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Effects of intermittent fasting on physiological and psychobiological variables in Taekwondo during the pre-competitive period

Efeitos do jejum intermitente em variáveis fisiológicas e psicobiológicas no Taekwondo durante período pré-competitivo

Júlia Pessoa Magalhães [ID], Igor Natan Rodrigues Araujo [ID], Ronaldo Ângelo Dias da Silva [ID], Marcos Daniel Motta Drummond [ID]

Universidade Federal de Minas Gerais (UFMG), Belo Horizonte, Minas Gerais, Brazil

ABSTRACT

Objective: To investigate the effects of a 12-hour intermittent fasting during a four-week pre-competitive training period in Taekwondo on physiological and psychobiological variables. **Methods:** The sample consisted of 9 Taekwondo athletes (age 18.4 ± 3.3 years; weight 63.58 ± 6.57 kg; height 1.72 ± 0.05 m; experience in the sport 9.2 ± 3.4 years), of both genders. As inclusion criteria, athletes had to be eutrophic and aim for body mass reduction. The total duration of the study was 6 weeks, with the first 2 weeks dedicated to familiarization and reliability, while the subsequent 4 weeks involved training with a 12-hour intermittent fasting in a pre-competitive period. The following variables were assessed before, during, and after the 4-week training period: perceived recovery scale, heart rate variability, subjective perception of session effort. The evaluation of sleep quality was conducted before and after this training period. **Results:** No significant differences were found in the perceived recovery scale, as well as in heart rate variability. In the assessment of sleep quality, no significant differences were found in "wake-up time," "sleep duration," and "overall score." Subjective perception of session effort also did not show significant differences throughout the study. **Conclusion:** A 12-hour intermittent fasting, carried out over 4 weeks during the pre-competitive training period of Taekwondo, does not negatively influence physiological and psychobiological variables.

Keywords: weight loss; martial arts; sleep; physical exertion.

RESUMO

Objetivo: Investigar os efeitos do jejum intermitente de 12 horas, realizado ao longo de quatro semanas, no período pré-competitivo de treinamento do Taekwondo, em variáveis fisiológicas e psicobiológicas. **Métodos:** A amostra foi composta por 9 atletas de Taekwondo (idade 18,4 ± 3,3 anos; peso 63,58 ± 6,57 kg; altura 1,72 ± 0,05 m; experiência na modalidade de 9,2 ± 3,4 anos), de ambos os sexos. Como critério de inclusão, os atletas deveriam ser eutróficos e objetivar redução da massa corporal. A duração total do estudo foi de 6 semanas, sendo as 2 primeiras destinadas a familiarização e confiabilidade, enquanto nas 4 semanas seguintes foi realizado o treinamento, com jejum intermitente de 12 horas, em um período pré-competitivo. Foram avaliadas as seguintes variáveis, antes, durante e após o período de 4 semanas de treinamento: escala de recuperação percebida, variabilidade da frequência cardíaca, percepção subjetiva do esforço da sessão. A avaliação da qualidade de sono foi realizada antes e após o período deste treinamento. **Resultados:** Não foram encontradas diferenças significativas na escala de recuperação percebida, assim como na variabilidade da frequência cardíaca. Na avaliação da qualidade de sono também não foram encontradas diferenças significativas na "hora de acordar", na "duração do sono" e no "score global". A percepção subjetiva do esforço sessão também não apresentou diferenças significativas ao longo do estudo. **Conclusão:** O jejum intermitente de 12 horas, realizado ao longo de 4 semanas, durante o período pré-competitivo de treinamento de Taekwondo, não influencia negativamente em variáveis fisiológicas e psicobiológicas.

Palavras-chave: redução de peso; artes marciais; sono; esforço físico.

Correspondência: Marcos Daniel Motta Drummond, zangmarcos@gmail.com

Introduction

Taekwondo is an Olympic combat sport with intermittent characteristics, alternating periods of high and low intensities [1]. In official competitions, athletes are divided into categories by total body mass and gender, male and female [2]. Therefore, with the aim of fitting into a certain category, either to comply with competition rules or gain competitive advantages, Taekwondo athletes adopt various strategies to reduce total body mass [2]. However, if this reduction is done improperly, these interventions can have deleterious effects on athletes' bodies, potentially compromising their health and sports performance [3,4].

Fasting, whether acute or chronically intermittent, is a nutritional strategy commonly used in the pre-competition period by Taekwondo athletes, both men and women, to adjust body composition [5-7]. Intermittent fasting is carried out over a period of several days or weeks, during which the individual abstains from food intake for predetermined periods, typically between 12 and 24 hours, followed by periods of ad libitum intake, cyclically [8,9]. Among several potential mechanisms by which intermittent fasting may be effective in reducing total body mass, changes in adiponectin, leptin, and ghrelin concentrations stand out [10]. These mechanisms may contribute to reduced appetite, lower food and energy intake, both instinctively and voluntarily [12]. Consequently, a negative calorie balance can be established over time, leading to a reduction in total body mass [7,13,14].

The negative calorie balance can negatively affect the health, recovery, and performance of Taekwondo athletes, especially during training in the competitive period [14]. The potential harmful effects are of metabolic origin [10] and neural [15]. The effects of metabolic origin are typically determined by increased levels of catabolic hormones, such as cortisol and glucagon, leading to a decline in lean body mass, mainly due to glycogen depletion, as well as losses of intracellular fluid and sodium [10,14]. Additionally, there may be stress and imbalance of the autonomic nervous system, with increased sympathetic nervous system activity, triggered by hunger-inducing stimuli from increased ghrelin levels, and reduced metabolism due to decreased leptin levels [10,15]. This environment may interfere with physical and psychological responses in the circadian cycle [15] and load training [14]. Thus, intermittent fasting may affect parameters commonly used in monitoring and control of training load, related to athletes' health and recovery, such as heart rate variability (HRV) [16], The session rating of perceived exertion (sRPE), the perception of recovery [17] and sleep quality [12].

Silva *et al*. [6] found that acute 12-hour fasting before a training session reduced the total body mass of Taekwondo athletes without compromising performance. Silva *et al*. [7] furthered this topic and also obtained results of reduced total body mass without impairing physical, specific, and overall performance when investigating potential effects of 12-hour intermittent fasting over four weeks of Taekwondo training in the pre-competitive period. However, no studies were found that investigated the responses of physiological and psychobiological variables related to the

recovery processes and health of Taekwondo athletes undergoing intermittent fasting. Measured these parameters is important for the safe and regular adoption of intermittent fasting, as this nutritional strategy can be effective for weight loss and is widely used by athletes.

In this perspective, the present study aimed to investigate the effects of 12-hour intermittent fasting, conducted over four weeks, during the pre-competitive training period of Taekwondo, on physiological and psychobiological variables related to athlete recovery and health. The hypothesis is that this nutritional strategy used to reduce total body mass has a deleterious effect on the variables evaluated in the present study.

Methods

Study design

The design of the present study was experimental, with the volunteers undergoing a total of 6 weeks of intervention. The first two weeks involved familiarization, reliability determination, and execution of the control session. In the following four weeks, the volunteers underwent the training sessions.

During the familiarization and reliability phases, the volunteers completed 10 training sessions and underwent HRV measurement [18], reported the Perceived Recovery Scale (PRS) [19] and the rating of perceived exertion to determine the sRPE [17]. At the end of this phase, the volunteers responded to the Sleep Quality Assessment (SQA) [20].

In the subsequent phase, over the course of four weeks of intermittent fasting, the variables HRV and RPE were obtained during the training sessions each week, while the session RPE was obtained at the end of the sessions. At the end of this four-week period, the SQA was conducted again. The experimental design of the present study is depicted in Figure 1.
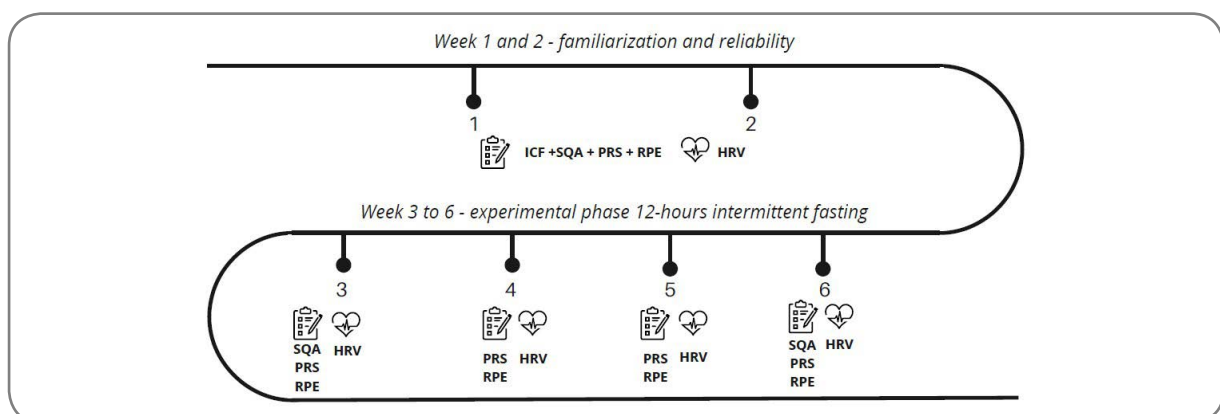
ICF = Informed Consent Form; PRS = Perceived Recovery Scale; SQA = Sleep Quality Assessment; RPE = Rating of Perceived Exertion
Figure 1 – Experimental design

To perform 12 hours of fasting and 12 hours of habitual free feeding (ad libitum), athletes were instructed to have a dinner and to skip breakfast the following morning. There was no nutritional intervention, thus characterizing the common protocol of intermittent fasting.

Throughout the intervention weeks, the training frequency was six sessions per week. From Monday to Friday, training sessions were held in the afternoon, in the fed state, with a 24-hour interval between sessions. On Saturdays, training occurred in the morning, with a minimum interval of 14 hours from the penultimate to the last session. Therefore, on Saturdays, athletes trained in a fasting state.

The Taekwondo training protocol remained the same throughout the 6 weeks. Therefore, the external training load did not vary during the study.

Sample

The sample consisted of 9 Taekwondo athletes (18.4 ± 3.3 years; 63.58 ± 6.57 kg; 1.72 ± 0.5 cm; BMI: 21.6 ± 1.6) of both male (n = 7) and female (n = 2) genders, black belts, with an mean experience in the sport of 9.2 ± 3.4 years and participation in national and international competitions. The sample size was determined by convenience. Characterization of the volunteers was performed using dual-energy X-ray absorptiometry (Lunar Prodigy Advance, GE Healthcare, USA) [7].

As inclusion criteria required athletes to be eutrophic, in the pre-competition period, and aiming to reduce body mass to fit into a weight category. Additionally, athletes should not have experienced any type of joint and/or muscle injury in the lower limbs in the previous six months, and should not have used nutritional or pharmacological ergogenic resources within the last 30 days. Furthermore, volunteers answered negatively to all questions in the Physical Activity Readiness Questionnaire [6].

As exclusion criteria included volunteers who showed variation in total body mass in the first two weeks of the study. Athletes who did not adhere to the 12-hour fasting period and/or suffered any type of joint and/or muscle injury in the lower limbs during training sessions would also be excluded. Throughout the study, there was no need to exclude any volunteers.

Ethical considerations

After receiving all relevant information about the research, the volunteers signed the Informed Consent Form agreeing to participate in the study. This project was approved by the Research Ethics Committee of the Federal University of Minas Gerais (CAAE: 15747219.8.0000.5149). In this study, all standards established by Resolution No. 466 of the National Health Council for research involving human subjects were respected.

Procedures

Intermittent Fasting Protocol

The intermittent fasting protocol consisted of a 12-hour time-restricted feeding window during the evening and early morning. The procedures adopted in the present study were the same as those conducted by Silva *et al.* [7]. To encourage and monitor the fasting periods, the authors regularly sent individual messages to the volunteers via short message service.

Perceived Recovery Scale (PRS)

Before the training sessions, the volunteers indicated a value according to the adapted scale proposed by Laurent *et al.* [19], based on their perceived recovery compared to the previous session. The values were recorded for subsequent analysis and comparison, week by week.

Heart Rate Variability (HRV)

The collection and recording of HRV were carried out through synchronization with Bluetooth® from heart rate sensor (Polar H10, Polar Electro Brasil, Ltda) and smartphone app (ELITE HRV®, America United States) validated [21]. The collection was performed in the morning after waking up, and volunteers were instructed to wait for 10 minutes lying down in a dorsal position, in silence, and keeping their respiratory rate as low as possible [22,23].

In the present study, the linear method was used for time domain analysis with data from mean RR interval, standard deviation of RR interval (SDNN), and the square root of the sum of the squares of adjacent RR intervals (RMSSD) [24]. For frequency domain analysis, the fast Fourier transform was used for low frequency (LF) and high frequency (HF), in addition to the LF/HF ratio [25]. After the measurement was taken, the volunteers sent a screenshot of the app for verification of the measurement date and time. Additionally, the data were exported and received by the volunteers via email in TXT file format, which was later forwarded to the principal researcher's email for filtering, noise exclusion, and analysis using the Kubios HRV software (version 3.5.0; University of Kuopio, Finland) [26].

Sleep Quality Assessment of Pittsburgh (SQA)

The SQA was conducted to identify potential negative alterations in the circadian rhythm, as observed in other fasting protocols [27,28]. This instrument was validated in Portuguese by Bertolazi *et al.* [20], and is applied in screening for sleep dysfunction [29]. The volunteers answered the questionnaire accompanied by the researchers of the present study, to clarify any doubts.

Session Rate of Perceived Exertion (sRPE)

To determine the sRPE, approximately 20 minutes after the end of the session, the volunteer was asked to indicate on the scale proposed by Foster *et al.* [30] a value according to the perceived effort in relation to the day's training session. The sRPE was calculated using the equation proposed by Foster *et al.* [30].

Statistics analysis

The data normality and sphericity were checked using the Shapiro-Wilk and Mauchly tests, respectively. To assess the responses of the PRS, HRV, and sRPE variables, repeated-measures ANOVA or the non-parametric equivalent (Friedman test) was performed. Bonferroni post-hoc analysis, when applicable, was adopted to identify where differences occurred. Paired t-tests were used to compare the mean values of the SQA. The Cohen's d for paired samples [31] and partial eta squared (ηp^2) [32,33] were adopted to assess effect size. Descriptive analysis of the data was also conducted using mean ± standard deviation and confidence interval (CI95%). Statistical analysis was performed using SPSS software (version 20.0). The significance level adopted was $\alpha = 0.05$.

Results

The results of PRS did not show a normal distribution. No significant differences were found regarding this variable. As for the time domain of heart rate variability, which showed a normal distribution, no significant differences were found between the means of the RR interval at different moments. Also, as they showed a normal distribution, no significant differences were found in the standard deviation of RR intervals (SDNN) and in the square root of the mean of the sum of the squares of differences between adjacent RR intervals (RMSSD). Regarding the frequency domain, which did not show a normal distribution, no statistically significant difference was found for LF, as well as for HF, which showed a normal distribution. For LF/HF, which did not show a normal distribution of the data, a significant difference was found, with a large effect size, in week 4 compared to the pre-intervention moment. Table I presents these results.

Regarding sleep, the SQA results showed a normal distribution, with a significant difference in the mean "bedtime" between pre- and post-intervention, with a small effect size. However, no significant difference was found in "wake-up time," "sleep duration," and "global score." Table II presents these results.

The sRPE showed a normal distribution, but no significant differences were found over the experimental period (Table III).

Table I - Psychophysiological recovery variables (means ± standard deviation)

Variables	Pre	W1	W2	W3	W4	F	p value	E.S(ηp^2)	Classfication
PRS	6.97 ±1.21	7.62 ±1.58	7.19 ±1.91	7.51 ±2.21	7.50 ±2.06	1.039	0.388	0.11	small
$RR_{(s)}$	1028.34 ±138.31	1085.03 ±112.76	1103.38 ±140.92	1124.79 ±192.17	1086 ±117.71	2.018	0.174	0.20	medium
SDNN	70.41 ±21.76	73.32 ±37.33	70.00 ±22.27	68.78 ±18.70	71.33 ±27.02	0.080	0.988	0.01	small
RMSSD	78.00 ±24.57	87.31 ±52.49	84.07 ±37.62	86.88 ±40.39	86.73 ±37.41	0.268	0.896	0.03	small
$LF_{(m^2)}$	2561.19 ±2040.47	5203.71 ±10492.50	2321.10 ±2100.90	1597.28 ±780.44	1990.47 ±1653.95	0.777	0.121	0.08	small
$HF_{(m^2)}$	2197.61 ±1194.68	4201.11 ±7054.58	3049.89 ±2705.39	2906.13 ±1887.17	3030.55 ±2230.33	0.485	0.541	0.05	small
LF/HF	1.40 ±1.11	1.11 ±1.00	1.58 ±1.53	1.03 0.97	0.93[*] ±0.84	2.111	0.046	0.31	large

PRS = perceived recovery scale; RR = mean RR interval; SDNN = Standard Deviation of RR intervals; RMSSD = Root Mean Square of Successive RR interval differences; LF (m^2): low frequency; HF (m^2): high frequency; LF/HF = LF/HF ratio; Pre = pre-intervention; W1 = week 1; W2 = week 2; W3: week 3; W4 = week 4; E.S (ηp^2) = Partial eta squared effect size. *statistically significant difference compared to pre-intervention ($p < 0.05$). Source: Prepared by the author

Tabela II - Resultados da AQS (média ± desvio padrão)

Variable	Pre	Pos	T	p value	E.S	Classification
Time to sleep	01:26 ± 1:21	23:50 ± 1:27[*]	3.501	0.016	0.10	small
Time to wake-up	8:13 ± 2:11	8:10 ± 1:36	0.079	0.939	0.01	small
Sleep duration	07:06 ± 1:21	07:40 ± 0:51	-1.644	0.139	0.20	small
Global Score	11.89 ± 2.02	11.00 ± 1.73	2.101	0.069	0.12	small

Pre = pre intervention; Pos = post-intervention; T = value-t; E.S (Cohen's d). *statistically significant difference compared to pre-intervention ($p < 0.05$). Source: Prepared by the author

Table III - sRPE results (mean ± standart deviation)

Variables	Pre	W1	W2	W3	W4	F	p value	E.S(ηp^2)	Classfication
sRPE (U.A)	631.69 ±185.41	505.26 ±152.09	497.77 ±197.84	435.73 ±122.85	588.77 ±201.40	2.511	0.061	0.23	Medium

Pré = pre-intervention; W1 = week 1; W2: week 2; W3 = week 3; W4 = week 4; F = value-f; E.S(ηp^2): Partial eta squared effect size. Source: Prepared by the author.

Discussion

The aim of this study was to investigate the effects of 12-hour intermittent fasting over four weeks in the pre-competitive training period of Taekwondo, on physiological and psychobiological variables related to athletes' recovery and health. The formulated hypothesis was that the adopted intermittent fasting protocol would negatively affect physiological and psychobiological variables: PRS; HRV; SQA; and sRPE. No deleterious effects were found in the evaluated variables in this study, during the intermittent fasting training. Therefore, the hypothesis was rejected.

The results of recovery perception from the PRS indicate that athletes reported feeling recovered, without accumulation of fatigue from previous training sessions. Also, the mean results of the PRS were similar throughout the intermittent fasting training period. These findings are supported by the findings of Silva et al. [7], intermittent fasting did not influence the overall and specific performance of Taekwondo athletes during the pre-competitive period. Silva et al. [6] also found that acute fasting did not reduce performance in Taekwondo. These results suggest that intermittent fasting may not have a negative effect on recovery and, consequently, on performance in Taekwondo. However, in the present study, performance was not measured throughout the intermittent fasting training period, which does not allow us to assert that the PRS corresponds to performance response.

Some studies have found that intermittent fasting increased fatigue perception and decreased performance in Judo, another combat sport [34,35]. Differences in results may be due to the specificity of the sport, tests applied, and the time of day when performance tests were conducted. No other studies were found that investigated the potential effects of intermittent fasting on PRS and/or performance in Taekwondo. This limits the discussion of the results of the present study and indicates that further research on the topic is needed.

Regarding the potential effects of intermittent fasting on HRV, the results indicated that this nutritional strategy did not influence the responses of this variable throughout the training period. Only the mean LF/HF ratio was significantly lower in the fourth week of intermittent fasting training, with a large effect size. These results suggest that intermittent fasting did not alter vagal (RR, SDNN, RMSSD), sympathetic, and parasympathetic (LF, HF) responses [24,25]. However, the variation in the LF/HF ratio may indicate disturbance in sympathovagal balance [25], but it did not influence the perception of recovery, sleep quality, and sRPE, according to the results of the present study. These findings suggest that intermittent fasting does not represent an additional stressful stimulus to the autonomic nervous system during training in the pre-competitive period. Also, it may not be a confounding factor in HRV analysis in performance monitoring.

However, Kammoun et al. [36] found that fasting during Ramadan influenced HRV in sedentary healthy individuals while playing football during fasting. However, these authors did not find a relationship between this effect and performance, which was not altered by fasting. The different results of the present study may be justified

by the different fasting protocol and, mainly, by the characteristics of the samples and modalities. No other studies were found that investigated the possible effects of intermittent fasting on HRV over a training period. This limits the discussion of the results and suggests that further studies on the topic are needed.

Regarding the quality of sleep of the volunteers, according to the results of the SQA, intermittent fasting did not influence this variable, as it did not fluctuate over the training period compared to the time before this experimental intervention. Thus, it is possible that intermittent fasting performed during the nighttime does not sufficiently impact the circadian cycle, as reported by Shepard *et al*. [28] and Chtoutou *et al*. [27]. According to these authors, daytime sleepiness is common during Ramadan fasting, possibly due to meals being consumed late at night and early in the morning, thereby disrupting sleep patterns that may negatively impact the rate of perceived exertion, fatigue perception, and compromise physical performance [27,28]. In conclusion, the maintenance of athletes' sleep quality throughout the training period conducted with intermittent fasting corroborates the other findings of this study. However, no other studies were found that investigated possible effects of intermittent fasting on sleep quality and other sleep parameters in Taekwondo athletes. This indicates that further research on the topic is needed to allow for optimal monitoring and control of the influence of sleep on performance [7,37] in Taekwondo.

The results of the sRPE, HRV, and SQA indicate that the training load was not perceived differently by the athletes, thus not influencing the sRPE. Once again, this suggests that intermittent fasting may not represent an additional stressor and may not interfere detrimentally with recovery during Taekwondo training in the pre--competitive period. Therefore, it is expected that performance in training will not be impaired by intermittent fasting over a 4-week period [7].

The present study has limitations in sample size, as it was determined by convenience. However, it is important to note that the sample is specific to a limited population, represented by eutrophic athletes aiming to reduce body mass during a specific training period. All volunteers who met the inclusion criteria were included in the sample. Another limitation of the study is the absence of performance measures to relate to the findings, thus being specific to the main training objective, performance. However, the study objectives were met, representing an advancement in science and guiding further research, as well as the safe prescription of intermittent fasting without detriment to physiological and psychobiological variables.

Conclusion

In conclusion, intermittent fasting conducted by eutrophic Taekwondo athletes aiming for weight loss over a period of 4 weeks during the pre-competitive training phase does not negatively influence perceived recovery, HRV, sleep quality, and session RPE.

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