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Behaviour of training loads and physical performance during a period of 6 weeks in high-intensity functional training practitioners

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ABSTRACT
Purpose. The present study aimed to analyse the behaviour of training loads and evaluate specific aspects of physical fitness during a period of 6 weeks in high-intensity functional training (HIFT) practitioners.
Methods. The study included 12 practitioners (4 men and 8 women; age: 31.08 ± 4.80 years) of HIFT. The session rating of perceived exertion was routinely collected after each training session for 6 weeks. The sum and average of the weekly loads of training, strain, monotony, and acute/chronic workload ratio were recorded for analysis. In addition, the athletes underwent sprint, countermovement jump, and handgrip strength tests before and after the 6 weeks of HIFT.
Results. A constant dynamic of the weekly internal training loads and the mean internal training loads was observed, with difference in the results from weeks 1 to 3 ($F = 3.283$; $p = 0.02$). In addition, the practitioners obtained superior results in countermovement jump ($t = 3.573$; $p = 0.005$) and lower limb muscle power ($t = 3.536$; $p = 0.005$) after the 6 weeks.
Conclusions. The internal training load varied significantly only from weeks 1 to 3 over the 6 weeks. In addition, we observed that the 6-week HIFT was able to generate functional adaptations only in countermovement jump and lower limb muscle power.
Key words: perceived exertion, sprint, muscle power, vertical jump, training monitoring

Introduction

Presently, the participation in high-intensity functional training (HIFT) has been gaining a high number of adepts [1, 2]. HIFT is characterized as presenting high intensities and variations in training (i.e., constantly varying exercises), with a set time to perform a number of repetitions or to perform certain tasks with shortest intervals [1]. In addition to the characteristic of the plurality of functional movements executed at high intensity, HIFT aims to improve the variables of physical fitness (i.e., strength, body composition, etc.) and performance (i.e., speed, power, etc.) [3]. Therefore, HIFT needs efficient training strategies and adequate training monitoring, so that the practitioners can give their maximum potential with an attenuated risk of injuries [4].

Internal training load (ITL) monitoring is used to assess the effects of training on the body [5]. Metabolic, cardiovascular, and respiratory evaluations are commonly used to verify the training responses of the respective practitioners [6]. Thus, adequate monitor-

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ing of ITL is extremely relevant, with the objective of minimizing the risk of injury [7]. For monitoring ITL, session rating of perceived exertion (session-RPE) can be used since it is a low-cost tool with excellent practical applicability [8]. For example, it has been shown that session-RPE is more sensitive and accurate to detect changes in ITL when compared with measurements derived from heart rate [9]. In addition, session-RPE has exhibited a strong association with blood lactate values, immediately ($\rho = 0.681$; $p = 0.004$) and 30 minutes ($\rho = 0.803$; $p < 0.0005$) after HIFT [9].

Previously, session-RPE was reported to be an effective, safe, and low-cost tool, sensitive to behaviour changes of ITL in collective sports [10] and for individual modalities such as HIFT [8]. Session-RPE is one of the most applied and popular instruments for ITL monitoring [11]. The training load control method based on session-RPE was proposed with the consideration of data of weekly mean, monotony, and strain [11]. The method has been popularized and session-RPE is widely used in various sports [11]. In particular, ITL monitoring is extremely relevant for daily adjustments in training sessions in accordance with the individuality of each athlete [12].

Recently, Tibana et al. [13], Williams et al. [14], and Crawford et al. [15] used session-RPE for quantification and monitoring of ITL in HIFT. The authors confirmed that the session-RPE method was efficient in differentiating ITL at different stages of training. Tibana et al. [8] recommend that the use of this tool is of immense importance in ITL control, since it can indicate the effects of the training, thus helping the coach to make adjustments when necessary, with the objective to individualize the training loads and prevent injuries. However, despite the exponential growth of the modality, as well as the number of practitioners, to the best of our knowledge, only 5 studies have analysed the behaviour of ITL [4, 8, 13–15]. Therefore, there is a shortage of research in HIFT practitioners that have monitored ITL in order to analyse the stress/recovery ratio [1] measured via session-RPE, acute/chronic workload ratio (ACWR), and verification of specific aspects of physical fitness after a 6-week training period.

Thus, the present study aimed to analyse the behaviour of ITL and evaluate specific aspects of physical fitness after 6 weeks of training in HIFT practitioners. The study hypothesis was that there would be large variations in training loads (i.e., high and low loads) and that the 6-week HIFT would be capable of generating functional adaptations in practitioners with increased physical fitness.

Material and methods

Participants

The sampling process was intentional and non-probabilistic. However, we emphasize that previous studies [4, 8, 13, 14] were carried out with similar or smaller sample sizes. The samples were recruited at an HIFT centre. A total of 12 practitioners of both genders volunteered and were followed for 6 weeks. It is important to note that 1 practitioner did not perform the post-intervention test for personal reasons. However, the athlete met all inclusion criteria and participated in the entire monitoring process (i.e., 6 weeks). Therefore, we decided to include the individual in the results regarding the monitoring of training load and exclude them only from the performance tests analysis (results presented in Table 3), since the athlete did not complete the post-intervention test. At all times (i.e., morning, afternoon, and evening) and for all practitioners, the project was conducted at the HIFT training centre. The researchers spent a week in the training centre facilities conducting the study explanation and aiming to recruit several practitioners; however, only 12 athletes (4 men and 8 women; age: 31.08 ± 4.80 years; height: 166.50 ± 9.26 cm; body mass: 70.22 ± 9.82 kg) with experience in HIFT (at least 4 months) volunteered to participate in the present study and completed the research (see Table 2). As an inclusion criterion, it was adopted not to present osteomioarticular injuries and to have practised the modality for at least 4 months. The exclusion criteria involved inability to complete at least 75% of training sessions or using ergogenic aids (i.e., anabolic steroids). All practitioners reached at least the recommended minimum (i.e., 75% of the training sessions; ca. 14 training sessions for athletes with a frequency of 3 times per week and ca. 23 training sessions for those with a frequency of 5 times per week) and all completed the study, with the exception of one individual, as mentioned above. A total of 18–30 training sessions were completed by the participants, since there were practitioners with lower (i.e., 3 times) and higher (i.e., 5 times) weekly training frequency (see Table 2 for more details).

Design and procedures

The study presents a longitudinal character with a quantitative approach. The practitioners were familiar with all the procedures and tests, as they were already routinely used in their training program. During the collection period, the periodization and the training

Table 1. High-intensity functional training program during 6 weeks

Weeks	Monday	Tuesday	Wednesday	Thursday	Friday
	Training of the week				
Week 1	• Dumbbell press 5-3-3-1-1-1 repetitions • Practice scales for 10 minutes	5 rounds for time of: • 1 L-sit rope climb, 15 ft • 35 strict push-ups	3 rounds for time of: • 5 strict L pull-ups • 15 strict push-ups • 5 strict L pull-ups • 15 strict push-ups • 750-m row	3 rounds for time of: • 20 walking lunges • 30 wall-ball shots • 40 triple unders *Men: 20-lb ball to 10 ft* *Women: 14-lb ball to 9 ft*	• Alternating-arm dumbbell row 1-1-1-1-1-1-1 repetitions (8 repetitions per arm) • Practice controlled descent from handstands for 15 minutes • 2000-m row
Week 2	3 rounds for time of: • 15 power snatches • 15 thrusters • 1000-m row *Men: 95 lb* *Women: 65 lb*	• Deadlift 5-3-3-1-1-1 repetitions • Practice scales and planks for 20 minutes	5 rounds for time of: • 9 deadlifts • 5 squat cleans • 3 thrusters *Men: 135 lb* *Women: 95 lb*	• 5000-m run or row • Stretch and practice handstands for 20 minutes	Cindy Complete as many rounds as possible in 20 minutes of: • 5 pull-ups • 10 push-ups • 15 squats
Week 3	3 rounds for time of: • 12 left-hand Turkish get-ups • 12 right-hand Turkish get-ups • 3 legless rope climbs, 15-ft rope *Men: 50-lb dumbbell* *Women: 35-lb dumbbell*	For time: • 1000-m row • 50 strict pull-ups • 1000-m row • 100 push-ups • 1000-m row • 150 squats	• 12 minutes of stretching • 12 minutes of L-sit practice • 12 minutes of handstand practice • 12 minutes of plank practice • 12 minutes of scales practice	3 rounds for time of: • 500-m row • 100 double unders • 20 thrusters *Men: 65 lb* *Women: 45 lb*	CrossFit Total • Back squat, 1 repetition • Shoulder press, 1 repetition • Deadlift, 1 repetition
Week 4	5 rounds for time of: • 7 left-arm dumbbell rows • 7 right-arm dumbbell rows • 21 dumbbell bench presses • 500-m row *Men: 50-lb dumbbells* *Women: 35-lb dumbbells*	Complete as many rounds as possible in 20 minutes of: • 5 strict L pull-ups • 10 ring dips • 15 single-leg squats	• Clean and jerk 1-1-1-1-1 repetitions Then, practice for 5 minutes each, in any order: • Stretching • Plank holds • L-sits • Scales • Handstand descents	Complete as many rounds as possible in 12 minutes of: • 5 strict muscle-ups • 20 walking lunges Then, practice for 5 minutes each, in any order: • Stretching • Plank holds • L-sits • Scales • Handstand descents	• Back squat 1-1-1-1-1 repetitions Then, practice for 5 minutes each, in any order: • Stretching • Plank holds • L-sits • Scales • Handstand descents

Week 5	Complete as many repetitions as possible in 12 minutes of: • 1 strict pull-up, 2 push-ups, 3 squats • 2 strict pull-ups, 4 push-ups, 6 squats • 3 strict pull-ups, 6 push-ups, 9 squats, etc. Start at a higher round if you think it will allow you to complete more repetitions in the 12 minutes, e.g., 5-10-15, then 6-12-18, then 7-14-21, etc.	4 rounds for time, alternating arms each round, of: • 10 single-arm squat snatches • 8 single-arm rows • 6 single-arm push presses • 4 single-arm Turkish get-ups *Men: 50-lb dumbbells* *Women: 35-lb dumbbells*	• 5000-m run or row	Tabata squats • L-sit for 2 minutes in as few sets as possible The Tabata interval is 20 seconds of work followed by 10 seconds of rest for 8 intervals. Score is the least number of repetitions performed in any of the 8 intervals	4 rounds for time of: • 21 bench presses • 15 pull-ups • 400-m run *Men: 135 lb* *Women: 95 lb*
Week 6	3 rounds for time of: • 15 cleans • 15 thrusters • 1000-m row *Men: 135 lb* *Women: 95 lb*	• 100 ft of legless rope ascent in as few sets as possible L-sit for 2 minutes in as few sets as possible Count rope progress from where your hands begin to where your hands end in each climb	Tabata This! • Tabata row, rest 1 minute • Tabata squat, rest 1 minute • Tabata pull-up, rest 1 minute • Tabata push-up, rest 1 minute • Tabata sit-up The Tabata interval is 20 seconds of work followed by 10 seconds of rest for 8 intervals. Tabata score is the least number of repetitions performed in any of the 8 intervals. Unit for the row is calories	CrossFit Total • Back squat, 1 repetition • Shoulder press, 1 repetition • Deadlift, 1 repetition	• Warm-up for 20 minutes with scales, L-sits, inversion (handstands), planks, and stretching. Fran (kipping!) 21-15-9 repetitions for time of: • Thrusters • Pull-ups *Men: 95 lb* *Women: 65 lb*

schedule were organized and planned by the coach that was responsible for managing the training centre in order to provide a control between stress and recovery, thus allowing the athletes to cope well with the physical and physiological demands. During the 6 weeks of training, different training loads were applied (Figure 1). A weekly frequency of 4.33 ± 0.89 training days was completed by the practitioners over the 6 weeks (see Table 2). All participants reached at least the recommended minimum for our study (i.e., 75% of the training sessions).

The training program (Table 1) was based on the popular model used in the HIFT community [16]. The structure of the training sessions was the same for all practitioners (i.e., warm-up, movement techniques, gymnastic exercises, and aerobic conditioning). However, in cases of possible difficulty to perform the exercise, variations were applied in order to adapt the exercise for each practitioner. In addition, we emphasize that the training intensity was based on the RPE planned by the coaches over the 6 weeks in the range of 4–10 on the 10-point scale of RPE. To increase the training intensity, the readiness status of each practitioner was considered with the use of a recovery scale [17] prior to each training session. Nevertheless, the athletes' recovery over the 6 weeks was in the range of 12–18 on the 6–20 recovery scale, with the smallest numbers corresponding to poor recovery and the highest values representing good recovery. The methodology used aimed to individualize training loads so that the practitioners performed their best at each training session.

In general, the training sessions commenced with a general warm-up (i.e., squats, press, deadlift, etc.; ca. 10 minutes), followed by sessions of movement technique (i.e., Olympic weightlifting, squats, and variations; ca. 20 minutes), gymnastic exercises (handstands, bar exercises, exercises on gymnastics rings, etc.), and aerobic conditioning (i.e., running, rowing, jumping rope, etc.; ca. 30 minutes) (Table 1). The training sessions lasted 1 hour. The purpose of these conditioning sessions was to complete training in the shortest possible time, whereas other conditioning sessions on subsequent days (depending on the periodization phase) were intended to perform the greatest number of repetitions within the practitioner's limit in a fixed time period.

Speed tests (i.e., 20-m sprint), countermovement jump (CMJ; heel height and muscle power of lower limbs), and handgrip strength tests were performed before and after the 6 weeks of training. In addition, over the course of the 6 weeks, session-RPE was calculated (RPE × session time) after each training session [11]. All practitioners were familiar with the training and testing procedures of the present study.

Measures

Internal training load: session rating of perceived exertion

ITL was recorded by using session-RPE [11]. Around 30 minutes after the end of each training session, the practitioners were invited to report the intensity of the session on a 10-point scale of perceived exertion suggested by Foster [11] by answering the question 'How intense was your training session?' The reported value was multiplied by the total duration of each training session (ca. 60 minutes), in minutes, which resulted in a value of arbitrary units (AU) [11]. Eventually, the session-RPE values (daily and weekly) were used for the analyses. It is important to note that all practitioners had already been familiar with the category-ratio (CR-10) scale for at least 4 months prior to this study (information provided by the training centre trainer).

Monotony of training

The monotony was verified by the average ratio of the ITL inherent in each week and its respective standard deviation. The objective of determining monotony is to indicate the variation of ITL during a training phase [11]. Foster [11] proposed values of monotony below 2.0 for attenuation of injury risks.

Strain

The strain was calculated as the sum of the daily ITL AUs of each week multiplied by the monotony of the same time interval [11]. The objective of determining strain is to indicate the overall stress required of the athlete during a given phase of training: in the case of the present study, each of the 6 weeks evaluated [11].

Acute/chronic workload ratio calculation

A week of internal workloads portrayed an acute workload, whereas the average of 3 weeks of antecedent workload depicted a chronic burden. ACWR was calculated by dividing the acute workload by the chronic workload [18] and should present values between 0.8 and 1.3 considered within the safe zone previously proposed by Gabbett [18]. Thus, when the acute workload is greater than the chronic load, ACWR is high; when the chronic workload is greater than the acute load, ACWR is low.

Recovery quality (recovery scale)

The perceived recovery was acquired in the morning before each training session with a recovery scale [17]. The practitioners were asked to report individually how they felt about their overall recovery in the previous 24 hours (including night sleep). The scores on the recovery scale vary between 6 and 20, where the smallest numbers correspond to poor recovery and the highest numbers reflect good recovery.

Physical performance

Speed test (20-m sprint). Before performing the speed tests and after the warm-up proposed by the trainer responsible for the training centre, 1 photocell (Cefise®, São Paulo, Brazil) was allocated 20 m from the starting point. The practitioners performed the test in duplicate, from the standing position with the front foot placed 0.3 m behind the photocell (i.e., starting line). In order to minimize the climatic effects, all speed tests were conducted in a covered training centre. An interval of 5 minutes between the series was offered and the best time was used for data analysis [19].

Muscle power of lower limbs and jump height (CMJ). The muscle power of lower limbs (i.e., absolute and relative muscle power) and the height of the vertical jump were verified with the use of CMJ. The athletes were familiar with the jump test and were able to exercise a downward movement followed by a complete extension of the legs; they were free to establish the amplitude of the countermovement in order to avoid changes in the coordination of the jumps. All attempts were performed with the hands fixed on the hips and the practitioners were encouraged to jump as high and fast as possible [12]. A contact platform (Cefise®, São Paulo, Brazil) connected to the Jump Test Pro 2.10 software was used to measure the muscular power of the lower limbs and the CMJ height. Moreover, 5 attempts with 15-second intervals were applied [19]. Eventually, the jump was considered valid for analysis if the take-off and landing positions remained visually analogous. Subsequently, the best result was used for data analysis.

Handgrip strength. The practitioner was comfortably seated, positioned with the shoulder slightly adducted, elbow flexed at 90°, forearm in neutral position, and, eventually, the positioning of the wrist could oscillate from 0° to 30° of extension. These procedures are in accordance with the specifications of the American Society of Hand Therapists [20]. The dynamometer measurement (Jamar®, São Paulo, Brazil) was regulated depending on the characteristics of each practitioner, and the best result of 3 attempts was used to analyse the data. The handgrip strength of both hands was assessed (see Table 3). However, our study did not differentiate between the dominant and non-dominant hand.

Statistical analyses

Normality was tested by using the Shapiro-Wilk test and *Z*-score analysis of asymmetry and kurtosis (–1.96 to 1.96). Continuous data are reported as mean and standard deviation or median and interquartile range. ANOVA of repeated measures was applied to verify the magnitude of ITL (AUs of the week and their respective means, strain, and monotony) over the 6 weeks in HIFT practitioners. Mauchly's test served to verify the sphericity of the data, and in any case of violation, the Greenhouse-Geisser correction was used. The Bonferroni *post-hoc* test allowed to identify the point differences. The paired *t*-test was applied to verify the differences in performance variables (pre- vs. post-intervention). For all analyses, $p < 0.05$ was considered as statistically significant. All analyses were performed with the Statistical Package for the Social Sciences software (SPSS; IBM®, New York, USA), version 20.0.

Ethical approval

The research related to human use has complied with all the relevant national regulations and institutional policies, has followed the tenets of the Declaration of Helsinki, and has been approved by the Federal University of Rio Grande do Norte Ethics Committee (approval No.: 3.082.357).

Informed consent

Informed consent has been obtained from all individuals included in this study.

Results

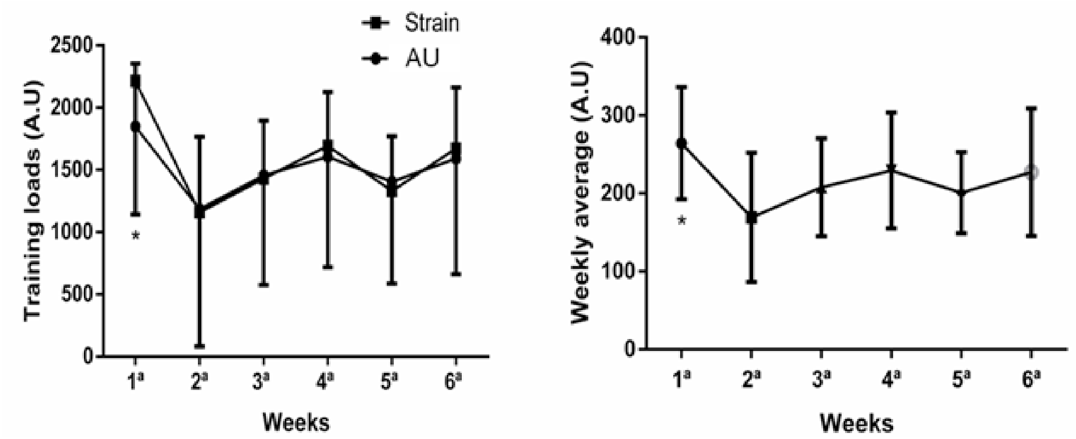
The demographic and training characteristics of the practitioners are reported in Table 2.

There was a significant difference in the weekly ITL (AU) and mean ITL (AU) [$F_{(5.55)} = 3.283$; $p = 0.01$; $\mathcal{E} = 0.054$; $\eta^2 = 0.230$; power = 0.863)] only in weeks 1–3 ($p = 0.02$). No significant difference was observed in strain [$F_{(2.428;\ 26.703)} = 2.773$; $p = 0.07$; $\mathcal{E} = 0.486$; $\eta^2 = 0.201$; power = 0.547)] (Figure 1) or monotony [$F_{(2.269;\ 24.957)} = 2.268$; $p = 0.11$; $\mathcal{E} = 0.454$; $\eta^2 = 0.171$; power = 0.443)] (Figure 2) over the 6 weeks.

Figure 2 reports weekly monotony and ACWR during the 6 weeks of training. The ACWR (values between 0.8 and 1.3) and the weekly monotony (values below 2.0) were within the safe zone as observed over the 6 weeks.

Table 2. Demographic and training characteristics of the 12 practitioners (4 men and 8 women)

Characteristics	Mean ± *SD*	Minimum	Maximum
Age (years)	31.08 ± 4.80	23	38
Body height (cm)	166.50 ± 9.26	155	188
Body mass (kg)	70.22 ± 9.82	58	91.2
Weekly training frequency (days)	4.33 ± 0.89	3	5
Training experience (months)	19 ± 10.63	4	36



* different from week 3 (p = 0.02)

Figure 1. Strain, weekly ITL, and mean ITL of the 12 practitioners

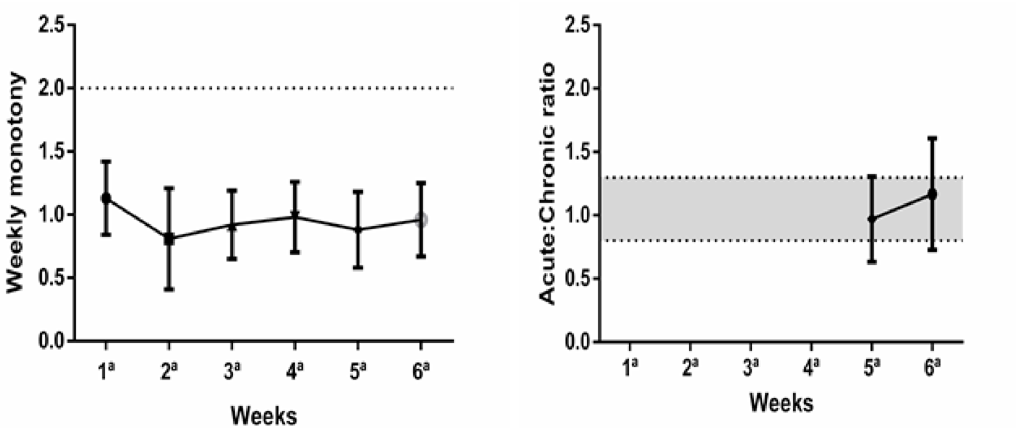


Figure 2. Weekly monotony and acute/chronic workload ratio among the 12 practitioners

No significant difference was observed in the sprint time between the pre- (4.35 ± 0.32) and the post-intervention test (4.42 ± 0.31; Δ% = 0.07; 95% CI: 0.19–0.04; $t_{(10)}$ = 1.370; p > 0.05). However, a significant increase was noted in the muscle power of lower limbs (watts) between the pre- (2954.63 ± 841.09) and the post-intervention test (3051.64 ± 850.65; Δ% = 97.00; 95% CI: 169.76–24.23; $t_{(10)}$ = 2.970; p = 0.01), in the relative wattage (watts/kilogram) between the pre- (42.06 ± 7.27) and the post-intervention test (43.52 ± 7.22; Δ% = 1.46; 95% CI: 2.38–0.54; $t_{(10)}$ = 3.536; p = 0.005), and in CMJ between the pre- (30.80 ± 8.29) and the post-intervention test (32.50 ± 8.21; Δ% = 1.70; 95% CI: 2.77–0.64; $t_{(10)}$ = 3.573; p = 0.005). In contrast, there was no significant difference in the left handgrip strength (Δ% = –0.45; 95% CI: 3.43 to –4.34; $t_{(10)}$ = –0.261) or in the right handgrip strength between the pre- and the post-intervention test (p > 0.05) (Table 3).

Table 3. Physical performance of the 11 practitioners (mean ± *SD*) (see the *Participants* section for more details)

Variables	Baseline	After intervention	*t*	*p*	*ES*
Sprint	4.35 ± 0.32	4.42 ± 0.31	1.370	0.201	0.39
LLMP (W)	2954.64 ± 841.09	3051.64 ± 850.65*	2.970	0.014	0.90
LLMP (W/kg)	42.06 ± 7.27	43.52 ± 7.22*	3.536	0.005	1.06
CMJ (cm)	30.80 ± 8.29	32.50 ± 8.21*	3.573	0.005	1.08
LHGS	37.45 ± 12.35	37.00 ± 11.34	–0.261	0.800	0.07
RHGS#	35 (16)	36 (12.5)	–	0.932	–

LLMP – lower limb muscular power, CMJ – countermovement jump, LHGS – left handgrip strength,
RHGS – right handgrip strength, *ES* – effect size
\# median and interquartile interval, * different from baseline

Discussion

The present study aimed to analyse the behaviour of the ITL and evaluate specific aspects of physical fitness after 6 weeks of training in HIFT practitioners. Improvement was noticed in the CMJ performance and muscle power after 6 weeks; however, no improvement was seen in the sprint, left handgrip strength, or right handgrip strength. The weekly mean values were 1515 AU; however, the monotony values remained low. Internal loading measures did not differ over the 6 weeks of training except for weeks 1–3. Therefore, in accordance with the hypothesis of our study, it was possible to observe that there were variations in the weekly and mean ITL, although significant differences were observed only between week 1 and week 3, without differences in strain and monotony. In addition, the 6-week HIFT was able to generate functional adaptations only in CMJ and lower limb muscular power.

Our findings revealed that the behaviour of training loads fluctuated over the 6 weeks and that the session-RPE was effective in differentiating the various loads assigned in the training sessions. Recently, certain studies have used the method (i.e., session-RPE) to quantify training loads in HIFT athletes [8, 13, 14] and new practitioners [15]. However, in our study and in the studies by Tibana et al. [8], Tibana et al. [13], and Williams et al. [14], the subjects were familiar with and accurately reported the session-RPE. On the other hand, in a study by Crawford et al. [15], the participants' ability to accurately report the session-RPE was not high, but improved over time, possibly owing to increasing familiarization with the method. Therefore, coaches must be aware of this situation and practitioners must carry out a period of familiarization with session-RPE so that the results are reliable and accurate. Tibana et al. [13] confirmed that the session-RPE method was efficient in differentiating workloads at various stages of training. Additionally, Williams et al. [14] investigated ITL through session-RPE and heart rate variability over a 16-week period. The authors reported that the risk of nonfunctional overreaching was highest when the burden of acute/chronic training measured through session-RPE was high. Eventually, Tibana et al. [8] recommend that the use of this tool is extremely important for the control of ITL, since it indicates the training effects, so that the coach can make the necessary adjustments, with an objective to individualize the training loads and prevent injuries.

It is important to highlight not only the global concentrated loads over a given period, but also the distribution of weekly loads and their respective 'adjustments' in accordance with the athletes' responses [21]. The American College of Sports Medicine published a consensus about HIFT on its structuring and listing the induction of fatigue training as a potential mechanism that could induce injuries in practitioners and suggested training load monitoring to minimize the risk of injury [7]. Williams et al. [14] reported that the average weekly training loads were 2591 ± 890 AU, similar to those in a study by Tibana et al. [8] (2092 AU) and higher than the ones observed by Tibana et al. [13]; however, in our study, ITL presented values of 1515 AU during the 6 weeks, which seems to confirm that more advanced athletes or practitioners have a higher ITL.

In the present study, no enhanced variation was observed in the monotony of the loads over the 6 weeks. Foster [11] reported monotony as the variation of training intensities over a period. The strain highlights the general stress imposed on the athlete during the training phases [11]. Our findings reveal that there were no significant variations among the investigated weeks; however, the values were lower than those previously observed in young adults [22]. Foster [11] implied that monotony peaks greater than 2.0 as well as high strain were correlated with 77% and 89% in illness occurrences, respectively. Ferrari et al. [23] investigated the internal workload of 8 cyclists trained in a 29-week period and found significant correlations between the upper respiratory tract infection and training strain at certain stages of training (i.e., preparatory and competitive; $r = 0.72$; $p = 0.03$ and $r = 0.73$; $p = 0.03$, respectively). In addition, it seems that high strain values are negatively related to the physical performance gains [24].

Regarding physical performance, no significant difference was observed in the sprint time. To the best of our knowledge, no study involved a 20-m sprint test to monitor the performance of HIFT practitioners before and after 6 weeks. In a recent study, there were also no differences in a 400-m run after 6 months of HIFT [25]. The absence of significant differences in sprint time can be interpreted with a possible increase in residual fatigue and, therefore, the sprint time may provide parameters to quantify the neuromuscular impairment [26]. In particular, it has been reported that sprint training enhances jumping and running skills [27]; however, these studies used specific training and higher volumes, unlike the present study, where sprint was only addressed as a form of performance tests. Moreover, sprint training was not included in the HIFT programming. Nevertheless, this training approach can be accommodated within the training schedule, since the training of this variable in addition to strength and power training is primordial for maximizing muscle strength and, consequently, the ability of short sprints [28]. The sprint measured in the present study was short distance (i.e., 20 m), which is considered the initial phase of acceleration [29]. Thus, presumably, for greater distances, different results may have been observed.

Muscle power is of extreme relevance to performance in numerous sports [30]. Studies have shown that considerable extensions of muscle power can provide valuable performance evolutions in both team and individual sports [19, 31]. Recently, several studies have demonstrated associations between Olympic weightlifting movements that are commonly used in HIFT [32] and improvement in muscle power performance [33] of the vertical jump [34]. The singularity of the Olympic weightlifting movements indicates a request for a maximum acceleration of the practitioner during the triple extension (i.e., ankle, knee, and hip), which is directly associated with power gains and muscle strength [33]. For example, it was observed that 6 months [25] and 16 weeks [35] of HIFT resulted in increases in muscle strength [25, 35] and metabolic conditioning [35]. In addition, a previous study with characteristics similar to HIFT (i.e., high intensity) presented increased physical performance and reduced fat content [36]. On the other hand, 6 weeks of HIFT were not enough to increase physical performance in subjects with different training volumes and frequencies [37]. Therefore, the training of this ability (i.e., muscle power), among others, is of fundamental importance for the practitioners. In addition, CMJ height has been widely used to identify neuromuscular fatigue and measure responses to training [38]. Thus, training loads can be defined in accordance with the oscillations of the jump height, and, additionally, this height can be applied in the training sessions (i.e., daily) in order to evaluate and effectively control the responses and the state of athlete readiness [12].

The handgrip strength test revealed no significant difference after the 6 weeks of HIFT ($p > 0.05$). In several sports, hands constitute a relevant body segment for performance development [39]. Among these modalities, we highlight the Olympic weightlifting [40], commonly used in HIFT [32]. Handgrip strength is a relevant variable for sports and can be of prime importance for optimum performance. In addition, the preservation of handgrip strength advocates the importance of central mechanisms involved in the same [41]; whereas, central (exercise-influenced) fatigue may provide a reduction in muscle activation [42]. Although our study did not show an increase in handgrip strength after the 6 weeks of HIFT, the development of this capacity is of fundamental importance in order to increase performance in the sport. Possibly, better results could have been found by using the tapering strategy (i.e., reducing training volume with maintenance or increasing training intensity). Therefore, this question needs to be considered and answered in future research.

The ITL monitoring and performance testing are extremely relevant to assist coaches, sports scientists, and other professionals in the field in adjusting and opting for better training strategies and, simultaneously, avoiding unwanted spikes in training loads and verifying adaptations to the training imposed via performance tests. High training loads can present risks of nonfunctional overreaching, overtraining, and, consequently, high risks of injuries. Thus, efficient and low-cost monitoring tools are needed that have excellent practical applicability and provide simple and objective assessments of both practitioner training load and readiness.

Although the results of this study are of considerable importance for coaches, some limitations need to be highlighted: (i) Absence of dietary control. However, it is important to note that all practitioners were instructed to follow the diet they were used to. (ii) Absence of tapering (i.e., reducing training volume with maintenance or increasing training intensity). This was because the practitioners were following the training proposed by their coach vs. researcher intervention. On the other hand, all subjects were instructed to refrain from high-intensity exercise in the 72 hours preceding the fitness tests. In this way, the intention of the study was to provide information based on field tests, which in turn present greater applicability for coaches. (iii) The small sample size. However, we emphasize that previous studies [4, 8, 13, 14] were carried out with similar or smaller sample sizes. (iv) Absence of power analysis for the sample.

Conclusions

The results of the present study suggest that ITL did not vary significantly over the 6 weeks (except from week 1 to week 3). In addition, we observed that the 6-week HIFT was able to generate functional adaptations only in CMJ and lower limb muscular power. In the context of practical applicability, the use of psychometric tools for ITL monitoring and specific fitness tests seems to be a valuable choice since they were sensitive in detecting changes in training loads and performance.

Disclosure statement
No author has any financial interest or received any financial benefit from this research.

Conflict of interest
The authors state no conflict of interest.

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