Effects of Two High-intensity Interval Training Concepts in Recreational Runners

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Bibliography

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ABSTRACT

This study investigated the effects induced by 8 weeks of two high-intensity interval training (HIIT) protocols, 10–20–30 and 30–30 concepts, characterized by significantly different training volume and intensity, on physiological parameters, running performance, body composition and psychophysiological stress of recreational divided into two groups: the 10–20–30 group performed two 10–20–30 sessions/wk and one continuous training (CT)/wk, whilst the 30–30 group performed two 30–30 sessions/wk and one CT session/wk. VO_2max, 1 km time, maximal aerobic speed (MAS), and body composition were evaluated before and after intervention. Internal load was measured through rating of perceived exertion (RPE). Both groups significantly improved running performance (1 km time: p = 0.04; MAS: p = 0.000001), aerobic fitness (VO_2max: p = 0.000002) and body composition (lean mass (kg) p = 0.0001; fat mass (%) p = 0.00005). RPE resulted significantly lower in the 10–20–30 group than in 30–30 group (10–20–30: 13.36 ± 0.28; 30–30:15.55 ± 0.21; p = 0.0002). Thus, the 10–20–30 group improved physiological parameters, performance and body composition, similar to 30–30 with significantly lower RPE values. These results suggest that in recreational runners the 10–20–30 training is effective in improving aerobic fitness and performance, with a lower subjective perception of effort, thus enhancing individual compliance and adherence to the prescribed training program.

Introduction

Over the last years, there has been a growing interest focused on training protocols to improve physiological parameters and performance in recreational runners [1–3]. Typical recreational runner's training program consists of different combinations among continuous high-volume, low-intensity training and high-intensity interval training (HIIT) sessions. Continuous training involves activity without rest intervals, whereas HIIT involves repeated short (about tens of seconds) to long (few minutes) bouts of high intensity exercise, interspersed with brief periods of low-intensity work or inactivity. The purpose of HIIT is to repeatedly stress the physiological parameters involved during a specific endurance-type exercise [4] largely than those actually required during the activity. HIIT has been shown to be effective in improving VO_2max, cardiovascular and peripheral adaptations, and running economy in both untrained and endurance-trained participants [5, 6].

Several variables should be taken into account when designing a training program, including work interval intensity and duration, as well as between-series recovery duration and intensity. As concerns exercise intensity, it has been demonstrated in both well-trained and moderate trained runners that the greater improvement in performance and VO_2max is obtained spending greater time per session in exercise bouts at an intensity close to or above the VO_2max (i. e., "red zone") [5–7]. Longitudinal studies demonstrated in endurance sports that the HIIT consisting of 30 s near maximal work interspersed with 30 s rest (30–30 training) improved performance [8–10] and oxygen uptake [11, 12].

Recently, it was proposed a new HIIT protocol for recreational runners, the 10–20–30 training concept, which consists of 1 min intervals of 30, 20 and 10 s at an intensity corresponding to ≈ 30, ≈ 60 and ≈ 90–100 % of maximal aerobic speed (MAS), respectively [13]. This training, in which 10 s sprint intervals are combined with 30 s of low and 20 s of moderate intensity running, integrates anaerobic near maximal sprint work with periods of aerobic work. A following study demonstrated that this training protocol was able to induce higher performance improvements compared to continuous training, when applied to moderately trained runners [14].

At present, the scientific literature focused on the comparison between the 10–20–30 training protocol and continuous training. However, it would be interesting to evaluate its efficacy in recreationally active runners with respect to others HIITs.

Furthermore, affective variables and psychophysiological stress are important predictors of individual compliance to training programs and future participation in recreational sport activities. Nevertheless, to the best of our knowledge, no study has compared physiological and performance effects as well as internal training loads between different HIIT regimes in recreational runners.

Thus, the aim of this study was to compare, in recreational runners physiological, performance and perceptual responses induced by 10–20–30 training program with those undergoing 30–30 training, in order to provide general recommendations for the more effective HIIT program in these runners. The psychophysiological stress experienced by the participants during the two different HIIT regimes was evaluated by measuring the whole-body rating of perceived exertion (RPE).

Materials and Methods

Participants

Twenty-two recreational male runners, with at least 3 years of experience in running and a weekly training volume of about 15 km, were enrolled for the study and randomly divided into 2 groups with a block randomization design. They were assigned to one of the 2 training programs: the 10–20–30 group (n = 11) and the 30–30 group (n = 11). The participant characteristics of the 2 groups at baseline are reported in ▶ **Table 1**.

Before entering the study, participants were fully informed about the study aims and procedures, and they provided written informed consent before the testing procedure. All participants were instructed not to change their diet and physical activity practices throughout the intervention period. The experimental protocol meets the ethical standards of the journal [15]; it was conformed to the code of Ethics of the World Medical Association (Declaration of Helsinki) and it was approved by the Ethics Committee of the University of Genoa.

▶ **Table 1** Participant characteristics at baseline. Data are means ± SE. p values refer to the result of t-tests comparing data of the 2 groups.

	10–20–30 group	30–30 group	p-value
Age (years)	32.54 ± 3.05	38.18 ± 3.57	0.24
Weight (kg)	69.83 ± 2.76	68.11 ± 2.68	0.65
Height (cm)	174.09 ± 1.84	169.27 ± 2.84	0.17
VO_2max (ml/kg/min)	43.01 ± 2.90	40.77 ± 2.78	0.62
1 km run time (min)	4.97 ± 0.24	5.15 ± 0.38	0.68
MAS (km/h)	13.36 ± 0.79	12.82 ± 0.79	0.63

Sample size

Estimation of sample size for this investigation was performed using VO_2max as a physiological response to exercise as one of our primary outcome measures. Sample size was estimated combining the normative data and the genuine change in VO_2max determined in previous works [16, 17]. These assumptions generated a desired sample size of at least 18 participants. However, we recruited 22 subjects, 11 in the 10–20–30 group and 11 in the 30–30 group, to allow for drop-out during the intervention period.

Experimental design

Before and after the intervention period, participants underwent a) body composition assessment; b) cardiopulmonary exercise test (CPET), to determine both the VO_2max (ml/kg/min and L/min) and the maximal aerobic speed (MAS) (km/h), and c) 1 km run test (min). Immediately after the end of the last session of the first (T1) and of the eighth-wk (T8) training, internal workload was assessed through RPE.

Intervention period lasted 8 wk. During the intervention, the 10–20–30 group performed two 10–20–30 training sessions/wk, interspersed with one continuous training (CT) session/wk, the 30–30 group performed two 30–30 training sessions/wk, interspersed with one CT session/wk (▶ **Fig. 1a**). Participants were instructed to arrive in a rested and fully hydrated state and at least 3 h after a standardized meal and to avoid strenuous exercise in the 24 h preceding each test session. In addition, they were asked to refrain from caffeine and alcohol 24 h before the test. All tests were performed at 11 a.m. (± 1 h) of the day to avoid influence of circadian rhythms. All participants completed the testing and training sessions without complication. The procedure was generally well tolerated, and participants did not report dizziness, light-headiness of nausea, symptoms that occasionally occur during this type of test. They were wearing a global position system (GPS) watch (FORERUNNER 15, Garmin, Olathe, KS, USA), to monitor the training intensity. All training sessions were performed outdoor on a 400 m synthetic track in dry and windless conditions.

10–20–30 training sessions

The 10–20–30 training session consisted of a standardized 10 min warm-up at a low intensity, followed by 5 min running period, interspersed by 2 min of rest. Each 5 min running period consisted of five consecutive 1 min intervals, divided into 30, 20, and 10 s, at an intensity corresponding to 30, 60, and 90–100 % of MAS, respectively [14]. The training in the first 5-wk and in the remaining 3-wk consisted of 3 series × 5 min intervals and, 4 series × 5 min intervals per training session, respectively (▶ **Fig. 1b**).

30–30 training sessions

The 30–30 training session consisted of a standardized 10 min warm-up at a low intensity, followed by the 30–30 interval training, that consisted of 30 s at 90–100 % MAS interspersed with 30 s of active recovery (50 % MAS) [11]. The 30–30 training lasted from 20 min (1–5 wk), to 30 min (6–8 wk) (▶ **Fig. 1c**).

Continuous training session

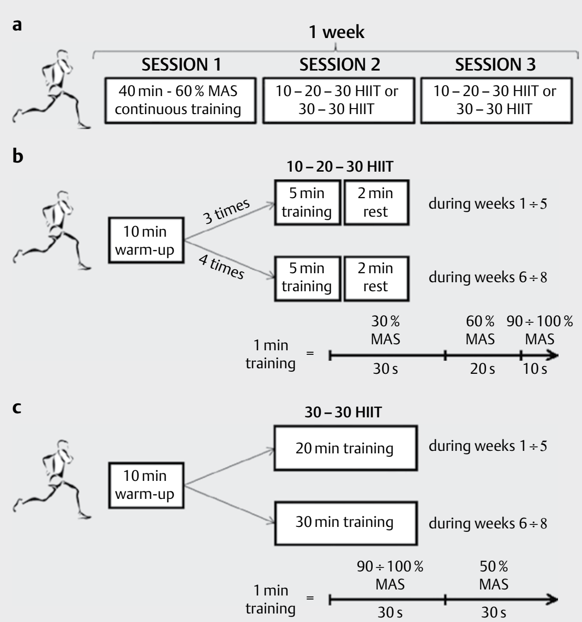
All subjects performed one CT session/wk, at an intensity corresponding to 60 % MAS. Each session lasted 40 min, including 10 min warm-up.

Body composition

Body composition was evaluated using bioelectrical impedance analysis (BIA; Tanita, BC-420 MA). The parameters used to measure the body composition were weight (kg), body mass index (BMI, kg/m^2), lean mass (kg) and fat mass (%).

Cardiopulmonary exercise test

Participants were asked to run on a treadmill for 5 min at 7 km/h speed at 1 % grade as warm-up, then strenuous exercise was performed, running with an increasing speed from 7 km/h with steps of 1 km/h at each minute until exhaustion. All subjects experimented maximal effort at the step of the exercise phase. The athletes performed the CPET with an ergospirometer (Sensormedics, Viasys, CA, USA) to obtain cardio-respiratory parameters all long the bouts, from warm-up to the end of the exercise. Before the measurement, the ergospirometer was calibrated following the recommendation of the manufacturer. Analysis of expired gas was sampled breath-by-breath. Heart rate (HR), maximal oxygen uptake (VO_2max), maximal aerobic speed (MAS) and respiratory exchange ratio (RER) were monitored to assess the intensity of the exercise. According to Thevenet, VO_2max was considered to be reached when at least 3 of the 4 following criteria were fulfilled: i) a steady state of VO_2 despite increasing running velocity (change in VO_2 at VO_2max ≤ 150 mL/min), ii) final respiratory-exchange ratio (RER) exceeded 1.1. iii) visible exhaustion or iv) a HR at the end of exercise (HRmax) equal to the predicted maximum [210– (0.65 × age)].



▶ **Fig. 1** Experimental design. **a**: weekly training program; **b**: 10–20–30 HIIT program; **c**: 30–30 HIIT program; HIIT, High Intensity Interval Training; MAS, Maximal Aerobic Speed.

1 km run test

The 1 km run test consisted of 2.5 laps in the first lane on a 400 m synthetic track. To avoid altering their self-regulatory cognition [18], athletes were asked not to wear the GPS during the test. The time to complete the 1 km was used as the test result.

Training volume

The weekly training volumes of the two groups (including warm-up ≈ 1.2 km) were measured during the 8-wk of the intervention period.

Rating of perceived exertion (RPE)

RPE was measured by the Borg's 6–20 scale [19]. A verbal-anchored scale was shown to the participants, after each training session. Each subject was previously familiarized on the use of this scale, including anchoring procedures.

Statistical analysis

We checked that variables were normally distributed (Shapiro-Wilk test) and that sphericity was respected (Mauchly's test). Training volume, fat mass, lean mass, weight, BMI, VO_2max, 1 km run time, and MAS were normally distributed, whilst RPE not. The training volumes of the two groups were compared by means of a t-test. Changes in body composition (fat mass, lean mass, weight and BMI), metabolic parameters (VO_2max ml/kg/min, VO_2max l/min), and running performance (1 km time and MAS) were evaluated by means of two-ways ANOVAs, with GROUP, as between subjects factor (2 levels, 30–30 and 10–20–30), and TIME, as within subjects factor (2 levels, PRE and POST). Since RPE values were not-normally distributed, non-parametric analyses were used to evaluate its modifications from T1 to T8 (Wilcoxon test) and between groups (Mann-Whitney test). A significance level of $p < 0.05$ was chosen. Data are presented as means ± standard error.

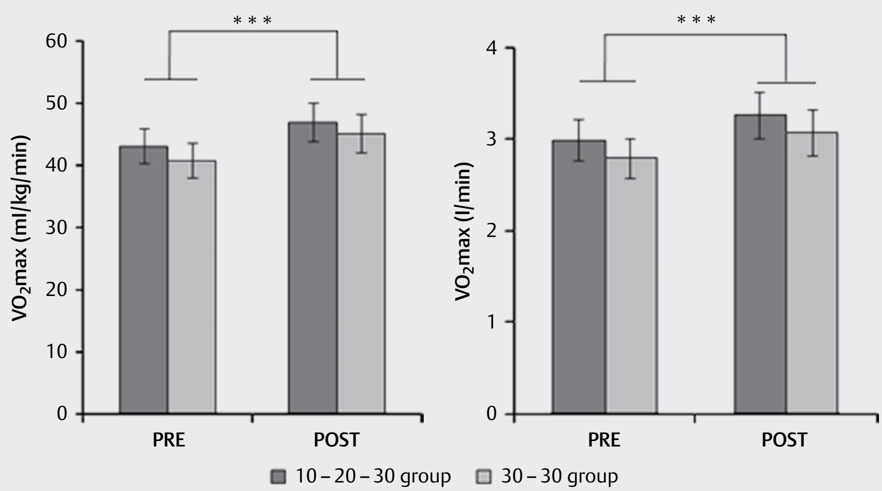
Results

Training volume

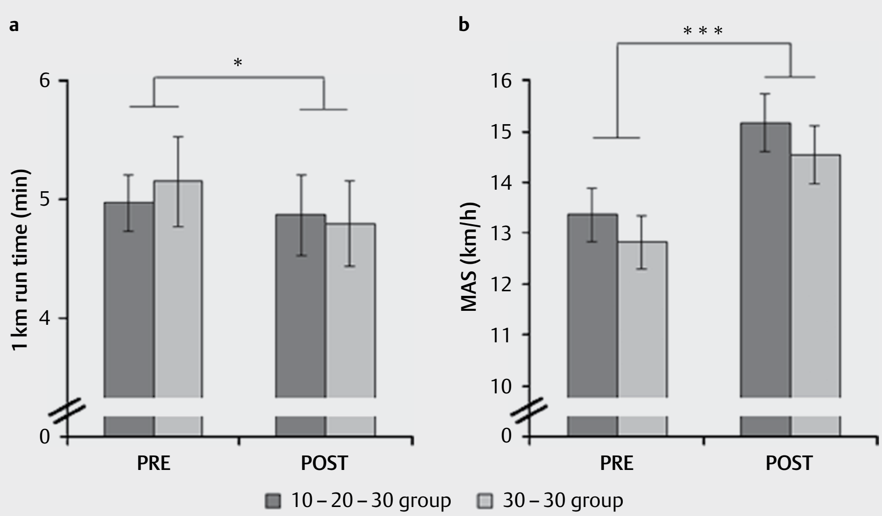
The results of the t-test showed that the measured training volume of the two groups were significantly different. In particular, the weekly training volume (including warm-up ≈ 1.2 km) of the 10–20–30 group (11.63 ± 0.55 km) was significantly lower than that of the 30–30 group (15.14 ± 0.79 km) ($t = 3.65$, $p = 0.002$).

Physiological parameters

The analyses on the aerobic fitness, evaluated by means of the VO_2max expressed as ml/kg/min and L/min, showed a significant effect of the factor TIME (ml/kg/min: $F(1,20) = 44.52$, $p = 0.000002$, L/min: $F(1,20) = 67.23$, $p = 0.000001$), showing an increase of the aerobic fitness after the training in both groups (▶ **Fig. 2**).



▶ **Fig. 2** Maximal oxygen uptake (VO_2max) values of 10–20–30 (dark grey) and 30–30 (light grey) groups, before (PRE) and after (POST) the intervention period. *** p<0.001.



▶ **Fig. 3** 1 km run time (panel **a**) and maximal aerobic speed (MAS; panel **b**) data, of 10–20–30 group (dark grey) and 30–30 groups (light grey) before (PRE) and after (POST) the intervention period. * p<0.05; *** p<0.001.

Running performance

The running performance parameters improved in both groups. The result of the statistical analyses showed a significant effect of the factor TIME. In particular, on the 1 km run time ANOVA showed a significant decrease of this value in both groups (TIME: F (1,20) = 4.51, p = 0.04) (▶ **Fig. 3a**). Coherently, the analysis on MAS values revealed a significant increase in both groups after the training period (TIME: F (1,20) = 77.60, p = 0.000001) (▶ **Fig. 3b**).

Body composition

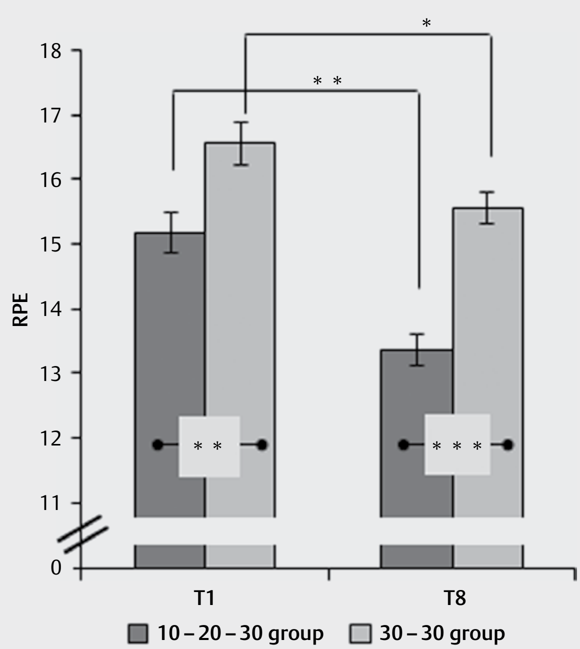
The results of the statistical analysis showed that, after the intervention period, the lean mass significantly increased (TIME: F (1,20) = 22.83, p = 0.0001), whereas the percentage of fat mass significantly decreased (TIME: F(1,20) = 26.54, p = 0.00005) in both training groups. In the end, BMI and body weight did not significantly change after the training period in both groups (▶ **Table 2**).

Rating of perceived exertion (RPE)

The comparison between the 2 groups after the first week of training showed a significantly higher RPE in the 30–30 group than in the 10–20–30 group (Z = − 2.59, p = 0.009). At the end of the intervention period RPE values of both groups decreased significantly (10–20–30 group: Z = 2.67, p = 0.008; 30–30 group: Z = 2.37, p = 0.02) and the mean RPE value of the 10–20–30 group was significantly lower than the 30–30 group (Z = − 3.68, p = 0.0002) (▶ **Fig. 4**).

▶ **Table 2** Body composition of the two groups, before (PRE) and after (POST) the intervention. Data are means ± SE.

	10–20–30 group		30–30 group		p-value (TIME)
	PRE	POST	PRE	POST	
Weight (kg)	69.83 ± 2.76	69.71 ± 2.80	68.11 ± 2.68	67.85 ± 2.75	0.50
BMI (kg/m²)	23.17 ± 0.89	22.95 ± 0.90	23.66 ± 0.66	23.48 ± 0.64	0.28
Lean mass (kg)	55.30 ± 2.51	58.01 ± 2.27	54.62 ± 3.31	56.40 ± 3.14	0.0001
Fat mass (%)	17.70 ± 2.89	13.43 ± 2.55	16.48 ± 2.75	13.30 ± 2.30	0.00005



▶ **Fig. 4** Rating of perceived exertion (RPE) of 10–20–30 (dark grey) and 30–30 (light grey) groups, measured at the end of the last session of the first (T1) and the eighth (T8) week. * p < 0.05; . * * p < 0.01; * * * p < 0.001.

Discussion

The present study analysed, for the first time, in recreational runners, 2 different HIIT regimes, 10–20–30 and 30–30 training concepts, characterized by significantly different training volume and intensity, and by different between-series recovery durations and intensities. This study was designed to provide general recommendations for the most feasible and effective HIIT program for recreational runners, from the perspective of both physiological and performance enhancements as well as internal training loads, measured through RPE. The major findings were that 8-wk of 10–20–30 training significantly improved VO_2max, 1 km time, maximal aerobic speed (MAS), and body composition. Furthermore, these physiological and performance enhancements were similar to those induced by 8-wk of 30–30 training, the last one being characterized by significantly higher training volume and time spent at or near the "red zone".

Effects on physiological parameters and running performance

The duration and intensity of the training and recovery modalities are the most important variables to consider in order to prescribe different HIIT protocols. Indeed, a number of studies reported that in well-trained subjects the increase in VO_2max is dependent on intensity and duration of the exercise [3, 20–22].

Indeed, it is believed that the optimal stimulus to improve cardiorespiratory and metabolic function and, in turn, physical performance of elite or well-trained athletes, is the one where they maintain long periods of time above 90 % of their maximal oxygen uptake, i. e., in their "red zone" [10].

Our results suggest that in recreational runners not only the 30-s near-maximal sprint intervals are efficient in improving aerobic fitness and performance, but also training with 10-s sprint intervals have an equally significant impact on maximal oxygen uptake and performance. These findings are in line with previous studies in moderately trained runners, showing that the 10–20–30 training concept improves performance and VO_2max, and lowers resting blood pressure, suggesting a beneficial effect also on the health profile of these runners [13, 14].

Effects on body composition

The present findings showed that both HIIT protocols induced significant improvements in body composition. In particular, after 8-wk of training, the percentage of fat mass significantly decreased and the lean mass significantly increased in both groups, whilst no changes in BMI and body weight were found. A limitation of this study is that energy intake was not quantified over the intervention period. However, participants were instructed to continue their normal dietary and physical activity practices throughout the experiment.

Effects on psychophysiological stress

The measure of internal load, derived from rating of perceived exertion, showed significant lower values in the 10–20–30 group compared to 30–30 group. RPE response may reflect "a conscious sensation on how hard, heavy and strenuous exercise is" [5], thus combining physiological and psychological stress-fatigue imposed on the body during exercise. Although this finding could be expected, considering the significant differences in training volumes between the 2 HIIT protocols, this information may be relevant to provide a further criterion to privilege the choice of 10–20–30 training in recreational runners, as this type of HIIT resulted to be more tolerable and easily applied. This conclusion can be reinforced by the awareness that rating of perceived exertion and effort are considered extremely important in the regulation of intensity of training during self-paced physical activity [23], particularly concerning recreational sport activity.

Conclusion

The evaluation of a hypothetical dose-response relationship, between training loads and improvements in physiological parameters and performance, leads to recommend to recreational runners a weekly training program characterized by two sessions of the 10–20–30 training concept, combined with an additional continuous training session. Indeed, the 10–20–30 training program has been demonstrated to be equally effective in promoting aerobic fitness, health and performance, with a lower subjective perception of exertion and effort, when compared to a 30–30 HIIT training program, characterized by a significantly higher training volume and intensity. In conclusion, the 10–20–30 HIIT concept is a feasible and effective training concept, resulting to be more pleasant and enjoyable, thus enhancing individual compliance and adherence to the prescribed training program.

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Conflict of Interest

Authors declare that they have no conflict of interest.

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