



Artículo Investigación

A new complementary HIIT program with *nage-kome* in under-18 judo athletes: Pilot Study

Un nuevo programa complementario de HIIT con *nage-kome* en judokas sub-18: Estudio Piloto

Um novo programa complementar de HIIT com *nage-kome* em atletas de judô sub-18: Estudo Piloto

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ABSTRACT

This study aimed to determine the effects of four weeks of complementary high intensity interval training (HIIT) sessions (3 weeks of intensified training load (TL) followed by 1 week with reduced TL) on physical performance, internal training load (ITL), stress tolerance (ST), recovery state, and well-being in under-18 judo athletes. Eight under-18 male judo athletes (15.4 ± 0.9 years) were evaluated before and after four weeks of a training period, with the following tests: countermovement jump (CMJ), Special Judo Fitness Test (SJFT), Uchi-Komi Speed Test (UST), and Judogi Chin-Up Test (JCT). Well-being and recovery state were evaluated before, and ITL after each training session, and ST at the end of each training week. The training program consisted of four weeks of a judo regular training routine with specific judo techniques, performed three times per week, added to the HIIT complementary training sessions with the *nage-komi* modality, performed twice a week. There was a significant improvement in the performance of the UST (18.5 ± 2.2 vs. 24.7 ± 2.2 reps) with a large effect size (ES) and a reduction in heart rate one minute after the SJFT (150 ± 9.1 vs. 139 ± 8.0 bpm; large ES) post-training. For ITL, a significant decrease was observed from week 3 to week 4. Therefore, the training period with HIIT led to positive improvements in judo athletes' performance, particularly in the UST, and in the recovery state, as assessed by heart rate (HR) one minute after the completion of the SJFT. In terms of practical applications, it is suggested that HIIT combined with *nage-komi* could be incorporated into judo training programs to enhance performance.

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Key words: Combat sports; Young Judokas; Athletic performance; Monitoring training.

RESUMEN

Este estudio tuvo como objetivo determinar los efectos de cuatro semanas de sesiones complementarias de *high intensity Interval training* (HIIT) (3 semanas de carga de entrenamiento intensificada (CE) seguidas de 1 semana con CE reducida) en el rendimiento físico, la carga interna de entrenamiento interna (CIE), la tolerancia al estrés (TE), el estado de recuperación y el bienestar en atletas de judo menores de 18 años. Ocho atletas de judo masculinos menores de 18 años ($15,4 \pm 0,9$ años) fueron evaluados antes y después de cuatro semanas de un período de entrenamiento, con las siguientes pruebas: salto con contramovimiento (CMJ), Special Judo Fitness Test (SJFT), Uchi-Komi Speed Test (UST) y Judogi Chin-Up Test (JCT). El bienestar y el estado de recuperación se evaluaron antes, e la CIE después de cada sesión de entrenamiento, y TE al final de cada semana de entrenamiento. El programa de entrenamiento consistió en cuatro semanas de una rutina de entrenamiento regular de judo con técnicas específicas de judo, realizadas tres veces por semana, agregadas a las sesiones de entrenamiento complementares de HIIT con la modalidad *nage-komi*, realizadas dos veces por semana. Se observó una mejora significativa en el rendimiento del UST ($18,5 \pm 2,2$ frente a $24,7 \pm 2,2$ repeticiones) con un gran tamaño de efecto (TE) y una reducción de la frecuencia cardíaca un minuto después del SJFT ($150 \pm 9,1$ frente a $139 \pm 8,0$ bpm; TE grande) después del entrenamiento. En el caso de la CIE, se observó una disminución significativa entre la semana 3 y la 4. Por lo tanto, el entrenamiento con HIIT produjo mejoras positivas en el rendimiento de los judokas, especialmente en el UST, y en el estado de recuperación, evaluado mediante la frecuencia cardíaca (FC) un minuto después de completar el SJFT. En cuanto a las aplicaciones prácticas, se sugiere que el HIIT combinado con *nage-komi* podría incorporarse en los programas de entrenamiento de judo para mejorar el rendimiento.

Palabras clave: Deportes de combate; Jóvenes Judocas; Rendimiento atlético; Monitoreo del entrenamiento.

RESUMO

Este estudo teve como objetivo determinar os efeitos de quatro semanas de sessões complementares de *high intensity Interval training* (HIIT) (3 semanas de carga de treinamento (CT) intensificadas seguidas de 1 semana de CT reduzida) sobre o desempenho físico, carga interna de treinamento (CIT), tolerância ao estresse (TE), estado de recuperação e bem-estar em atletas de judô menores de 18 anos. Oito atletas de judô do sexo masculino menores de 18 anos ($15,4 \pm 0,9$ anos) foram avaliados antes e após um período de treinamento de quatro semanas com os seguintes testes: salto com contramovimento (CMJ), *Special Judo Fitness Test* (SJFT), *Uchi-Komi Speed Test* (UST) e *Judogi Chin-Up Test* (JCT). O bem-estar e o estado de recuperação foram avaliados antes e após cada sessão de treinamento, e a CIT ao final de cada semana de treinamento. O programa de treinamento consistiu em quatro semanas de uma rotina regular de treinamento de judô com técnicas específicas de judô, realizadas três vezes por semana, além de sessões complementares de treinamento de HIIT utilizando a modalidade *nage-komi*, realizadas duas vezes por semana. Uma melhora significativa no desempenho do UST ($18,5 \pm 2,2$ vs. $24,7 \pm 2,2$ repetições) com tamanho do efeito (TE) grande e uma redução na frequência cardíaca (FC) um minuto após o SJFT ($150 \pm 9,1$ vs. $139 \pm 8,0$ bpm; TE grande) foram observadas após o treinamento. Na CIT, uma diminuição significativa foi observada entre as semanas 3 e 4. Portanto, o treinamento HIIT produziu melhorias positivas no desempenho dos judocas, especialmente no UST, e no estado de recuperação, avaliado pela frequência cardíaca (FC) um minuto após a conclusão do SJFT. Em termos de aplicações práticas, sugere-se que o HIIT combinado com o *nage-komi* poderia ser incorporado aos programas de treinamento de judô para melhorar o desempenho.

Palavras chave: Esportes de combate; Judocas jovens; Desempenho atlético; Monitoramento do treinamento.

INTRODUCTION

Judo is a combat sport characterized by high-intensity actions, requiring complex skill and tactical developments for success in competitions. Aerobic metabolism predominantly supplies energy throughout the 4-min judo fight and anaerobic metabolism is used to execute techniques with strength and power, in addition to the defending actions of the opponents (da Silva et al., 2021; Franchini et al., 2014; Julio et al., 2017). In judo training programs, sessions focused on modality-specific exercises combined with complementary physical training, such as running, cycling, and/or strength training (Agostinho et al., 2015; Bonato et al., 2015; Marques et al., 2017).

In judo training programs, sessions focused on modality-specific exercises are combined with complementary physical training, such as running. Among complementary physical training programs, high intensity interval training (HIIT), which is characterized as a high-intensity and short-duration training modality (Laursen & Bucheit, 2019), has been used as a strategy with judo athletes to improve muscular strength, as well as aerobic and anaerobic performance (Magnani Branco et al., 2017; Ouergui et al., 2022; Ouergui et al., 2020). Considering HIIT as a complementary strategy to judo training, some studies used cycle ergometer and running training sessions (Magnani Branco et al., 2017; Franchini et al., 2016), however, given the need for modality specificity, other studies have applied HIIT using specific judo exercises, such as randori (grip competition without throwing), uchi-komi (repeated entries of the technique), and kumi-kata (grip competition with a partner without throwing) (Ouergui et al., 2022; Ouergui et al., 2020).

Although effective, HIIT programs impose a heavy internal training load (ITL), which needs careful and individual monitoring to obtain information on how athletes are responding to different training stimuli. Considering this, the session rating of perceived exertion (sRPE), represents a practical and valid method for ITL quantification, that has been used to monitor judo athletes during training sessions (Magnani Branco et al., 2017; Ouergui et al., 2020). Together with the sRPE, self-report scales and questionnaires are used to determine stress tolerance, recovery state, and well-being of athletes in relation to the TL imposed during training (Ouergui et al., 2020). Furthermore, it is important to mention that a period of intensified training with HIIT generally induces neuromuscular, physiological, and hormonal responses that lead to changes in the ITL, well-being, and recovery states of athletes. Thus, a period with a reduced TL (*i.e.*, tapering) is frequently used as a strategy for physical and mental restoration (Araujo et al., 2022; Ouergui et al., 2022; Papacosta et al., 2013).

Specifically, there is limited research on the effects of judo-specific HIIT sessions as a complementary training method to enhance performance (Magnani Branco et al., 2017; Ouergui et al., 2022; Ouergui et al., 2020). For example, Ouergui et al. (2020) investigated the effects of HIIT followed by a tapering period using different judo exercise modalities (*e.g.*, kumi-kata group [KG], uchi-komi group [UG], and running group [RG]), and found that the KG led to significant improvements in vertical jump performance, and in isometric and dynamic judogi chin-ups, compared to the UG, RG, and CG. Additionally, the UG demonstrated better performance in the Uchi-Komi Speed Test compared to the RG and CG. The study by Magnani Branco et al. (2017), which aimed to investigate the effects of 4 weeks of training with three different HIIT modalities (lower and upper body cycle-ergometer and Uchi-Komi), demonstrated no differences in ITL, psychometric questionnaires and hormone levels between groups. However, no previous studies have structured a complementary HIIT training program using modality-

specific *nage-komi* exercises (execution of the techniques), combining a TL intensification period followed by a reduced TL period.

The present study proposes a new complementary HIIT program that differs from previous studies (Magnani Branco et al., 2017; Ouergui et al., 2022; Ouergui et al., 2020) mainly because the *nake-komi* exercises were the modality-specific used during the complementary sessions, and the strategy for the periodization was the combination between intensified plus reduced TL during the training program. Thus, this study aimed to determine the effects of four weeks of complementary HIIT sessions (3 weeks of intensified training followed by 1 week with reduced TL) on physical performance, internal training load (ITL), stress tolerance (ST), recovery state, and well-being in under-18 judo athletes. We hypothesized that athletes would present improvements in performance after the training period and that the ITL, ST, recovery and well-being would be different between the training phases.

METHODS

Participants

Eight under-18 male judo athletes (age: 15.4 ± 0.9 years, stature: 170.0 ± 0.1 cm, body mass: 65.7 ± 12.7 kg, and fat percentage: $14.4 \pm 4.3\%$), competing at state level, participated in this study. The athletes were recruited from two different training sites in the same city, each comprised of judo athletes who met the inclusion criteria; after recruitment, all athletes completed the training period together at the same site. The inclusion criteria were (a) having all “no” responses on the Physical Activity Readiness Questionnaire (PAR-Q); (b) having a minimum of three years of experience in judo training; (c) being at least a green belt or higher; (d) training at least three times a week; (e) participating in stage-level competitions in the previous year; (f) not being diabetic, hypertensive, or having any cardiovascular or respiratory disorders, and (g) not having suffered any injury in the previous six months. The exclusion criteria were being injured during the training protocol, not performing all the HIIT complementary sessions, and not achieving a 75% frequency in regular judo training.

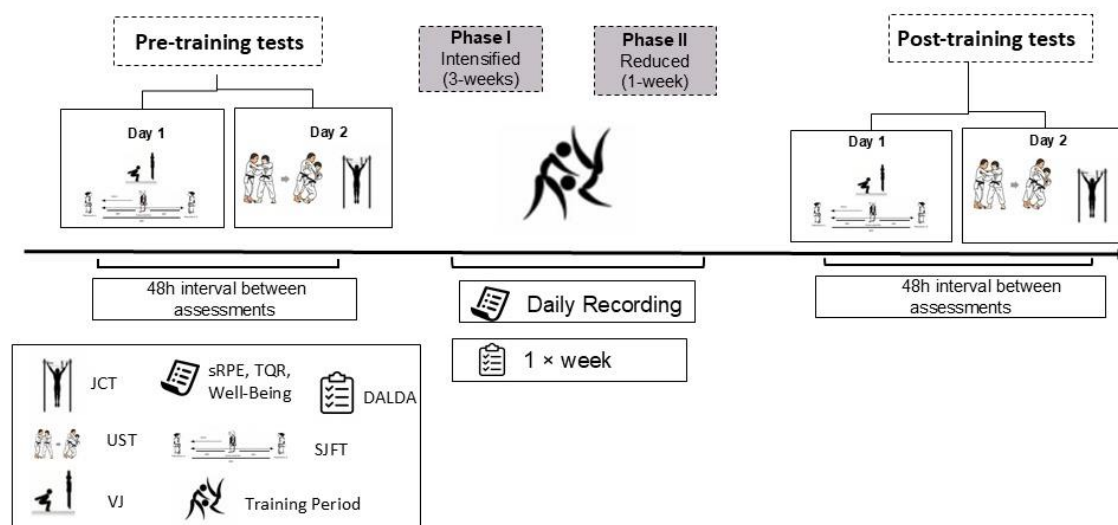
Prior to testing, all procedures and test protocols were explained individually to each participant and written informed consents were obtained from parents and informed assents from athletes. This study was approved by the Human Research Ethics Committee at the State University of Maringá (n°4.177.256/2020).

Experimental Design

The present study has a quasi-experimental design because of the absence of a control group. One week before the beginning of the experimental period the athletes were familiarized with the procedures (e.g., training exercises, scales, and questionnaire). In the first week, before the training period, they performed the following tests, with a 48h interval between trials: vertical jump test and special judo fitness test (SJFT) (day 1); uchi-komi speed test (UST) and judogi chin-up tests (JCT) (day 2). These tests were repeated after the end of the training program following the same procedures. The training program consisted of two phases: phase I made up of 3 weeks of intensified training (IT), and phase II made up of 1 week with a reduced TL. During both phases, the ITL, recovery state, and well-being of each athlete were monitored daily, and the stress tolerance (ST) was evaluated at the end of each training week. The experimental protocol is illustrated in Figure 1.

Figure 1

Schematic representation of the experimental design



Note. VJ, Vertical Jump; UST, Uchi-Komi Speed Test; JCT = Judogi Chin-Up test; SJFT, Special judo fitness test; DALDA, daily analysis of life demands for athletes; TQR, total quality of recovery scale; sRPE, session rating of perceived exertion.

Vertical jumps (VJs)

The VJs were measured using an electronic platform (Jump System Pro Cefise®, Nova Odessa – SP, Brazil) designed to determine contact time, vertical jump flight time, and muscle power of the lower limbs. Participants performed the countermovement jump (CMJ), in which the athlete stood on the mat, fully erect with his hands positioned at the waist; at the signal of the appraiser, the athlete squatted quickly and jumped as high as possible. The warm-up consisted of 10 min of running on a treadmill at low intensity, with an RPE between 10-12 points (Borg, 1982), followed by five submaximal CMJs for familiarization (Magnani Branco et al., 2022). The athletes performed three VJs, with an interval of 30 s between repetitions, and the highest values obtained for height (cm) and relative power (W/kg) were used as the performance variables (Nuzzo et al., 2008; Petridis et al., 2019).

Special Judo Fitness Test (SJFT)

The SJFT is a test with intermittent judo actions characterizing a measure of physical performance in judoka athletes (Sterkowicz et al., 1999; Sterkowicz-Przybycień et al., 2019), with ippon-seoi-nage projections in pairs with similar body mass and height: one tori (apply the technique) and two ukes (receive the technique). The test was separated into 3 blocks: A = 15 seconds, B and C = 30 seconds, with 10 seconds of passive rest between the blocks. The uke remained 6 meters apart, and tori remained in the center. The number of throws per block was counted: A + B + C. Furthermore, during and after the test, and the heart rate (HR) of the tori was monitored (Polar® RS800sd, Kempele, Finland). The HR recovery (SJFT HRrecovery) was obtained by the difference between the final HR recorded immediately at the end of the test and the HR measured one minute after the end of the test. Data obtained in the test were imputed in the following equation to obtain the SJFT index: SJFT index = Final HR + HR 1

minute after the test at rest / Total number of throws in 3 blocks. It is important to mention that a lower SJFT index indicates better performance (Sterkowicz et al., 1999; Sterkowicz-Przybycień et al., 2019).

Uchi-Komi Speed Test (UST)

For the UST the athletes were instructed to repeat the ippon-seoi-nage technique as fast and as many times as possible, without throwing, during 15 s (Ouergui et al., 2022). The test result was the number of repetitions performed by the athletes.

Judogi Chin-Up Test (JCT)

The athletes performed isometric and dynamic judogi chin-ups with a 15-min rest between them. For the isometric test, the athlete remained with their elbows flexed and their chin above their hands, for as long as possible, and the total time was recorded. For the dynamic test, the athlete was suspended and gripped the judogi. They were requested to complete an extension and flexion, crossing their chin to above the bar, and repetitions of completed exercises were counted. The test was finished when the athlete could not perform the complete movement or due to voluntary exhaustion (Franchini et al., 2011).

Training Protocol

The training program consisted of four weeks of a judo regular training routine with specific judo techniques added to the HIIT complementary training program, divided into two phases: 3 weeks of intensified training (Phase I) followed by 1 week with a reduced TL (Phase II). The regular judo training sessions were composed by the modality *uchi-komi* and *randori*, and they were performed on Monday, Wednesday and Friday. The complementary training sessions were performed twice a week (Tuesday and Thursday), and consisted of an HIIT protocol with the modality *nage-komi* (throwing). All sessions in the complementary training had a warm-up with 10 series with 20 *uchi-komi* (repeated entries of the technique) and different types of ukemi. The HIIT during phase I consisted of two blocks of 6-min and 40 s (10 series x 30 s of *nage-komi* with 10s passive rest). The HIIT during phase II consisted of two blocks of 5 min (5 series x 30s of *nage-komi* of 30s passive rest). The athletes were allowed a 5-min rest between sets (Franchini et al., 2016). Table 1 presents the description of the HIIT complementary training sessions.

Table 1

Description of the specific HIIT training program during the 4-week protocol

	Week 1	Week 2	Week 3	Week 4
Warm-up	10 to 20 UC and Ukemi	10 to 20 UC and Ukemi	10 to 20 UC and Ukemi	10 to 20 UC and Ukemi
Repetitions	10 to 30" x 10"	10 to 30" x 10"	10 to 30" x 10"	5 to 30" x 30"
Goal intensity	All out	All out	All out	All out
Rest period between repetitions	5 min	5 min	5 min	5 min

Note. HIIT = High Intensity Interval Training. UC = *uchi-komi*.

Internal Training Load (ITL)

The ITL was monitored and quantified using the session RPE (sRPE) with the CR-10 scale (Foster et al., 2001). Thirty minutes after the end of each training session, athletes answered the following question “How was your training session?”. The ITL was calculated as the product of session duration (minutes) and sRPE score (CR-10), and results are expressed in arbitrary units (AU). The ITL mean and the weekly-accumulated ITL (ITL total) was calculated intra-individually for the analysis. From the ITL data, strain and monotony were calculated weekly (Foster et al., 2001).

Well-Being and Recovery State

Athletes completed the well-being questionnaire (Hooper & Mackinnon, 1995) and the total quality of recovery (TQR) scale (Kenttä & Hassmén, 1998) 15 minutes before each training session to assess well-being and recovery state, respectively. The mean of each week was used for the analysis. The well-being questionnaire consists of four factors (stress, sleep quality, fatigue, and delay onset muscle soreness - DOMS) using a Likert scale, scored from 1-7 points, and the sum of these factors was used to calculate the Hooper Index (HI), for which high values indicate greater stress, fatigue, and DOMS, worse sleep, and poor overall recovery (Hooper & Mackinnon, 1995). The TQR scale, scored from 6-20 points was used to assess athletes' recovery and was reflective of the responses to the preceding training day, in which a high TQR score indicates better recovery (Kenttä & Hassmén, 1998).

Stress Tolerance (ST)

To evaluate ST, the Portuguese version (Moreira & Cavazzoni, 2009) of the DALDA (Rushall, 1990) was completed at the end of each training week. The DALDA questionnaire is divided into parts A (9 questions) and B (25 questions), which represent the sources and symptoms of stress. The possible answers to each question are “better than normal”, “normal”, and “worse than normal”. The sum of the responses marked as “worse than normal” on the questionnaire was recorded for analysis.

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences (SPSS® v.20, Inc, Chicago, IL). Data normality was verified using the Shapiro Wilk test, that indicated the normality of all data presented in Tables 2 and 3. The results are presented as mean $\pm$ standard deviation (SD). To evaluate differences in performance variables from the pre- to post-training intervention, a paired-sample t-test was used. Additionally, the percentage change values (%) were calculated for each variable, as the effect size (ES) to express the magnitudes of changes between pre- and post-training (Cohen, 1988). The threshold values for es were as follows: < 0.20 (trivial), 0.20-0.59 (small), 0.60-1.20 (moderate), and >1.20 (large) (Hopkins et al., 2009). ANOVA for repeated measures, followed by the Bonferroni post-hoc test was used to evaluate differences in ITL, well-being, recovery state, and ST values across the training weeks. The level of significance was set at $P < 0.05$ for all statistical analysis.

RESULTS

The comparisons between pre- and post-training for the variables obtained during the performance tests are demonstrated in Table 2. A significant increase was found in the number of repetitions in the UST after the training period ($P < 0.001$) presenting a large ES. The values of percentage changes

indicated improvements in the JCT tests, however with small ES. The SJFT results for pre- and post-training demonstrated small to large ES values, with a significant reduction in HR 1 minute after the test (HR₁) ($P = 0.049$). Furthermore, the mean SJFT HR_{recovery} was significant faster ($P = 0.008$) in the post-training (46.0 ± 7.9 bpm) compared to the pre-training (29.0 ± 12.5 bpm).

Table 2

Variables obtained in the performance tests at pre- and post-training (mean $\pm$ SD)

Variables	Pre-training	Post-training	% Change	ES (classification)
CMJ (cm)	38.6 $\pm$ 6.3	37.7 $\pm$ 6.1	-1.9 $\pm$ 8.9	-0.15 (trivial)
CMJ (W·kg ⁻¹)	3268.1 $\pm$ 726.1	3214.1 $\pm$ 740.4	-1.5 $\pm$ 6.9	-0.07 (trivial)
UST (rep)	18.5 $\pm$ 2.2	24.7 $\pm$ 2.2*	35.1 $\pm$ 17.6	2.82 (large)
Isometric strength-endurance JCT (s)	48.1 $\pm$ 11.5	52.1 $\pm$ 9.9	10.7 $\pm$ 17.8	0.38 (small)
Dynamic strength-endurance JCT (rep)	14.6 $\pm$ 6.3	15.9 $\pm$ 5.3	18.8 $\pm$ 25.0	0.22 (small)
SJTF throws (rep)	27.1 $\pm$ 1.1	28.0 $\pm$ 2.7	3.1 $\pm$ 7.0	0.47 (small)
SJFT index (beats·min ⁻¹ ·throws ⁻¹)	12.1 $\pm$ 0.3	11.6 $\pm$ 1.2	- 4.2 $\pm$ 9.3	-0.67 (moderate)
SJFT HR ₁ (bpm)	150 $\pm$ 9.1	139 $\pm$ 8.0*	-7.2 $\pm$ 8.1	-1.29 (large)

Note. $n = 8$; CMJ, Countermovement Jump; UST, Uchi-Komi Speed Test; JCT = Judogi Chin-Up test; reps= repetitions; SJTF, Special judo fitness test; HR₁: heart rate 1 minute after the test

* $P < 0.05$ compared to pre-training.

Table 3 presents the mean and total ITL, DALDA responses “worse-than-normal”, TQR score, and Hooper Index obtained during each of the 4 weeks of training (HIIT sessions and judo training sessions). A significant decrease was found for ITL from week 3 to week 4 ($P < 0.001$). No significant differences were found between the training weeks for any other variables ($P > 0.05$), although the responses “worse-than-normal” demonstrated a tendency to decrease in week 4.

Table 3

Internal training load (ITL), DALDA responses “worse-than-normal”, TQR score, and Hooper index obtained during the 4-week training program (mean $\pm$ SD)

Variables	Week 1	Week 2	Week 3	Week 4
ITL mean (AU)	484.3 $\pm$ 57.1	402.8 $\pm$ 96.2	526.5 $\pm$ 162.1	366.8 $\pm$ 134.3*
ITL total (AU)	2362.5 $\pm$ 342.7	2013.8 $\pm$ 480.9	2632.5 $\pm$ 810.4	1833.8 $\pm$ 671.7*
DALDA “worse-than-normal”	8.5 $\pm$ 2.1	7.1 $\pm$ 5.2	6.1 $\pm$ 3.5	5.4 $\pm$ 3.2
TQR score	14.8 $\pm$ 2.1	15.3 $\pm$ 2.5	14.2 $\pm$ 2.0	15.0 $\pm$ 2.6
Hooper Index	12.9 $\pm$ 2.1	12.8 $\pm$ 4.1	13.1 $\pm$ 3.9	13.5 $\pm$ 4.0

Note. ITL: internal training load; DALDA: daily analysis of life demands for athletes; TQR: total quality of recovery; Hooper Index obtained to the Well-Being scale.

* $P < 0.05$ compared to week 3.

DISCUSSION

The present study aimed to determine the effects of four weeks of complementary HIIT sessions (3 weeks of intensified training followed by 1 week with reduced TL) on physical performance, internal training load (ITL), stress tolerance, recovery, and well-being in under-18 judo athletes. The main findings were that performance in the UST and SJFT (represented by the HR₁ and HR_{recovery}) improved

after the training period presenting ES values classified as large, and ITL values decreased from week 3 to week 4, partially confirming the initial hypothesis.

Although previous studies have investigated HIIT as a complementary training strategy in judo (Magnani Branco et al., 2017; Ouergui et al., 2022; Ouergui et al., 2020), only the current study structured a HIIT training program using the *nage-komi* modality, combining a TL intensification followed by one week of reduced TL. Concerning the mean values and percentage variations in the performance tests, although a significant difference was only demonstrated in the UST, all results showed improvement after the training period, except for the CMJ test.

Our findings regarding the CMJ are similar to previous studies with judo athletes that did not demonstrate changes in CMJ performance before training periods with complementary sessions (Magnani Branco et al., 2022; Ouergui et al., 2022). Ouergui et al. (2022) evaluated 59 adolescent male and female judo athletes (15 ± 1 years) who performed four weeks with intensified training followed by 12 days of tapering, consisting of HIIT sessions with different exercise modalities (*kumi-kata*, *uchi-komi* and running) added to the regular training program, and did not find differences in CMJ performance comparing pre- and post- training in any training groups. Magnani Branco et al. (2022) investigated the effects of a complementary strength program on physical fitness in 21 under-18 judo athletes, in which the experimental group performed the same judo training routine added to sessions of strength training for eight weeks, and did not presented improvements in the CMJ test after the period evaluated. Similarly to the present study, Ouergui et al. (2022) and Magnani Branco et al. (2022) did not apply any specific training to improve lower limb power assessed by the CMJ, which could explain the lack of changes between pre- and post-training.

Unlike CMJ, in the present study the performance in the *Uchi-Komi* Speed Test (UST) showed significant improvements post-training, presenting a large ES for the comparison between pre- and post-training. Ouergui et al. (2022) also evaluated judo athletes using the UST test after 4-weeks of HIIT training followed by tapering and found that the *uchi-komi* group demonstrated better performance compared to the RG and control groups. The authors suggested that the *uchi-komi* and *nage-komi* involve specific movements in the UST, thereby enhancing athletes' performance when incorporated into training.

Concerning the isometric and dynamic strength *Judogi* Chip-Up Test (JCT), the present study found no significant differences and small ES in performance after the training period, although the percentage changes indicated a notable trend toward improvement. Similar to our findings, Ouergui et al. (2022) did not observe significant improvements in the JCT between pre- and post-training, but the *kumi-kata* group obtained higher values post-training compared to the running and control groups. It is important to mention that in both the present study and the study of Ouergui et al. (2022) the training programs did not focus on improving strength of the upper limbs, thus explaining the lack of changes in the performance of JCT.

The Special Judo Fitness Test (SJFT) is one of the most commonly used test to assess physical performance in judo (Sterkowicz-Przybycień et al., 2019; Papacosta et al., 2013; Ouergui et al., 2022). In the present study, although we did not demonstrate a statistically significant improvement in the SJFT index after the training period, the ES for the comparison between pre- and post-training was moderate. In addition, the significant reduction in HR_1 and faster $HR_{recovery}$ after the training period, added to the large ES for this comparison, indicated a positive effect of the HIIT training on SJTF

performance. Ouergui et al. (2022), after an HIIT complementary training period, found no significant difference for the SJFT index in the *kumi-kata* group (14.5 ± 2.5 vs. 11.9 ± 1.5 beats·min⁻¹·throws⁻¹) and *uchi-komi* group (16.0 ± 1.4 vs. 13.3 ± 1.3 beats·min⁻¹·throws⁻¹), similar to our results. Papacosta et al. (2013) evaluated 11 judo athletes (20 ± 6 years) before and after four weeks of training with the *randori* modality, in which two intensified training weeks were followed by two weeks of reduced TL (*a.*, tapering), and also reported no significant changes between pre- and post-training for the SJTF index (12.3 ± 2.0 *a.*; 11.3 ± 1.9 beats·min⁻¹·throws⁻¹). It is important to note that the values of the SJTF index obtained in the present study (12.1 ± 0.3 vs. 11.6 ± 1.2 beats·min⁻¹·throws⁻¹) were similar to those obtained by Ouergui et al. (2022) and Papacosta et al. (2013) with judo athletes.

Concerning the ITL values, the present study reported a significant reduction in week 4 compared to week 3, as expected. Studies with judo training programs have used sRPE monitoring to confirm the changes between intensified and reduced TL (Ouergui et al., 2020; Magnani Branco et al., 2017; Papacosta et al., 2013). For example, Ouergui et al. (2020) with 61 adolescent male and female judo athletes (15 ± 1 years) monitored the sRPE during intensified and tapering phases of judo training in three experimental groups with HIIT complementary training sessions (*i.e.*, *randori*, *uchi-komi*, running); the results revealed that training sessions during reduced ITL (*i.e.*, tapering) had significantly lower sRPE values compared to intensified training sessions, as in our findings. Papacosta et al. (2013) also demonstrated a significant increase in ITL and sRPE values during the intensified weeks, with a significant reduction during the tapering weeks. Together with sRPE to monitor ITL, the TQR scores and the Hooper index were determined in the present study, and neither measure showed significant differences between the training weeks. These results contrast with the findings of Ouergui et al. (2020) who reported that both the TQR and Hooper index significantly decreased during the tapering period compared to the early weeks of intensified training.

Specifically, regarding the results related to ST, no significant differences were found between the training weeks, although there was a tendency to reduced responses of "worse-than-normal" in the final training week with reduced ITL. Only the study of Magnani Branco et al. (2017) used the DALDA to monitor ST in 35 judo athletes during four weeks of three different modes of HIIT (cycle-ergometer for lower limbs, cycle-ergometer for upper-limbs and *uchi-komi* groups) and demonstrated that ST did not significantly change during the monitoring period, similar to the present study.

Despite the important findings of the current study, some limitations should be highlighted, such as the lack of a control group that did not perform the complementary HIIT training for the same period. In addition, we should mention the lack of performance tests at the end of the third week, which would provide more data related to the effects of increased ITL on performance.

CONCLUSION

Therefore, four weeks of complementary HIIT sessions with the *nage-komi* modality, using 3 weeks of intensified training followed by 1 week of reduced TL, led to positive improvements in judo athlete performance, particularly in the UST and in the athletes' recovery, as assessed by HR one minute after the completion of the SJFT. Furthermore, as expected, the reduced TL period significantly reduced the ITL. In terms of practical applications, the current study provides a suggestion for judo coaches to incorporate HIIT combined with *nage-komi* into their training programs, to enhance power and speed

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in judo techniques. Additionally, the combination of using simple tools, such as sRPE, TQR, the Well-Being scale, and DALDA is a suggestion for coaches to monitor judo training.

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