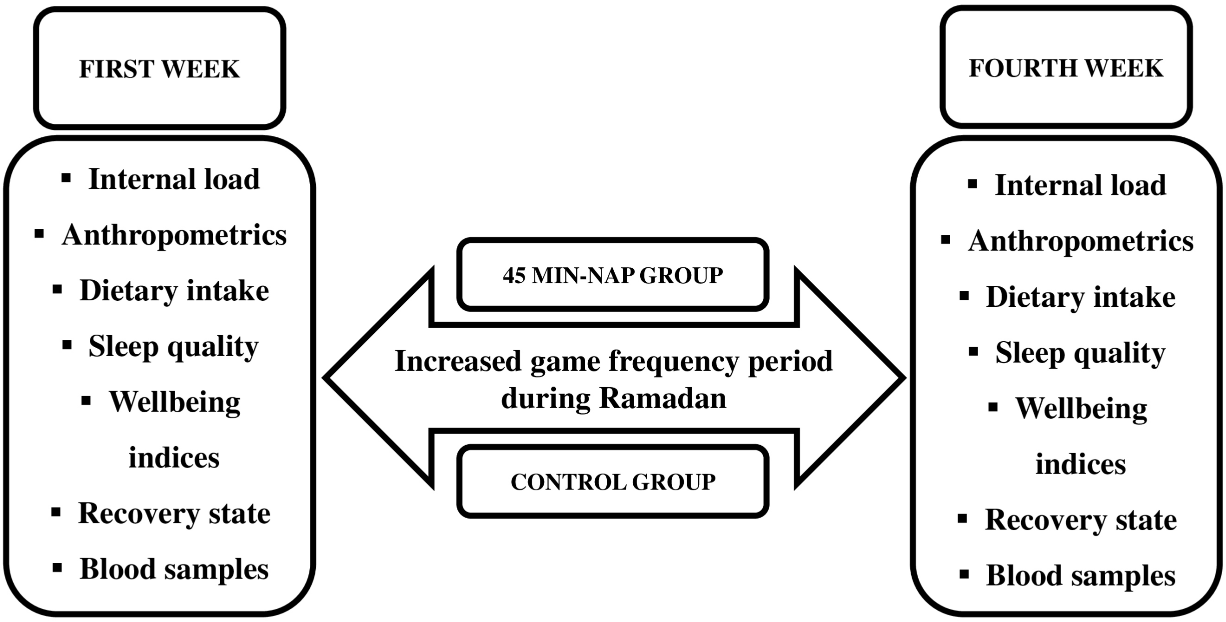

FIGURE 1. Experimental design.

HR (HRmax). To determine HRmax%, we used the formula HRmax% = (HR mean/HRmax) × 100, where HR mean stands for mean HR. The decision was made to utilize average HR (HRavg). For each period, the weekly HRavg was calculated using the average value for the full week.

2.3.6 Blood samples

During the first and fourth week of RIF (between 9.30 and 10 AM), blood samples were collected from the antecubital vein while the patient fasted to determine plasma C and T concentrations. Blood was collected 48 hours after the latest intense training session. Blood serum was kept cold until analyzed. An automated analyzer assessed plasma C and T levels using validated kits and the Enzyme Linked-Fluorescent-Assay method. The ICC for T and C was 0.95 and 0.97, respectively.

2.4 Statistical analysis

Using the G*Power program (Version 3.0, University of Dusseldorf, Dusseldorf, Germany) [47], an a priori power analysis was performed to establish the necessary sample size, with α set at 0.05 and power ($1-\beta$) set at 0.80. Using a power of 0.82, the study determined that 13 patients were sufficient to detect significant differences. Quantitative data means and standard deviations are shown. Following the Shapiro-Wilk test's confirmation of data's normality, baseline differences between groups were calculated using *t*-tests for independent samples. A 2-by-2 repeated measures analysis of variance (ANOVA) was conducted to examine the impact of napping on T/C ratio, body composition, nutritional intake, sleep patterns, weekly internal training load, and well-being indices (groups: NAP, CON) at week 1 and week 4. If an interaction effect was statistically significant, Bonferroni adjusted *post-hoc* tests were computed. Effect sizes (ES) were then calculated using Cohen's *d* to convert partial eta-squared to ANOVA output [48]. ES was classified as trivial (<0.2), small (0.2–0.6), moderate (0.6–1.2), large (1.2–2.0) and very large (2.0–4.0) based on Hopkins *et al.* [49]. A significance threshold of $p < 0.05$ was used. Data analysis was performed using SPSS 20.0 (SPSS Inc., Chicago, IL, USA).

3. Results

Throughout the study, no participants suffered test-related or training-related injuries. For NAP, adherence rates were 98.1%, while 97.9% for CON. NAP players averaged 24.5 ± 1.4 min per game compared to 23.3 ± 1.2 min for CON. Each measure examined showed no baseline differences between groups.

Table 3 illustrates changes in body composition and estimated daily nutritional intake over time. BF% showed a significant group-by-time interaction (p = 0.02; ES = 0.36, small). After the trial, both groups showed significant declines with favor NAP having a lower value (NAP: 8.12%; $p < 0.001$; ES = 0.21, small; CON: 2.72%; $p < 0.05$; ES = 0.16, trivial). Group-by-time interactions were significant when it came to the amount of carbohydrates consumed (p = 0.01; ES = 0.41, small). Both groups had substantial declines (NAP: 3.63%; $p < 0.001$; ES = 0.24, small; CON: 2.39%; $p < 0.001$; ES = 0.31, small).

Table 4 displays changes in sleep quality, well-being indices, recovery status and internal load after 4 weeks of RIF. RPE exhibited a significant group-by-time interaction (p = 0.02; ES = 0.35, small). RPE significantly increased for both groups, with a lower value favoring NAP (NAP: −12.96%; $p < 0.001$; ES = 0.14, trivial; CON: −23.52%; $p < 0.001$; ES = 0.15, trivial). HRavg also displayed significant group-by-time interactions (p = 0.002; ES = 0.55, small). HRavg decreased significantly in both groups (NAP: −1.50%; $p < 0.001$; ES = 0.27, small; CON: −0.84%; $p < 0.001$; ES = 0.17, trivial). Group-by-time interactions were significant when it came to TQR and DOMS (TQR (p = 0.02; ES = 0.38, small); DOMS (p = 0.04; ES = 0.30, small)). A better value in favor NAP was found (DOMS: (NAP: −26.08%; $p < 0.001$; ES = 0.48, small; CON: −35.06%; $p < 0.001$; ES = 0.49, small); TQR (NAP: +99.03%; $p < 0.001$; ES = 0.25, small; CON: +156.77%; $p < 0.001$; ES = 0.31, small)).

Figs. 2,3,4 show variations in T, C and T/C ratio during the experiment. A significant group-by-time interaction was found for the T/C ratio (p = 0.04; ES = 0.28, small). RIF resulted in significant decreases in both groups (NAP: −32.45%; $p < 0.001$; ES = 0.001, trivial; CON: −47.24%; $p < 0.05$; ES = 0.002, trivial).

4. Discussion

Male professional basketball players' T/C ratio, weekly internal training load, and psychometric factors were examined during an increased game frequency period crossing RIF with 45-min midday sleep. Both groups showed increased RPE and DOMS after RIF, with a better value in favor NAP. The study's findings also indicated that NAP had a better recovery condition than CON. Moreover, BF% decreased significantly at the end of the present experiment, with a lower value reported for NAP. Most of the results of this study support our hypothesis that daytime napping improves basketball performance. According to earlier studies [50, 51], RPE and HRavg were used to evaluate the weekly internal load throughout the experimental period. Weekly loads in this study were higher than those seen in basketball players under RIF conditions, but similar to training loads during the in-season (2400 arbitrary units) [5]. Both groups' RPE scores increased significantly at the conclusion of RIF, with a much smaller value favoring NAP. This may be explained by the fact that muscular exhaustion increased at the conclusion of RIF, due mainly to tiredness building up throughout the congested phase, which raised RPE and fatigue perception significantly. A previous study [10] indicated that RIF leads to more fatigue.

RIF leads to higher fatigue levels during training, sickness and injury rates, according to the elevated RPE score. Physical dysfunction may, in fact, increase perceived effort and cause weariness to set in sooner, causing sickness or injury [21]. NAP's lower RPE levels are in line with previous research. A 40-min sleep decreased RPE mean values by 12.4% [26], 16.7% [52] and 19.6% [23] after a 40-min sleep. Based on the findings, it is possible to assume that allowing players to sleep before official games and training sessions would reduce their perception of fatigue. Their RPE would decrease as a result of more recuperation opportunities. In this regard, Boukhris *et al.* [53] found a substantial association between physical performance and recovery, indicating that sleeping could help participants recover faster. Brotherton *et al.* [54] also showed that subjective mood and weariness ratings were favorably affected by one-hour sleep. Researchers hypothesized that better sleep might lead to better recuperation and lower perceived effort [54].

Both groups' final RIF values were significantly lower than their first week's values based on HRavg. HRavg declines for two main reasons. First, due to a poor recovery state and greater DOMS, cumulative muscular fatigue rose at the end of

TABLE 3. Body composition and estimated daily dietary intake recorded during the first and the fourth weeks of Ramadan intermittent fasting.

Variables	First week		Fourth week		*p* value (ES)		
	NAP	CON	NAP	CON	Time	Group	Group × Time
Body mass (kg)	89.4 ± 5.8	89.6 ± 6.7	85.5 ± 5.9	85.1 ± 7.3	<0.001 (0.96)	0.97 (0.01)	0.43 (0.05)
BMI (kg/m^2)	22.9 ± 1.5	23.0 ± 0.7	21.8 ± 1.6	21.9 ± 0.9	<0.001 (0.95)	0.88 (0.001)	0.38 (0.06)
Body fat (%)	12.1 ± 2.3	12.3 ± 2.5	11.1 ± 2.0	12.0 ± 2.5	<0.001 (0.66)	0.28 (0.09)	0.02 (0.36)
Total energy intake (kcal)	2766.4 ± 173.0	2811.4 ± 92.5	2217.9 ± 183.7	2369.3 ± 175.4	<0.001 (0.90)	0.02 (0.34)	0.25 (0.10)
Carbohydrate intake							
(g)	310.7 ± 19.8	309.3 ± 16.9	284.3 ± 16.0	297.1 ± 14.9	0.002 (0.54)	0.30 (0.08)	0.01 (0.41)
(%)	45.1 ± 3.6	44.0 ± 2.6	51.6 ± 5.6	50.4 ± 3.9	<0.001 (0.70)	0.31 (0.08)	0.91 (0.001)
Protein intake							
(g)	88.2 ± 5.0	86.5 ± 3.9	83.4 ± 4.7	83.0 ± 3.8	<0.001 (0.83)	0.51 (0.04)	0.20 (0.12)
(%)	12.8 ± 1.1	12.3 ± 0.6	15.1 ± 1.3	14.1 ± 1.4	<0.001 (0.80)	0.05 (0.26)	0.36 (0.06)
Fat intake							
(g)	122.9 ± 11.4	123.2 ± 9.3	95.1 ± 7.4	103.1 ± 12.7	<0.001 (0.81)	0.11 (0.18)	0.07 (0.10)
(%)	40.1 ± 4.3	39.5 ± 2.8	38.9 ± 4.3	39.1 ± 3.7	0.547 (0.03)	0.83 (0.004)	0.60 (0.02)

Data are reported as means and standard deviations. NAP: 45-NAP group; CON: control group; BMI: body mass index; ES: Effect size.

TABLE 4. Measurement of the subjective quality of sleep, well-being indices, recovery state and internal load recorded during the first and the fourth weeks of Ramadan intermittent fasting.

Variables	First week		Fourth week		*p* value (ES)		
	NAP	CON	NAP	CON	Time	Group	Group × Time
Quality of sleep							
Sleep latency (min)	14.78 ± 0.89	14.93 ± 0.92	14.86 ± 0.95	15.07 ± 1.14	0.428 (0.05)	0.58 (0.02)	0.79 (0.005)
Sleep efficiency (%)	94.36 ± 0.84	94.93 ± 1.07	94.57 ± 1.60	94.92 ± 1.64	0.659 (0.02)	0.13 (0.16)	0.79 (0.005)
Sleep duration (h)	9.71 ± 1.44	9.79 ± 1.53	7.00 ± 1.11	7.43 ± 0.94	<0.001 (0.74)	0.43 (0.05)	0.42 (0.05)
Total score of PSQI	4.78 ± 0.89	4.86 ± 0.95	4.43 ± 1.02	4.86 ± 0.86	0.417 (0.05)	0.35 (0.007)	0.47 (0.04)
Well-being indices							
Sleep (1–7)	3.92 ± 0.46	4.14 ± 0.69	6.35 ± 0.36	6.24 ± 0.38	<0.001 (0.95)	0.72 (0.01)	0.14 (0.16)
Fatigue (1–7)	3.86 ± 0.44	4.27 ± 0.64	5.65 ± 0.58	6.04 ± 0.78	<0.001 (0.91)	0.03 (0.31)	0.95 (0.000)
Stress (1–7)	3.61 ± 1.29	4.00 ± 1.03	5.88 ± 0.51	5.72 ± 0.61	<0.001 (0.84)	0.68 (0.01)	0.24 (0.10)
DOMS (1–7)	2.55 ± 0.61	2.22 ± 0.58	4.77 ± 0.53	5.27 ± 0.84	<0.001 (0.92)	0.44 (0.05)	0.04 (0.30)
HI	13.94 ± 1.92	14.64 ± 2.01	22.66 ± 1.34	23.28 ± 1.53	<0.001 (0.95)	0.15 (0.16)	0.91 (0.001)
Recovery state							
TQR (out of 28)	12.91 ± 1.42	13.66 ± 1.12	9.43 ± 1.01	8.80 ± 0.64	<0.001 (0.91)	0.77 (0.007)	0.02 (0.38)
Internal load							
RPE (0–10)	5.94 ± 0.53	5.91 ± 0.40	6.71 ± 0.30	7.30 ± 0.32	<0.001 (0.91)	0.02 (0.34)	0.02 (0.35)
W load	2397.86 ± 171.52	2359.28 ± 112.62	2584.29 ± 89.50	2674.28 ± 108.39	<0.001 (0.76)	0.47 (0.04)	0.10 (0.19)
HR average	167.45 ± 2.30	166.36 ± 2.61	164.93 ± 2.18	164.97 ± 2.62	<0.001 (0.93)	0.49 (0.04)	0.006 (0.52)

Data are reported as means and standard deviations. NAP: 45-nap group; CON: control group; HR: heart rate; RPE: The rating of perceived exertion; PSQI: sleep quality index; DOMS: delayed onset of muscle soreness; TQR: Total Quality Recovery; W load: weekly load; HI: Hooper Index (sum of scores for sleep, fatigue, stress and DOM); ES: Effect size.

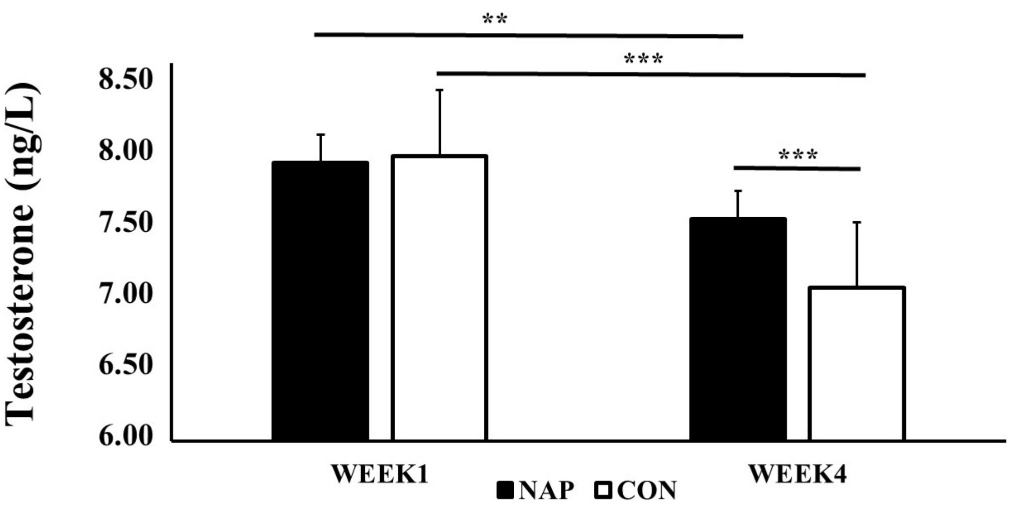

FIGURE 2. Testosterone variations during the first and the fourth weeks of RIF for both NAP and CON groups. Legends: NAP: 45-NAP group; CON: control group, **: $p < 0.01$; ***: $p < 0.001$.

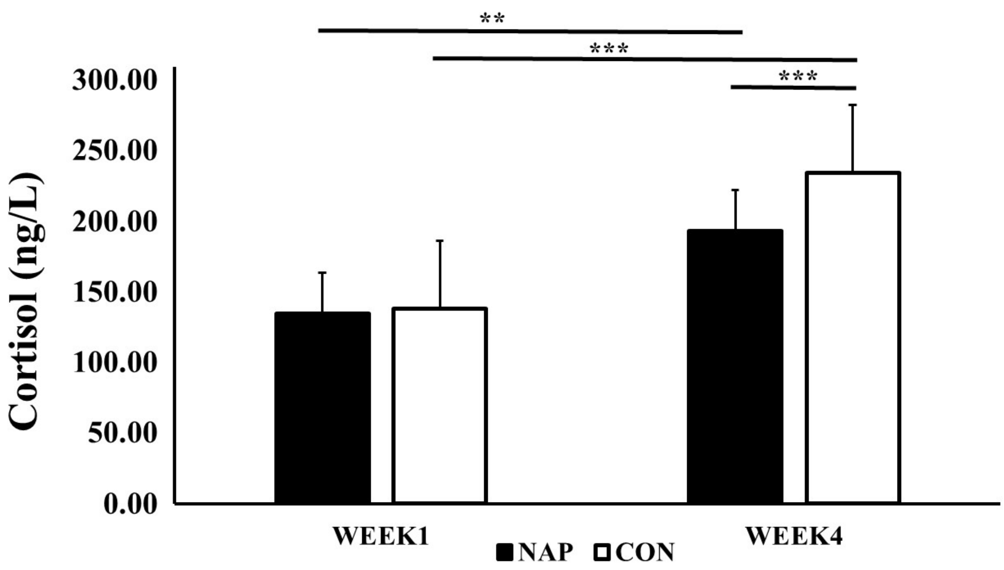

FIGURE 3. Cortisol variations during the first and the fourth weeks of RIF for NAP and CON groups. Legends: NAP: 45-NAP group; CON: control group; **: $p < 0.01$; ***: $p < 0.001$.

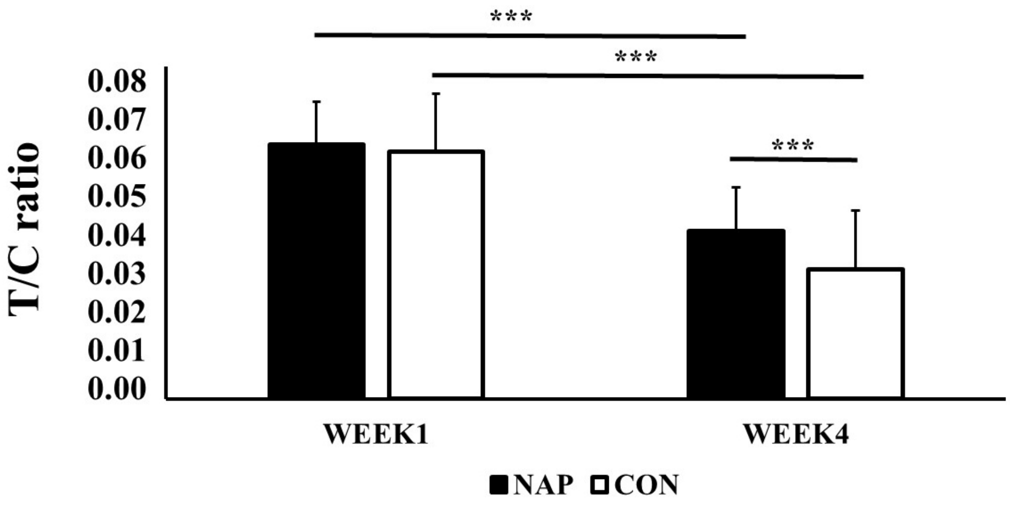

FIGURE 4. T/C ratio variations during the first and the fourth weeks of RIF for NAP and CON groups. Legends: NAP: 45-NAP group; CON: control group; T/C: Testosterone-to-cortisol ratio. ***: $p < 0.001$.

RIF. This resulted in an increase in tiredness during training and sports, which prevented HRavg from reaching high values [7]. Second, RIF also affects hormonal and metabolic factors. BaHammam and Almeneessier [55] elucidated that fasting is associated with catecholamine inhibition and decreased venous return, leading to a drop in sympathetic tone. Consequently, cardiac output, HR and blood pressure drop. Additionally, naps may reduce stress by lowering HRmax during exercise and cortisol levels [3, 56].

Both groups experienced a negative impact on night sleep quality at the end of the experimentation, which is considered a vital component of effective training, competition and recuperation [57]. We found similar findings to those Brini *et al.* [5] had previously published on professional basketball players. According to Prasetya *et al.* [15], sleep deprivation caused by repetitive stress fractures may interfere with the sleep-wake cycle, leading to increased tiredness and decreased cognitive and physical abilities. Bouzid *et al.* [58] also found that Muslim athletes often get up early and eat before dawn to prepare for RIF after notable diurnal fluctuations. Sleep loss or fragmentation may impair their athletic performance [58]. During RIF, Muslims adopted a culture characterized by staying up late at night, which may explain no differences in night sleep quality between groups.

A significant decrease in BF% for both groups was noted after the RIF, with NAP having a lower value. Throughout RIF, basketball players' body composition reduced, consistent with other articles [5, 11]. Variations were often related to lifestyle modifications made during RIF, including sleep schedules, physical activity levels, food intake, meal frequency and dietary habits. Athletes who attempted to compete physically during this demanding period suffered particularly [5]. Additionally, the substantial weight loss may be explained by a decrease in fluid consumption [59, 60], a decrease in water storage bound to glycogen [10] and a decrease in total calories and macronutrients. It has been found that little body fat was lost during RIF, which has been attributed to the observed change in body composition [11, 12, 14]. Despite the fact that we do not have a strong scientific explanation for the significant lower BF% in favor of NAP during the current investigation, we believe that NAP, by having a better recovery (a sufficient nap opportunity) before the training sessions and games, allows for better body energy, which leads to greater physical effort and heigh-intensity actions, which stimulates metabolism. This topic could be better explained in the future by in-depth studies using sophisticated measurement tools. Psychometric indicators were significantly altered in both groups. DOMS and TQR highlighted adverse impacts in the fourth week relative to RIF start for both groups, with better value documented in support of NAP. Research into basketball and team sports generally supports this study [5, 23]. During RIF, players may experience partial sleep deprivation if they alter their daily routines (*e.g.*, rising earlier and having breakfast before sunrise). This may have an adverse effect on the higher cognitive centers of the central nervous system, which might harm mental activity and be one of the primary causes of performance declines [10, 61]. Wan *et al.* [62] suggest that tiredness may modify neurotransmitter activity and/or reduce muscle glycogen depletion, which may impair cognitive and motor skills. Souabni *et al.* [3] also confirmed the beneficial effects of daytime napping on recovery and preventing muscle fatigue among professional basketball players under normal circumstances. A 40-min daytime nap may reduce fatigue, anger, anxiety and boost vigor, resulting in better technical and tactical performance.

Concerning the T/C ratio, our findings revealed a significant decrease for NAP and CON at the end of RIF, with a higher value for CON. A decrease in testosterone levels and an increase in cortisol levels were observed during this study as a result of the end of RIF, which had a negative effect on fatigue sensations, increased stress, and recovery states among basketball players [5, 7, 12]. In general, testosterone variations among athletes are controversial and extremely dependent on type, intensity, and duration of effort. During RIF, testosterone levels may be affected by nutritional and chronobiological changes [12]. The fact that not getting enough sleep can elevate cortisol, thus raising stress, especially during RIF [3, 12, 56], may be a normal explanation for the higher cortisol value in favor of CON.

5. Limitations

Although this study adds unique data, several limitations should be considered. Time-motion variables, such as distance traveled and frequency of sprints and high-intensity runs, were left out, which would have added another layer of data. Volunteer type and quantity may influence outcomes. It is quite likely that research on a larger and more diverse population would yield different outcomes. Exclusion of other groups (*e.g.*, control groups devoid of sports and training, groups that do not observe Ramadan, *etc.*). Additionally, this study uses a quasi-experimental design without random assignment, which makes establishing a cause-and-effect relationship difficult. It uses pre-existing groups, which limits the ability to draw causal conclusions. Furthermore, baseline measurements should have been taken prior to the RIF. A future study is needed to address this gap regarding naps and nighttime sleep. Last but not least, Ramadan's season must be considered. Research examining Ramadan in other meteorological conditions may yield different conclusions.

6. Conclusions

This study demonstrated that including a daytime nap opportunity during an increased game frequency period, crossing RIF led to better recovery in professional basketball players. This study should, however, be interpreted with caution due to certain major limitations.

7. Practical applications

• Professional basketball players are advised to schedule a nap before practice and/or competition during periods of increased game frequency crossing RIF to reduce stress and fatigue and improve performance.

• Basketball coaches and physical trainers should plan some 45-minute daytime naps during increased game frequency crossing RIF to overcome any sleep loss and/or improve physical and cognitive performance.

• The use of some hormonal and psychometric parameters during an increased basketball game frequency crossing RIF, such as T/C, RPE, DOMS and TQR, could be a successful and accessible strategy to control fatigue and manage the impacts of this critical period.

ABBREVIATIONS

ANOVA, analysis of variance; BF%, body fat percentage; C, cortisol; CON, control group; DOMS, delayed onset of muscle soreness; ES, effect sizes; HR, Heart rate; HRavg, average HR; HRmax, maximum heart rate; HR mean, mean heart rate; HI, Hooper's Index; NAP, nap group; RIF, Ramadan intermittent fasting; RPE, rating of perceived exertion; T, testosterone; T/C, testosterone to cortisol ratio; TQR, Total Quality Recovery.

AVAILABILITY OF DATA AND MATERIALS

The datasets generated during and analyzed during the current study are not publicly available due to confidential participant information. Still, they are available from the corresponding author on reasonable request.

AUTHOR CONTRIBUTIONS

SB, UG, HN, FHY and LPA—conceived and designed the investigation. SB, JCG, JAK, FHY and SME—dealt with writing-original draft preparation. SB and JAK—analyzed and interpreted the data. JRG, JCG, FMC, MHA and SME—dealt with writing-review and editing. SB, HN, FHY, FMC, MHA, SME, GB and JRG—drafted the paper. All the authors critically reviewed the paper and approved the final version submitted for publication.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was conducted during the competitive season. It was approved by a local Clinical Research Ethics Committee (approval No. 1/2018) and the protocol was conducted according to the Declaration of Helsinki. All participants provided their written informed consent to participate in the study.

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CONFLICT OF INTEREST

The authors declare no conflict of interest. Georgian Badicu is serving as one of the Editorial Board members of this journal. We declare that Georgian Badicu had no involvement in the peer review of this article and has no access to information regarding its peer review. Full responsibility for the editorial process for this article was delegated to DM.

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