Increases in game frequency during Ramadan intermittent fasting decreases fat mass, sleep duration, and recovery in male professional basketball players

Seifeddine Brini [Corresp., Equal first author, 1], **Luca Paolo Ardigò** [Corresp., Equal first author, 2], **Filipe Manuel Clemente** [3, 4, 5], **Javier Raya-González** [6], **Jennifer A. Kurtz** [7], **Gretchen A. Casazza** [8], **Carlo Castagna** [9, 10], **Anissa Bouassida** [11], **Hadi Nobari** [12, 13, 14]

1 Research Unit, Research Unit, Sportive Performance and Physical Rehabilitation, University of Jendouba, Kef, Tunisia, Kef, --- Select One ---, Tunisie
2 Department of Teacher Education, NLA University College, Oslo, Norway, Oslo, Norway
3 Escola Superior Desporto e Lazer, Instituto Politécnico de Viana do Castelo, Viana do Castelo, Portugal, Viana do Castelo, Portugal
4 Research Center in Sports Performance, Recreation, Innovation and Technology (SPRINT), Melgaço, Portugal, Melgaço, Portugal
5 Delegação da Covilhã, Instituto de Telecomunicações, Lisboa, Portugal, Lisboa, Portugal
6 Facultyof Sport Sciences, University of Extremadura, Cáceres, Spain, Cáceres, Spain
7 Department of Kinesiology and Health, Georgia State University, Atlanta, Alabama, USA, Atlanta, USA
8 Department of Kinesiology, California State University, Sacramento, California, USA, California, USA
9 Department of Biomolecular Sciences, School of Sport and Heath Sciences, University of Urbino "Carlo Bo", Urbino, Italy, Urbino, Italy
10 Department of Sports Science and Clinical Biomechanics, SDU Sport and Health Sciences Cluster (SHSC), University of Southern Denmark, Odense, Denmark, Odense, Denmark
11 Research Unit, Research Unit, Sportive Performance and Physical Rehabilitation, University of Jendouba, Kef, Tunisia, Kef, Tunisie
12 Faculty of Sport Sciences, University of Extremadura, Cáceres, Spain, Caceres, Spain
13 Department of Exercise Physiology, Faculty of Educational Sciences and Psychology, University of Mohaghegh Ardabili, Ardabil, Iran, Ardabil, Iran
14 Department of Motor Performance, Faculty of Physical Education and Mountain Sports, Transilvania University of Braşov, Braşov, Romania, Braşov, Romania

Corresponding Authors: Seifeddine Brini, Luca Paolo Ardigò
Email address: bseifeddine15@gmail.com, luca.ardigo@univr.it

Background: Increased physiological load combined with intermittent fasting can affect athlete overall well-being and recovery. The objective of the present investigation was to assess the impacts of increased game frequency, as a measure of increased physiological load, on body composition, sleep habits, indices of well-being, recovery state and dietary intake in professional male basketball players during Ramadan intermittent fasting (RIF).

Methods: Twenty-eight professional basketball players participated in this study and were divided into increased-games-frequency (INCR) or normal games-frequency (NORM) groups. INCR trained four times and completed two games per week, whereas NORM completed only one game per week. During the first and fourth weeks of RIF, the following variables were assessed: internal-load (weekly session rating-of-perceived-exertion [s-RPE}, heart-rate [HR]), dietary-intake, body-composition, sleep-quality (PSQI survey), well-being indices questionnaire (sleep, fatigue, stress, delayed-onset-of-muscle-soreness [DOMS]), and recovery state with the Total Quality Recovery (TQR) questionnaire.

Results: Bonferroni post-hoc tests revealed increased internal load after 4 weeks of RIF in INCR compared to NORM. In addition, a significant decrease in session-average HR, sleep duration and recovery and increased DOMS. Both groups experienced a decrease in body mass and fat mass that was greater in INCR compared to NORM.

Conclusion: Basketball players are significantly affected by increased game frequency (physiological load) during Ramadan with larger decreases in sleep duration, carbohydrate intake, and recovery state and increased DOMS; all of which could affect exercise performance and health.

Research article

Increases in game frequency during Ramadan intermittent fasting decreases fat mass, sleep duration, and recovery in male professional basketball players

Seifeddine Brini [1,*,#], Luca Paolo Ardigò [2,*,#], Filipe Manuel Clemente [3,4,5], Javier Raya-González [6], Jennifer A. Kurtz [7], Gretchen A. Casazza [8], Carlo Castagna [9,10], Anissa Bouassida [1], Hadi Nobari [11,12,13]

[1] *Research Unit, Research Unit, Sportive Performance and Physical Rehabilitation, University of Jendouba, Kef, Tunisia; bseifeddine15@gmail.com; bouassida_anissa@yahoo.fr*

[2] *Department of Teacher Education, NLA University College, Oslo, Norway; luca.ardigo@nla.no*

[3] *Escola Superior Desporto e Lazer, Instituto Politécnico de Viana do Castelo, Viana do Castelo, Portugal; filipe.clemente5@gmail.com*

[4] *Research Center in Sports Performance, Recreation, Innovation and Technology (SPRINT), Melgaço, Portugal;*

[5] *Delegação da Covilhã, Instituto de Telecomunicações, Lisboa, Portugal;*

[6] *Facultyof Sport Sciences, University of Extremadura, Cáceres, Spain; rayagonzalezjavier@gmail.com*

[7] *Department of Kinesiology and Health, Georgia State University, Atlanta, Alabama, USA; jkurtz2@gsu.edu*

[8] *Department of Kinesiology, California State University, Sacramento, California, USA; gcasazza@csus.edu*

[9] *Department of Biomolecular Sciences, School of Sport and Heath Sciences, University of Urbino "Carlo Bo", Urbino, Italy; castagnac@libero.it*

[10] *Department of Sports Science and Clinical Biomechanics, SDU Sport and Health Sciences Cluster (SHSC), University of Southern Denmark, Odense, Denmark;*

[11] *Department of Exercise Physiology, Faculty of Educational Sciences and Psychology, University of Mohaghegh Ardabili, Ardabil, Iran; hadi.nobari1@gmail.com*

[12] *Department of Motor Performance, Faculty of Physical Education and Mountain Sports, Transilvania University of Braşov, Braşov, Romania;*

[13] *Faculty of Sport Sciences, University of Extremadura, Cáceres, Spain*

[*] ***Correspondence:*** *luca.ardigo@nla.no; bseifeddine15@gmail.com*.

[#] ***These authors share first authorship***

Abstract:

Background: Increased physiological load combined with intermittent fasting can affect athlete overall well-being and recovery. The objective of the present investigation was to assess the impacts of increased game frequency, as a measure of increased physiological load, on body composition, sleep habits, indices of well-being, recovery state and dietary intake in professional male basketball players during Ramadan intermittent fasting (RIF).

Methods: Twenty-eight professional basketball players participated in this study and were divided into increased-games-frequency (INCR) or normal games-frequency (NORM) groups. INCR trained four times and completed two games per week, whereas NORM completed only one game per week. During the first and fourth weeks of RIF, the following variables were assessed: internal-load (weekly session rating-of-perceived-exertion [s-RPE}, heart-rate [HR]), dietary-intake, body-composition, sleep-quality (PSQI survey), well-being indices questionnaire (sleep, fatigue, stress, delayed-onset-of-muscle-soreness [DOMS]), and recovery state with the Total Quality Recovery (TQR) questionnaire.

Results: Bonferroni post-hoc tests revealed increased internal load after 4 weeks of RIF in INCR compared to NORM. In addition, a significant decrease in session-average HR, sleep duration and recovery and increased DOMS. Both groups experienced a decrease in body mass and fat mass that was greater in INCR compared to NORM.

Conclusion: Basketball players are significantly affected by increased game frequency (physiological load) during Ramadan with larger decreases in sleep duration, carbohydrate intake, and recovery state and increased DOMS; all of which could affect exercise performance and health.

Keywords: team sport; fatigue; delayed onset of muscle soreness (DOMS), nutrition, wellbeing, sleep quality

INTRODUCTION

Basketball is a demanding team sport in which the on-court success depends on technical-tactical skill as well as physiological variables such as cardiovascular fitness, speed, agility, power, and strength (O Brien et al.,2020; Petway et al.,2020; Stojanović et al., 2018). Previous studies have reported that performance measures (e.g., shooting accuracy, decision making and sports specific motor performance (Ardigò et al., 2018; Padulo., 2015., Padulo et al., 2018)) can be negatively affected by an athlete's physiological or mental fatigue state (e.g., overtraining, congested games period or inadequate nutrition (Brini et al., 2020; Clemente et al., 2019; Edwards et al., 2018; Fox et al., 2022; García et al., 2022). In this context, several studies have monitored and quantified the physiological load (session rate of perceived exertion (s-RPE), heart rate (HR), blood lactate concentration, etc.) in basketball during training sessions and matches to manage the players' fatigue during any phase of the sports season (Fox et al., 2022 Conte et al., 2018 Fox et al., 2017; Moreno-Villanueva et al., 2022). Different circumstances could influence the s-RPE values in basketball, such as congested schedules with multiple matches played in close succession (Edwards et al., 2018), the weekly workloads encountered by players (Conte et al., 2018) and tapering strategies (Edwards et al., 2018; Fox et al., 2022; Conte et al., 2018).

In addition, congested game periods may coincide with special situations, such as the Ramadan intermitting fasting (RIF), which represents an added stress, especially for Muslim players who continue professional sports during RIF with no modified sports calendar (Brini et al., 2018; Kirkendall., 2008). The RIF requires that adult Muslims complete only two daily meals (before sunrise and after sunset (Zerguini et al., 2007). Additionally, the RIF is associated with significant changes in lifestyle rhythms (Nobari et al., 2022), body composition (Brini et al., 2020), sleep (Roky et al., 2004), biochemical variables (Brini et al., 2021) and physical activity level, which could influence sport performance (Brini et al., 2020; Nobari et al., 2022; Brini et al., 2020; Roky et al., 2004; Brini et al., 2021; Chaouachi et al., 2008; Memari et al., 2011). In this context, Mujika et al., (2010) suggested Muslim athletes may reduce the training load during the RIF. Recently, Brini et al. (2021) reported significantly greater decreases in body mass (4%), body fat percentage (9%), total energy intake (20%), carbohydrate intake (8%), protein intake (6%), sleep duration (29%) and sleep quality (22%) (using the Pittsburgh Sleep Quality Index (PSQI)) after 4 weeks of RIF in profession male basketball players. Players also reported significant increases in s-RPE after RIF. Moreover, these researchers reported that technical performances were negatively affected independent of changes in body composition, sleep habits, and s-RPE. This study had only 1 game pre week. To the best of our knowledge there are no studies which have investigated the specific impact of an increased games frequency period (more than one game per week) during the RIF, on body composition, sleep quality, wellbeing and recovery in basketball players.

Therefore, the aim of this study was to examine the changes in body composition, internal load, sleep habits, well-being indices, recovery state and dietary intake with an increased game frequency (2 versus 1 game per week) during the RIF in male professional basketball players. Based on previous studies (Fox et al., 2017; Fox et al., 2022; Conte et al., 2018 Brini et al., 2020), we hypothesized that the time coincidence of RIF and an increase in basketball games would negatively affect the sleep habit, well-being indices, recovery state and dietary intake in professional male basketball players.

MATERIELS AND METHODS

Study Design

A longitudinal study design was applied to assess the effects of increased game frequency during RIF on professional basketball players' body composition, dietary intake, sleep habits, well-being indices and recovery state. Participants were divided into groups (an increased game frequency group [INCR, n=14] and normal game frequency group [NORM, n=14]). Overall, the study lasted five weeks and was conducted during the 2021/2022 basketball season, coinciding with the RIF (from April until May). The daily fasting length was 15–16 h (temperature: 25.3±3.4 °C; relative humidity: 43.1±9.8%; training session time: between 5:00 and 6:30 p.m.; game time: between 4:00 and 6:00 p.m.). During the RIF period, INCR trained four times per week and completed two games per week (Wednesday and Saturday), whereas NORM trained five times per week and completed one game per week (Saturday). Changes in weekly internal load (sum of all daily session RPE * session durations), dietary intake, body composition, well-being indices (sleep, fatigue, stress, delayed-onset-of-muscle-soreness [DOMS]), recovery state with the Total Quality Recovery (TQR) questionnaire and sleep quality (PSQI) were investigated during the first and the fourth week of the RIF for both groups (Figure 1).

*******Please insert Figure 1 near here*******

Participants

The power of the simple size was calculated using G*Power v. 3.0 software (Heinrich Heine University Düsseldorf, Düsseldorf, Germany). A total of twenty-eight basketball players competing in the Tunisian league first division volunteered to participate in this study (Table 1). For both groups, players had similar training experience (13.12±1.21 years) and weekly practice load (≈8 h). The baseline physical fitness and technical skill levels were measured (Delextrat et al., 2013) and no significant differences between groups were found. Each team included three guards, three shooting guards, three small for-wards, three forwards and two centers. The inclusion criteria for study participation were: (1) participation in at least 90% of the training sessions during the RIF period; (2) participants were fasting all over the experimental period; (3) free of injuries the two months prior to RIF (4) and not taking any supplements, medications or other drugs. All participants were informed about the purposes, benefits and risks associated with the study and provided written informed consent to participate. The investigation was approved by the local Clinical Research Ethics Committee of the Heigh Institute of Sports and Physical Education of kef, University of Jandouba, kef, Tunisia (approval No. 4/2018) and the protocol was performed according to the Declaration of Helsinki.

*******Please insert Table 1 near here*******

Procedures

Familiarization sessions were conducted for all participants before beginning of the experimentation. Participant were instructed to wear the same footwear and the training and testing sessions were conducted at the same time of day. All over the experimental period training duration (~90 min per session). Training sessions for INCR and NORM started with warm-up followed by basketball specific (technical/tactical drills), specific basketball movements, basketball technique fundamentals and basic defensive. (Table 2).

*******Please insert Table 2 near here*******

Assessment

Internal Load Monitoring

The RPE was recorded Thirty minutes following each training session using Borg's 10-point Likert scale according to the methods described by Foster et al. (2001). The s-RPE was calculated by multiplying the session duration (minutes) by the session RPE. The weekly load was then determined by summing the daily loads (s-RPE) for each athlete during each week.

Heart rate was continuously monitored throughout the training intervention using heart rate (HR) monitors (Polar Team Sport System, Polar-Electro OY, Kempele, Finland) and was recorded at five-second intervals. The relative HR for each participant was obtained from the Yo-YoIR1. The following formula was used to calculate %HRmax: [%HRmax=(HRmean/HRmax) ×100]. Weekly HRavg was calculated by the average value for the entire week for each period.

Anthropometrics

Height was measured in cm with a precision of 0.1 cm using a portable stadiometer (Seca, Maresten, UK). Participants were weighed wearing light clothes and without shoes using an electronic balance (Soehnle Pharo 200 Analytic, Soehnle Industrial Solutions GmbH, Backnang, Germany), with a precision of 0.1 kg and the body mass index (BMI) was calculated by dividing the weight (kg) by the square of the height (m). The four site skinfolds method (biceps, triceps, sub-scapular and suprailliac skin folds) was used to determine the body fat percentage. A caliper (Harpenden caliper) was utilized during this technique. Body fat percent-age was then calculated: BF% = ((4.95/body density) −4.5) ×100 (body density=1.1631–0.0632·log of the sum of four skin folds) (Sisic et al., 2015). Anthropometric measurements were taken according to the International Society for the Advancement of Kinanthropometry (ISAK) recommendations. The same qualified technician took all these measures.

Dietary Intake

Participants noted all meals consumed throughout the experimental period, noting and recording the amounts and types of food and fluid consumed. Additionally, they were interviewed and a nutritionist analyzed data by means of the software program Bilnut (Nutrisoft Bilnut: Food Survey Program version 2.01) and the food-composition tables of the Tunisian National Institute of Statistics (Hammouda et al., 2013).

The Pittsburgh Sleep Quality Index

The validated Arabic version of the Pittsburgh Sleep Quality Index (Suleiman et al.,2009) was used to assess subjective sleep quality during the RIF (Buysse et al.,1989). It comprised 19 questions covering seven components of sleep: duration, quality, latency, efficiency, disturbances, daytime dysfunction and the use of sleeping medications. The total score ranges from 0 to 21, where “0-4” designates good sleep and “5-21” indicates poor sleep in all sleep areas.

Psychometric Markers

Fifteen minutes before the warm-up, each player was asked to complete ratings of well-being indices (quality of sleep, fatigue, stress and delayed onset of muscle soreness [DOMS]) considering the timeline from the last (training or match) session until the moment of the new session. Players rated each index using a scale from 1 to 7 points, where one 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) (Sampaio et al., 2009). The sum of these four scores was used to calculate the Hooper Index (HI (Ouergui et al., 2020). A higher HI score indicates a more negative state of well-being. After each player completed the well-being indices, the recovery state was evaluated using the Total Quality Recovery (TQR) scale (Selmi et al., 2018). The TQR scale ranges from 6 to 20, where 6 indicates “very, very poor re-covery” and 20 indicates “very, very good recovery.” Previous studies have used this scale as an indicator of athletes’ perceived recovery (Selmi et al., 2018).

Statistical Analyses

The statistical analyses were computed using SPSS for Windows, version 20.0 (SPSS Inc., Chicago, IL, USA). The cutoff esteem was set to be $p \leq 0.05$ for all measures to represent statistical significance. The normality was tested and confirmed using the Shapiro–Wilk test and data were presented as means and standard deviations (SD). Baseline values were compared using t-tests for independent samples. The variation of all measures was compared using a 2 (groups: INCR, NORM) ×2 (time: week1, week4) repeated measures ANOVA. The Bonferroni corrected post-hoc tests were performed if significant interactions were found. Additionally, effect sizes (ES) were determined from ANOVA output by converting partial eta-squared to Cohen’s d (1973). Following Hopkins et al. (2009), ES were considered 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). In order to examine the relationship between weekly internal load, sleep habits, dietary intakes, recovery state and well-being indices at the end of the experimental period, Pearson’s linear correlation coefficient was used. The magnitude of the correlation was expressed as trivial: r<0.1; low: 0.1–0.3; moderate: 0.3–0.5; large: 0.5–0.7; very large: 0.7–0.9; nearly perfect > 0.9 and perfect: 1.

Results

All over the experimentation we didn't notice several injuries. No significant differences between groups concerning adherence (97.8% for INCR and 97.6% for NORM) and playing time per game (21.3±1.2 min for INCR and 20.8±1.9 min for NORM).

Changes in body composition and estimated daily dietary intake during the experimental period are presented in Table 3. Significant group x time interaction was observed for BM (p=0.006, ES=0.46, small), FM () and for BF% (p=0.025, ES=0.33, small) with INCR having a greater decrease in all these values. Bonferroni corrected post hoc tests revealed a significant decrease in BM, FM and BF% at the end of the experimental period for both groups (INCR: 3.63%, p<0.001, ES=0.24, small; NORM: 2.39%, p<0.001, ES=0.31, small); and BF% (INCR: 7.99%, p<0.001, ES=0.21, small; NORM: 2.74%, p<0.05, ES=0.18, trivial; respectively).

*******Please insert Table 3 near here*******

Significant group x time interaction was observed for a greater decrease in carbohydrate intake in INCR compared to NORM (p=0.010, ES=0.44, small). Bonferroni corrected post hoc tests revealed significant decrease for the INCR (8.32%, p<0.001, ES=3.75, large).

In Table 4 are shown changes in quality of sleep, well-being indices, recovery state and internal load after 4 weeks of RIF. There was a significant group x time interaction for RPE (p=0.025, ES=0.33, small) with INCR have a larger increase after 4 weeks of RIF. Bonferroni corrected post hoc tests revealed significant increases for both groups in RPE (INCR: -22.63%, p<0.001, ES=0.16, trivial; NORM: -12.52%, p<0.001, ES=0.15, trivial; respectively). There was also a significant group x time interaction for HR average (p=0.002, ES=0.55, small) with INCR having a greater decrease. Bonferroni corrected post hoc tests revealed significant decrease in HR average for both groups (INCR: 1.54%, p<0.001, ES=0.25, small; NORM: 0.79%, p<0.001, ES=0.16, trivial; respectively). There were significant group x time interactions for sleep duration, TQR and DOMS (p=0.009, ES=0.41, small; p=0.039, ES=0.29, small; p=0.045, ES=0.28, small; respectively) with INCR having the greater decrease in sleep duration and TQR and greater increases in DOMS. Bonferroni corrected post hoc tests revealed significant decrease of TQR, sleep duration and a significant increase of DOMS only for INCR (26.93%, p<0.001, ES=0.48, small; 33.83%, p<0.001, ES=0.40, small; 161.17%, p<0.001, ES=0.32, small; respectively).

*******Please insert Table 4 near here*******

Correlation analysis showed that BF% was negatively correlated with HR average (p=0.024, r=-0.42, large magnitude), DOMS was positively correlated with RPE (p=0.024, r=0.42, large magnitude), and sleep duration was positively correlated with percentage of changes in HR (p=0.016, r=0.45, large magnitude).

Discussion

The current investigation aimed to assess the effects of an increased games frequency period during RIF on professional basketball players' body composition, sleep habits, well-being indices, recovery state and dietary intake. The main results showed a greater decrease in body mass, % body fat, fat mass, carbohydrate intake, sleep duration, average session HR and recovery in INCR versus NORM. INCR also had greater increases in session RPE and DOMS at the end of the experimental period compared to NORM. In general, the combination of RIF and increased basketball games frequency period negatively affected sleep, well-being, recovery state and dietary intake in professional basketball male players.

Weekly Internal Load

The weekly load values obtained during the current study were similar to those reported in prior studies in basketball field (Fox et al., 2021; Fox et al., 2017), which were conducted during the regular competitive season period (2400 AU). However, our values were higher than observed in basketball players before and after RIF in a study by Brini et al. 2021, although in that study the players only trained 2 times per week and had no games during RIF. Concerning the s-RPE variability, our findings showed a significant increase in s-RPE scores at the end of the RIF for both groups, with a significantly higher increase in favor of INCR. This could be explained by increased muscle fatigue and damage at the end of RIF, primarily because of the congested games period. This explanation concords with previous research that reported decreased muscle power and higher RPE during RIF (Chtourou et al., 2011). The increased muscle damage due to the greater intensity of games versus practice combined with lower carbohydrate ingestion and thus possibly lower muscle glycogen levels could explain the higher RPE in the INCR group. In the same context, Leiper et al., (2008) reported that decreases in physical function can increase perceived exertion and lead to an earlier onset of fatigue and which may increase risk of injury.

Concerning HR average and %HRmax, the present investigation revealed a significant decrease at the end of Ramadan for both groups compared with the first week. This decrease in the HR may be justified by the accumulated muscle fatigue observed at the end of the RIF. The lower recovery state associated with a higher DOMS index resulted in more significant fatigue in the players and a lack of high-performance effort during training and games. Internal (hydration status, emotional state), environmental (temperature, humidity), technical and activity-specific factors may influence HR responses. For example, HR responses may vary due to natural variation since HR data were collected across multiple training sessions or games spanning several weeks. In the same context, Al Suwaidi et al. (2006) explained this decrease by the interaction between the fast state, catecholamine inhibition and reduced venous return which may decrease the sympathetic tone, leads to a decrease in blood pressure, HR and cardiac output.

Sleep Quality

Several investigations showed the importance of sleep as a crucial component of successful training, competition and recovery (Samuels, 2008). In this sense and following significant diurnal changes, Muslim athletes tend to prepare for RIF by several habits' changes (i.e., sleeping and eating time and frequency) (Waterhouse et al., 2009). As a result, they likely suffer from sleep loss or sleep fragmentation, which may reduce athletic performance (Waterhouse et al., 2009). The result of the present study revealed an adverse effect of the RIF only on sleep duration which supports the findings of Brini et al. (2021) in a prior study conducted with professional basketball players. The decrease in sleep duration was greater in the INCR group. In the same context, Roky et al. (2004) reported that sleep loss accumulated during RIF may disrupt the sleep–wake cycle, leading to more fatigue and reducing mental and physical performance. This information must be considered by practitioners in order to adapt their recovery strategies during RIF.

Body Composition and Dietary Intakes

Our results revealed a decrease in BM, FM and BF% for both groups recorded at the end of the RIF. Our findings are in the same line with previous studies in athletes and basketball players more specifically (Brini et al., 2020; Memari et al., 2011). In general, these variations are due to changes in lifestyle during the RIF in variables such as sleep hours, physical activities, food consumption, frequency of meals and dietary patterns for different reasons, especially for athletes who try to maintain their physical performance during this extreme and exhaustive period. In addition, the significant body mass reduction noticed at the end of the RIF in the current study may also be attributed to the decrease in fluid intake (Baklouti et al., 2017; Beltaifa et al., 2004), the decrease in glycogen-bound water stores (Chtourou et al., 2011) and the reduction in total energy and macronutrient intake. Moreover, these observed decline in body composition is attributed to a decrease in fluid intake and hypohydration with little body fat loss (Brini et al., 2020; Chaouachi et al., 2008; Memari et al., 2011). Future studies exploring the game frequency-dependent effects of RIF on body composition should strictly measure the hydration status of participants to better account for the potential confounding influence of this factor on study results.

Markers of Well Being

The most interesting findings about the wellbeing markers were the reported increase in DOMS and decrease in TQR values, which were more negatively affected in the fourth week compared with the beginning of RIF for INCR. Our results were similar to previous studies in team sports and basketball (Brini et al., 2021). Those studies reported that changes in the daily habits of players during RIF, such as rising earlier and eating a meal before sunrise, may affect them by partial sleep deprivation, which will affect the higher cognitive centers of the central nervous system, which negatively affect mental activity, which has been posited as one of the main reasons for performance decrements (Chtourou et al., 2011; Fashi et al., 2021; Smith et al., 2016). In the same context, Davis (2000) reported that fatigue might reduce muscle glycogen depletion and/or alter neurotransmitter activity that could, in turn, negatively influence cognition and motor skill performance. The lower carbohydrate intake with INCR could also have negatively affected muscle and liver glycogen stores and thus cognitive function.

Finally**,** our investigation has some limitations especially in some parameters which were not measured such as the examination of the time-motion analysis during games, shooting accuracy. These parameters may give coaches and physical trainers more information about this critical period. Finally, future studies may produce different results by investigating the RIF under other climatic circumstances, in both sexes and with different sports.

Conclusions

Our results showed that body composition, sleep duration, carbohydrate intake, DOMS and TQR were significantly affected at the end of RIF in association with the changes in weekly internal load, specifically by adding one more game per week. Increasing carbohydrate intake, reducing training session duration or adding other recovery methods could improve sleep and reduce the increased muscle soreness experienced with increased game frequency during Ramadan. The present study's findings should be considered by researchers and practitioners when players are experiencing congested basketball games during RIF.

Author Contributions:

Conceptualization, S.B., L.P.A., F.M.C., J.R.-G., J.A.K., G.A.C., C.C., A.B. and H.N.; methodology, S.B., L.P.A., F.M.C., J.R.-G., J.A.K., G.A.C., C.C., A.B. and H.N.; software, S.B., L.P.A., F.M.C., J.R.-G., J.A.K., G.A.C., C.C., A.B. and H.N.; validation, S.B., L.P.A., F.M.C., J.R.-G., J.A.K., G.A.C., C.C., A.B. and H.N.; formal analysis, S.B., L.P.A., F.M.C., J.R.-G., J.A.K., G.A.C., C.C., A.B. and H.N.; investigation, S.B., L.P.A., F.M.C., J.R.-G., J.A.K., G.A.C., C.C., A.B. and H.N.; re-sources, S.B., L.P.A., F.M.C., J.R.-G., J.A.K., G.A.C., C.C., A.B. and H.N.; data curation, S.B., L.P.A., F.M.C., J.R.-G., J.A.K., G.A.C., C.C., A.B. and H.N.; writing—original draft preparation, S.B., L.P.A., F.M.C., J.R.-G., J.A.K., G.A.C., C.C., A.B. and H.N.; writing—review and editing, S.B., L.P.A., F.M.C., J.R.-G., J.A.K., G.A.C., C.C., A.B. and H.N.; visualization, S.B., L.P.A., F.M.C., J.R.-G., J.A.K., G.A.C., C.C., A.B. and H.N.; supervision, S.B., L.P.A., F.M.C., J.R.-G., J.A.K., G.A.C., C.C., A.B. and H.N.; project administration, S.B., L.P.A., F.M.C., J.R.-G., J.A.K., G.A.C., C.C., A.B. and H.N.. All authors have read and agreed to the published version of the manuscript.

Funding:

Javier Raya-González was supported by a Ramón y Cajal postdoctoral fellowship (RYC2021-031072-I) given by the Spanish Ministry of Science and Innovation, the State Research Agency (AEI) and the European Union (Next Generation EU/PRTR).

Informed Consent Statement:

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement:

The data presented in this study are available on request from the corresponding author, without undue reservation.

Acknowledgments:

The authors would like to acknowledge with considerable gratitude all those, who volunteered to participate in this study.

Conflicts of Interest:

The authors declare no conflict of interest.

References

Al Suwaidi J, Bener A, Gehani AA, Behair S, Al Mohanadi D, Salam A, Al Binali HA. 2006. Does the circadian pattern for acute cardiac events presentation vary with fasting? J. Postgrad. Med. 52, 30–34.

Ardigò LP, Kuvacic G, Iacono AD, Dascanio G, Padulo J. 2018. Effect of Heart rate on Basketball Three-Point Shot Accuracy. Front. Physiol. 9, 75. https://doi.org/10.3389/fphys.2018.00075

Baklouti H, Rejeb N, Aloui A, Jaafar H, Ammar A, Chtourou H, Girard O, Souissi N. 2017. Short versus long small-sided game training during Ramadan in soccer players. Phys. Ther. Sport. 24, 20–25. https://doi.org/10.1016/j.ptsp.2016.10.002

Beltaifa L, Bouguerra R, Ben Slama C, Jabrane H, El-Khadhi A, Ben Rayana MC, Doghri T. 2004. Food intake, and anthropometrical and biological parameters in adult Tunisians during fasting at Ramadan. East Mediterr. Health J. 8, 603–611. https://doi.org/10.26719/2002.8.4-5.603

Brini S, Ben Abderrahman A, Boullosa D, Hackney AC, Zagatto AM, Castagna C, Bouassida A, Granacher U, Zouhal H. 2020. Effects of a 12-Week Change-of-Direction Sprints Training Program on Selected Physical and Physiological Parameters in Professional Basketball Male Players. Int. J. Environ. Res. Public Health. 17, 8214. https://doi.org/10.3390/ijerph17218214

Brini S, Castillo D, Raya-González J, Castagna C, Bouassida A, Khalifa R, Chortane SG, Clemente FM. 2021. Basket-ball-Specific Small-Sided Games Training during Ramadan Intermitting Fasting: Do Changes in Body Composition, Sleep Habits, and Perceived Exertion Affect Technical Performance? Int. J. Environ. Res. Public Health 2021, 18, 12008. https://doi.org/10.3390/ijerph182212008

Brini S, Marzouki H, Castagna C, Bouassida A. 2018. Effects of a four-week small-sided game and repeated sprint ability training during and after Ramadan on aerobic and anaerobic capacities in senior basketball players. Ann. Appl. Sport Sci. 6, 7–13. https://doi.org/10.3390/ijerph182212008

Brini S, Ouerghi N, Bouassida A. 2020. Small sided games vs. repeated sprint training effects on agility in fasting basketball players. Rev. Bras. de Medicina do Esporte. 26, 248–252. https://doi.org/10.1590/1517-869220202603213948

Brini S, Ben Abderrahman A, Clark CT, Zouita S, Hackney AC, Govindasamy K, Granacher U, Zouhal, H. 2021. Sex-specific effects of small-sided games in basketball on psychometric and physiological markers during Ramadan intermittent fasting: A pilot study. BMC Sports Sci. Med. Rehab. 13: 56. https://doi.org/10.1186/s13102-021-00285-1

Buysse D J, Reynolds C 3rd, Monk TH, Berman SR, Kupfer DJ. 1989. The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. Psychiatry Res. 28, 193–213. https://doi.org/10.1016/0165-1781(89)90047-4

Chaouachi A, Chamari K, Roky R, Wong P, Mbazaa A, Bartagi Z, Amri M. 2008. Lipid profiles of judo athletes during Ramadan. Int. J. Sports Med. 29, 282–288. https://doi.org/10.1055/s-2007-965338

Chtourou H, Hammouda O, Souissi H, Chamari K, Chaouachi A, Souissi N. 2011. The effect of ramadan fasting on physical performances, mood state and perceived exertion in young footballers. Asian J. Sports Med. 2, 177–185. https://doi.org/10.5812/asjsm.34757

Clemente FM, Mendes B, Bredt SGT, Praca GM, Silverio A, Carrico S, Duarte E. 2019. Perceived training load, muscle soreness, stress, fatigue, and sleep quality in professional basketball: A full season study. J. Hum. Kinetics. 67, 199–207. https://doi.org/10.2478/hukin-2019-0002

Cohen J. 1973. Eta-squared and partial eta-squared in fixed factor ANOVA designs. Educ. Psychol. Meas. 33, 107–112. https://doi.org/10.1177/001316447303300111

Conte D, Kolb N, Scanlan A.T, Santolamazza F. 2018. Monitoring Training Load and Well-Being During the In-Season Phase in NCAA Division I Men's Basketball. Int. J. Sports Physiol. Perform. 13, 1067–1074. https://doi.org/10.1123/ijspp.2017-0689

Davis JM. 2000. Nutrition, neurotransmitters and central nervous system fatigue. In: Nutrition in Sport; Maughan, R.J., Ed.; Wiley: Hoboken, NJ, USA, pp. 171–184.

Delextrat A, Kraiem S. 2013. Heart-Rate Responses by Playing Position during Ball Drills in Basketball. Int. J. Sports Physiol. Perform. 8, 410–418. https://doi.org/10.1123/ijspp.8.4.410

Edwards T, Spiteri T, Piggott B, Bonhotal J, Haff GG, Joyce C. 2018. Monitoring and managing fatigue in basketball. Sports (Basel). 6, 19. https://doi.org/10.3390/sports6010019

Fashi M, Ahmadizad S, Nobari H, Pérez-Gómez J, Oliveira R, Carlos-Vivas J, Ardigò LP. 2021. Effect of Acute Ramadan Fasting on Muscle Function and Buffering System of Male Athletes. Healthcare (Basel). 9, 397. https://doi.org/10.3390/healthcare9040397

Foster C, Florhaug JA, Franklin J, Gottschall L, Hrovatin LA, Parker S, Doleshal P, Dodge C. 2001. New approach to monitoring exercise training. J. Strength Cond. Res. 15, 109–115. https://doi.org/10.1519/00124278-200102000-00019

Fox JL, Scanlan AT, Stanton R. 2017. A Review of Player Monitoring Approaches in Basketball: Current Trends and Future Directions. J. Strength Cond. Res. 31, 2021–2029. https://doi.org/10.1519/JSC.0000000000001964

Fox JL, Stanton R, O'Grady CJ, Teramoto M, Sargent C, Scanlan AT. 2022. Are acute player workloads associated with in-game performance in basketball? Biol. Sport. 39, 95–100. https://doi.org/10.5114/biolsport.2021.102805

García F, Schelling X, Castellano J, Martín-García A, Pla F, Vázquez-Guerrero J. 2022. Comparison of the most demanding scenarios during different in-season training sessions and official matches in professional basketball players. Biol. Sport. 39, 237–244. https://doi.org/10.5114/biolsport.2022.104064

Hammouda O, Chtourou H, Aloui A, Chahed H, Kallel C, Miled A, Chamari K, Chaouachi, A, Souissi N. 2013. Concomitant effects of Ramadan fasting and time-of-day on apolipoprotein AI, B, Lp-a and homocysteine responses during aerobic exercise in Tunisian soccer players. PLoS One. 8, e79873. https://doi.org/10.1371/journal.pone.0079873

Hopkins WG, Marshall SW, Batterham, AM, Hanin J. 2009. Progressive statistics for studies in sports medicine and exercise science. Med. Sci. Sports Exerc. 41, 3–13. https://doi.org/10.1249/MSS.0b013e31818cb278

Kirkendall DT, Leiper JB, Bartagi Z, Dvorak J, Zerguini Y. 2008. The influence of Ramadan on physical performance measures in young Muslim footballers. J. Sports Sci. 26, S15–S27. https://doi.org/10.1080/02640410802422199

Leiper JB, Watson P, Evans G, Dvorak J. 2008. Intensity of a training session during Ramadan in fasting and non-fasting Tunisian youth football players. J. Sports Sci. 26, S71–S79. https://doi.org/10.1080/02640410802526924

Memari AH, Kordi R, Panahi N, Nikookar LR, Abdollahi M, Akbarnejad A. 2011. Effect of ramadan fasting on body composition and physical performance in female athletes. Asian J. Sports Med. 2, 161–166. https://doi.org/10.5812/asjsm.34754

Moreno-Villanueva A, Rico-González M, Pino-Ortega J. 2022. Monitoring of internal and external loads to interpret acute and chronic fatigue in indoor team sports: A systematic review. Int. J. Sports Sci. Coach. 17, 1531–1552. https://doi.org/10.1177/17479541221096396

Mujika, I., Chaouachi, A., Chamari, K. 2010. Precompetition taper and nutritional strategies: special reference to training during Ramadan intermittent fast. Br. J. Sports Med. 44, 495–501. https://doi.org/10.1136/bjsm.2009.071274

Nobari H, Saedmocheshi S, Murawska-Ciałowicz E, Clemente FM, Suzuki K, Silva AF. 2022. Exploring the Effects of Energy Constraints on Performance, Body Composition, Endocrinological/Hematological Biomarkers, and Immune System among Athletes: An Overview of the Fasting State. Nutrients. 14, 3197. https://doi.org/10.3390/nu14153197

O Brien J, Browne D, Earls D. 2020. The Effects of Different Types of Eccentric Overload Training on Strength, Speed, Power and Change of Direction in Female Basketball Players. J. Funct. Morphol. Kinesiol. 5, 50. https://doi.org/10.3390/jfmk5030050

Ouergui I, Ardigò LP, Selmi O, Levitt DE, Chtourou H, Bouassida A, Bouhlel E, Franchini E. 2020. Changes in Perceived Exertion, Well-Being, and Recovery During Specific Judo Training: Impact of Training Period and Exercise Modality. Front. Physiol. 11, 931. https://doi.org/10.3389/fphys.2020.00931

Ouergui I, Franchini E, Selmi O, Levitt DE, Chtourou H, Bouhlel E, Ardigò LP. 2020. Relationship between Perceived Training Load, Well-Being Indices, Recovery State and Physical Enjoyment during Judo-Specific Training. Int. J. Environ. Res. Public Health. 17, 7400. https://doi.org/10.3390/ijerph17207400

Padulo J, Attene G, Migliaccio G M, Cuzzolin F, Vando S, Ardigò LP. 2015. Metabolic optimisation of the basketball free throw. J. Sports Sci. 33, 1454–1458. https://doi.org/10.1080/02640414.2014.990494

Padulo J, Nikolaidis PT, Cular D, Dello Iacono A, Vando S, Galasso M, Lo Storto D, Ardigò LP. 2018. The Effect of Heart Rate on Jump-Shot Accuracy of Adolescent Basketball Players. Front. Physiol. 9, 1065. https://doi.org/10.3389/fphys.2018.01065

Petway AJ, Freitas TT, Calleja-González J, Medina Leal D, Alcaraz PE. 2020. Training load and match-play demands in basketball based on competition level: A systematic review. PLoS One. 15, e0229212. https://doi.org/10.1371/journal.pone.0229212

Roky R, Houti I, Moussamih S, Qotbi S, Aadil N. 2004. Physiological and chronobiological changes during Ramadan inter-mittent fasting. Ann. Nutr. Metab. 48, 296–303. https://doi.org/10.1159/000081076

Sampaio J, Abrantes C, Leite N. 2009. Power, heart rate and perceived exertion responses to 3x3 and 4x4 basketball small-sided games. Rev. de Psicol. del Deporte 18, 463–467.

Samuels C. 2008. Sleep, recovery, and performance: the new frontier in high-performance athletics. Neurol. Clin. 26, 169–180. https://doi.org/10.1016/j.ncl.2007.11.012

Selmi O, Gonçalves B, Ouergui I, Sampaio J, Bouassida A. 2018. Influence of well-being variables and recovery state in physical enjoyment of professional soccer players during small-sided games. Res. Sports Med. 26, 199–210. https://doi.org/10.1080/15438627.2018.1431540

Sisic N, Jelicic M, Pehar M, Spasic M, Sekulic D. 2015. Agility performance in high-level junior basketball players: the pre-dictive value of anthropometrics and power qualities. J. Sports Med. Phys. Fitness. 56, 884–893.

Smith MR, Coutts AJ, Merlini M, Deprez D, Lenoir M, Marcora SM. 2016. Mental Fatigue Impairs Soccer-Specific Physical and Technical Performance. Med. Sci. Sports Exerc. 48, 267–276. https://doi.org/10.1249/MSS.0000000000000762

Stojanović E, Stojiljković N, Scanlan AT, Dalbo VJ, Berkelmans DM, Milanović Z. 2018. The Activity Demands and Phys-iological Responses Encountered During Basketball Match-Play: A Systematic Review. Sports Med. 48, 111–135. https://doi.org/10.1007/s40279-017-0794-z

Suleiman KH, Yates BC Berger AM, Pozehl B, Meza J. 2009. Translating the Pittsburgh Sleep Quality Index Into Arabic. West. J. Nurs. Res. 32, 250–268. https://doi.org/10.1177/0193945909348230

Waterhouse J, Alabed H, Edwards B, Reilly T. 2009. Changes in sleep, mood and subjective and objective responses to physical performance during the daytime in Ramadan. Biol. Rhythm Res. 40, 367–383. https://doi.org/10.1080/09291010902863438

Zerguini Y, Kirkendall D, Junge A, Dvorak J. 2007. Impact of Ramadan on physical performance in professional soccer players. Br. J. Sports Med. 41, 398–400. https://doi.org/10.1136/bjsm.2006.032037

Figure 1

Experimental protocol

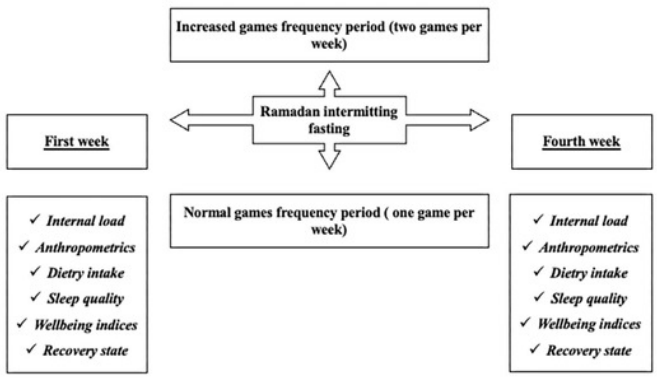

Figure 1. Experimental protocol.

Table 1(on next page)

Anthropometric characteristics

Table 1. Anthropometric characteristics of the participating basketball players.

Groups	Age (years)	Height (m)	BM (kg)	BMI (kg.m^{-2})
INCR (n=14)	26.2±2.1	1.96±0.02	88.6±6.1	23.4±1.1
NORM (n=14)	25.8±2.1	1.95±0.06	88.7±6.8	23.2±1.5

Data are reported as means and standard deviations. INCR: increased game frequency group; NORM: normal game frequency group; BM: body mass; BMI: body mass index.

Table 2(on next page)

Weekly training program

Table 2. Weekly training program during the experimental period for the increased game frequency group (INCR) and the normal game frequency (NORM) group.

Days	Training program for INCR	Training program for the NORM
Monday	- Warm up, 15 min - Specific basketball fundamental training, 15 min - Moderate strength training (Upper/Lower), 20min - Ball drill transition training ,15 min - Technical/Tactical training, 20 min	- Warm up, 15 min - Specific basketball fundamental training, 25 min - Ball drill transition training ,15 min - Technical/Tactical training, 30 min
Tuesday	- Warm up, 15 min - Moderate intensity shooting exercises, 35 min - Tactical training, 20 min - Liveliness training, 10min - Free throw shooting, 5 min	- Warm up, 15 min - Moderate strength training (Upper/Lower), 25min - Heigh intensity mid-range and 3 point shot exercises, 15 min - Technical/Tactical training, 30 min
Wednesday	- Match of four 10 min quarters (FIBA)	- Warm up, 15 min - Specific basketball fundamental training, 30 min - Ball drill transition training, 20 min - Three point shot exercises, 20 min
Thursday	- Warm up, 15 min - Stretching (dynamic/static), 5min - Free throw shooting, 10 min - Moderate intensity shooting exercises, 30 min - Technical/Tactical training, 25 min	- Warm up, 15 min - Strength training (Lower body), 20min - Moderate intensity mid-range and 3 point shot exercises, 20 min - Technical/Tactical training, 25 min
Friday	- Warm up, 15 min - Low intensity 3 pts shooting exercises, 30 min - Tactical training, 20min - Liveliness training, 10min - Free throw shooting, 10 min	- Warm up, 15 min - Low intensity 3 pts shooting exercises, 30 min - Tactical training, 15min - Liveliness training, 10min - Free throw shooting, 10 min
Saturday	- Match of four 10 min quarters (FIBA)	- Match of four 10 min quarters (FIBA)
Sunday	- recovery	- recovery

Table 3 (on next page)

Body composition and estimated daily dietary intake

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)		
		INCR	NORM	INCR	NORM	Time	Group	Group x Time
Body mass (kg)		88.6±6.1	88.7±6.8	85.4±5.9	86.6±6.6	<0.001(0.92)	0.79(0.01)	0.01(0.46)
BMI (kg/m^2)		23.4±1.1	23.2±1.5	23.3±1.1	23.3±1.5	<0.001(0.90)	0.72(0.01)	0.07(0.24)
Body fat (%)		12.1±2.3	12.3±2.5	11.1±2.0	12.0 ±2.5	<0.001(0.65)	0.28(0.09)	0.03(0.33)
FM (kg)		10.68±2.05	10.96±2.54	9.43±1.69	10.40±2.44	<0.001(0.65)	0.23(0.10)	0.016(0.37)
FFM (kg)		77.97±6.05	77.76±6.10	75.98±5.92	76.17±5.80	0.993(0.00)	<0.001(0.79)	0.249(0.10)
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	0.55(0.03)	0.83(0.004)	0.60(0.02)

Data are reported as means and standard deviations. INCR: increased game frequency group; NORM: normal game frequency group; BMI: body mass index; FM: fat mass; FFM: fat free mass

Table 4(on next page)

Measurement of the subjective quality of sleep, well-being indices, recovery state and internal load

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)		
	INCR	NORM	INCR	NORM	Time	Group	Group x Time
Quality of sleep							
Sleep latency (min)	14.64±1.01	14.78±0.89	14.71±1.99	14.93±1.14	0.43(0.05)	0.58(0.02)	0.79(0.01)
Sleep efficiency (%)	94.21±0.69	94.79±0.89	94.43±1.45	94.78±1.53	0.66(0.02)	0.13(0.16)	0.79(0.01)
Sleep duration (h)	9.78±153	9.64±1.50	7.00±1.11	8.07±0.99	<0.001(0.67)	0.12(0.18)	0.01(0.41)
Total score of PSQI	4.64±1.01	4.72±0.82	4.28±1.06	4.71±0.83	0.46(0.05)	0.35(0.0.07)	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±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)	2.20±0.60	2.53±0.59	5.25±0.83	4.77±0.53	<0.001(0.92)	0.49(0.04)	0.05(0.28)
HI	12.94±1.69	14.21±2.49	22.94±1.53	22.73±1.73	<0.001(0.95)	0.30(0.08)	0.18(0.13)
Recovery state							
TQR (out of 28)	13.66±1.12	12.85±1.44	8.96±0.66	9.34±1.06	<0.001(0.91)	0.38(0.06)	0.04(0.29)
Internal load							
RPE (0-10)	5.91±0.40	5.93±0.53	7.21±0.33	6.63±0.33	<0.001(0.90)	0.02(0.34)	0.03(0.33)
W load	2359.29±112.62	2.397.85±171.51	2648.56±98.05	2565±84.65	<0.001(0.76)	0.47(0.04)	0.10(0.19)
HR average	167.45±2.30	166.22±2.56	164.86±2.11	164.90±2.60	<0.001(0.95)	0.42(0.05)	0.002(0.52)
%HR max	83.79±1.46	83.06±1.47	82.50±1.28	82.39±1.48	<0.001(0.94)	0.40(0.05)	0.002(0.52)

Data are reported as means and standard deviations. INCR: increased game frequency group; NORM: normal game frequency 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 DOMS).

9