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Article Title: Comparison of Reduced Volume-High Intensity Interval Training Compared to High Volume Training on Endurance Performance in Triathletes

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Abstract

Purpose: The aim of this study was to investigate changes in physiological and performance variables in triathletes following a four week period of reduced training volume and increased training intensity. **Methods:** Sixteen moderately trained triathletes were randomly allocated to two groups: a control (CON) group which followed their usual training, or a high intensity training (HIIT) group which completed two HIIT sessions per week during four weeks of reduced training volume **Results:** Maximal oxygen comsumption (VO_{2max}) increased significantly in the HIIT group (p = .03, d = .5) but remained unchanged in the CON. Cycling power at first and second ventilatory threshold (PVT_1 and PVT_2) increased significantly in the HIIT subjects (p = .03, d = 1.0) and was unchanged in the CON participants (p = .57). During the simulated triathlon test, pre-post test cycling times and average power (P_{av}) were unchanged in both groups (p > .05). No significant interactive effects between groups were observed for running time (p = .50). **Conclusion:** After a 4-week HIIT program, VO_{2max} and PVT_1 and PVT_2 were found to have increased significantly while cycling and running performance were unchanged, despite an overall reduction in training time. However, in order to improve running or cycling performances, high volume training programs are highly recommended. In the present study, performance was only shown to improve with usual (high volume) training.

Keywords: High intensity, intermittent training, VO_{2max}, ventilatory thresholds, performance.

Introduction

As athletes strive to improve physical fitness and performance there is greater pressure to push the boundaries of exercise training. This often manifests itself as increased training volume, especially training time, but also, for example, incorporation of cross-training and specificity of training such as transition drills for triathletes [1]. Eventually there comes a point where athletes cannot train longer because higher volumes of training are associated with health problems such as compromised immunity, and overuse injuries [2]. There is also the constant problem of finding enough time for physical training yet also ensuring periods for optimal recovery and physiological adaptation [3]. Therefore, a common objective of coaches and scientists is to find more efficient ways to optimise performance outcomes for athletes while minising the risk of over-training and injury.

Recently the effects of short periods of intensified, or High Intensity Interval Training (HIIT), in athletes has become popular and underpinned by research studies showing it to be an effective method of training [1,4,5], although not in all studies [6]. HIIT is a training method structured as repeated bouts (repetitions) of vigorous intensity exercise of between 10 s to 5 min duration, separated by lower intensity recovery periods[7]. Previous authors have examined both short duration sets (from 10 to 60 s at maximal and supramaximal intensities), and long duration sets (from 2 min to 5 min at submaximal intensities) [1,2,5,8], while durations between 1 and 2 min at maximal intensities need further investigation. It is common for athletes to incorporate HIIT performed at intensities greater than the anaerobic threshold (AT) for training sessions of 20 - 40 min total duration [1,9]. Typical endurance training incorporates a significant number of hours (elevated training volume) of sub-threshold intensity exercise to observe physiological and biochemical adaptations to enhance aerobic performance [10]. However, it is unclear whether HIIT training may be able to achieve larger improvements in aerobic capacity (maximal oxygen comsuption, VO_{2max}) or endurance performance by building on work and recovery sets at or close to maximum intensities [7,11]. A number of researchers have concluded that HIIT shows a greater increase in VO_{2max} when compared to continuous endurance training in running [12-14]. However, Hottenrott and colleagues [12] did not observe any significant differences in half marathon performance following either HIIT or lower intensity endurance training. Therefore, there is still some controversy surrounding the efficacy of HIIT for endurance performance improvement in athletes.

Besides VO_{2max}, several studies have considerated a number of physiological variables obtained from laboratory tests on endurance athletes. Peak aerobic power output (P_{peak}), time to fatigue at different supramaximal intensites, ventilatory threshold (VT), lactate accumulation and oxidative enzymes activity are common physiological variables which frequently show significant enhacements on highly trained and recreational cyclist [9] while running economy (RE), running speed associated with onset of blood lactate accumulation (OBLA), peak treadmill speed (PTS) together with VT and capillarisation and oxidative enzyme activity were usually increased in different levels of runners after HIIT sessions [9,15]. Most of these researches also collected performance variables such as time to complete, rating of perceived exertion (RPE), maximum and average heart rate (HR) during running or cycling time trial or race simulation [6,9,16-19]. Referring to triathlon, Etxebarria et al. [1] observed a moderate increase in VO_{2max} values with a significant improvement in maximal aerobic power (MAP) and maximal repeat sprint ability during a 1 h variable power cycling, simulating the cycling section of a triathlon race where the pace is varied, after three weeks of HIIT program. Likewise, 5 km run ability improved significantly following 6 sessions of cycle interval HIIT sessions [1]. Despite this article observed specific performance variables, no previous researches were found that focused on the effect of HIIT program in triathlete's performances during a competition or simulated competition. Millet et al. suggested that cycle high intensity training combined with cross-training might improve running performance [2]. In addition, Mutton et al. [20] found a period of HIIT in either running or running-cycling group showed similar changes in VO_{2max}, standardised heart rate (HR) and blood lactate responses, and in 5000 m and 1609 m time trial performances. The enormous training volume that runners perform is associated with an increased risk of injuries [2,20]. There are limited studies investigating the effects on triathlon performances when replacing part of running volume by HIIT cycling.

Therefore, the aim of this study was to investigate changes in fitness and performance variables in triathletes following a four week period of reduced training volume and increased training intensity. Previous literature supplemented athletes training programs with long and short intervals, while in the current study the subjects training program volume was reduced significantly and replaced by twice a week HIIT cycle sessions from 1 to 2 min duration in order to observe the effect on physiological markers, cycling and running performance on triathletes.

Methods

Participants

A group of sixteen moderately trained triathletes (8 females and 8 males; age = 40 ± 12 yr; height = 172.4 ± 10.8 cm; body mass = 73.0 ± 12.1 kg; body mass index (BMI) = 24.4 ± 2.4 $kg.m^{-2}$) competing in triathlon, cycling or running events were recruited from a number of community clubs. The inclusion criteria required to participate in the study was that subjects were competitive athletes currently training or competing in any triathlon distance on a regular basis (with a minimum two years of experience in competition) and completed a sprint triathlon distance between 1 h15 min and 1 h 45min. The exclusion criteria were : (1) adults with no competition experience in the previous 1 month; (2) adults with less than two years competitive experience in their sport; (3) adults who had an injury that prevented them from participating in training or testing. A number of 16 participants consented and completed pre-intervention testing. However, 14 participants completed the study including post-intervention testing (Table 1). One athlete withdrew from the study due to a viral illness and another due to work and training constraints. One athlete did not complete the last 5 km running time trial (RTT) during post-testing due to acute calf pain during the treadmill run. Participants were informed of the study protocols and experimental procedures, and provided written informed consent. The study was approved by the Southern Adelaide Clinical Human Research Ethics Committee (HREC code 334.16) and it adhered to the Declaration of Helsinki guidelines (2013).

Procedures

Participants allocated to the HIIT group, reduced their training volume (min) by an average of 43% ($p < .01$, $d = -2.7$) and replaced this with supervised HIIT cycling sessions in the laboratory. However, the CON group maintained their training volume (-3%, $p > .05$, $d = -.1$) over the four week intervention (Table 2). An overall training load was calculated using the rating of perceived training load (RPE-min) method [2,11]. The RPE-min value was the average rating of perceived exertion (RPE) score for the session [8] multiplied by the duration of the session (min) in order to obtain the self-reported session training load (AU)[21].

Testing protocols

Prior to the 4-week intervention period all participants completed physiological testing at the University's Exercise Physiology Laboratory. The testing involved standard anthropometric measures (height and body mass) followed by an incremental exercise test to exhaustion to determine VO_{2max} on a cycle ergometer (Wattbike Trainer, Nottingham, UK). The cycle ergometer was fitted with the triathlete's own pedals and the dimensions of the bike were adjusted to achieve the athlete's usual bike position. The test procedure was as follows: (a) 10 min for athletes to perform their usual warm-up (b) an incremental test where the initial load was set at 80 or 100 W, depending on the gender (female or male). Each stage lasted one min and the load was increased by 20 W until exhaustion. Power output (PO) was obtained in each stage, HR and RPE recorded in the final 15 s of every stage, HR maximum (HR_{max}) and peak power output (PPO) were determined as previously described [22]. Expired gases were analysed by TrueOne2400 (ParvoMedics, Utah, USA), HR was recorded using Polar RS400 (Kempele, Finland) series HR monitor until test completion. Power (average and maximum) were recorded by the Wattbike software (Nottingham, UK). The Borg Scale (from 0 to 10) was employed in order to monitor the RPE and ensure the athlete performed the correct intensity, and recorded at the end of each stage. The first ventilatory threshold (PVT_1) for each participant was established as the power output at which ventilator equivalent for oxygen (VE/VO_2) and the End-tidal O_2 pressure ($PETO_2$) started to increase without a corresponding increase in the postapneic End-tidal CO_2 pressure ($PETCO_2$). The second ventilatory threshold was identified as the power output (PVT_2) when a decrease in $PETCO_2$ was observed together with an increase in ventilator equivalent of carbon dioxide output (VE/VCO_2)[22,23]. Additionally, a simulated triathlon performance (3) was conducted consisting of three parts: (a) 20 km cycling time trial (CTT) on a cycle ergometer (Wattbike Trainer, Nottingham, UK) (b) 1-2 min transition where participants changed from cycling to running shoes, and (c) 5 km RTT on the treadmill (Trackmaster TMX58, Kansas, USA) in order to simulate an identical sprint triathlon distance for cycling and running [24]. Subjects were asked to complete the simulation triathlon flat out, changing power output on the bike and velocity on the treadmill as many time as they needed. HR was recorded continuously and RPE was recorded every 10 min during the cycling and running. Average and maximum power, and time to completion were recorded for the 20 km cycle and average and maximum speed were recorded every 10 min for the 5 km run. All laboratory testing was repeated within 2 days following the 4-week HIIT intervention period.

Training intervention

Participants who were randomly allocated to the HIIT intervention attended supervised HIIT sessions on a cycle ergometer twice a week. Individual training zones at 95 and 115% of power obtained at VO_{2max} (PVO_{2max}) were determined for each participant based on their pre-intervention testing. The session structure was similar for all HIIT training sessions: a 10 min warm-up where participants determined the preferred power and cadence, followed by 6 x 2 min at 95% of PVO_{2max}; 4 x 1 min at 115% of PVO_{2max} ; followed by 5 min cool-down. All HIIT sessions were performed beyond individual AT. The recovery periods for the 1 and 2 min interval sets were 1 min 30 s and 2 min, respectively, where athletes continuing to pedal at a low intensity of choice. Average (HR_{av}) and HR_{max}, RPE, average power (P_{av}) and power output (PO) during each repetition and recovery session were recorded. Participants were provided with a HR monitor (Polar RS400, Kempele, Finland) to record session time and HR. They were instructed to reduce their training volume from their individualised training program focusing on session-RPE. The RPE was recorded and RPE-min (RPE average of the session x duration of the session) was calculated by researchers in each session [21]. The athletes were instructed to record all training in the four week period and this was reviewed by the researchers weekly to ensure program compliance. Participants reported time, distance, and HR data from the monitors, type of activity and RPE in their training diaries.

Participants randomised to the CON group performed their usual training program without volume reductions. HR monitors were provided to the CON group participants who were asked to record type of activity, time, distance, HR and RPE data for each training session performed during the four week period. This was reviewed by the researchers each week to ensure protocol compliance.

Statistical analysis

Results are presented as mean ± SD. A t-test for paired samples was used to analyze the differences between the usual week and intervention week training volume and RPE-min independently for each group (HIIT and CON). A t-test for independent samples was used to analyze the differences in training load (RPE-min, AU) between groups (HIIT and CON) during intervention weeks (week 1-4).The between-group (HIIT and CON) comparison from pretest to posttest in aerobic capacity and simulated triathlon test variables was calculated by a 2-way mixed ANOVA (group x time). In addition, a t-test for paired samples was used to analyze the differences between the pretest and posttest independently for each group (HIIT and CON). To allow a better interpretation of the results, practical significance between the pretest and posttest independently for each group was assessed by calculating Cohen's effect size. Effect sizes (d) of above .8, between .8 and .5, between .5 and .2, and lower than .2 were considered as large, moderate, small, and trivial, respectively [25].The statistical significance was set at $p < .05$. Data analysis was performed using the Statistical Package for Social Sciences (version 21.0 for Windows; SPSS Inc, Chicago, IL, USA).

Results

Weekely training load

Table 3 shows the RPE-weighted training loads on a week-by-week basis for the two groups. There were no significant differences in weighted training loads between the groups across all weeks of the intervention phase.

Aerobic Capacity

Differences in HIIT and CON group for pre and post-tests in VO_{2max}, power at 1st (PVT_1), 2nd (PVT_2) ventilatory threshold and peak power output (PPO) during cycle ergometer maximal are show in table 4. The VO_{2max} increased significantly in the HIIT group ($p < .05$, d

= .5) but remained stable in the CON group for the maximal cycle ergometer tests. Furthermore, the greater VO_{2max} increase in HIIT group produced a significant interaction between groups (F (1,12) = 4.72, p = .05) (Table 4). Both groups significantly increased PVT_1 following the intervention phase. However, only the HIIT participants showed an improvement at the PVT_2. There was a significant interaction for PVT_2 between the two groups (F (1,12) = 6.32 p = .03). There were no differences between groups in PPO although the HIIT participants significantly increased there PPO following the four week intervention.

Simulated Triathlon Test

The HIIT group mantained cycling time from 33.3 ± 2.1 min to 32.9 ± 2.3 min (p = .23, d = .18), average power (P_{av}) from 193 ± 46 W to 192 ± 34 W (p = .98, d = .02), running time from 28.8 ± 1.9 min to 28.4 ± 1.8 min (p = .59, d = .22) and RPE_{av} in both sports (from 6 ± 2 to 7 ± 1, p = .86, d = .50 in CTT and from 6 ± 2 to 6 ± 1, p = .55, d = .50 in RTT) pre-post intervention testing (Figures 1 and 2). Additionally, the HR_{av} in bike and running tests were similar (163 ± 7 bpm and 161 ± 8 bpm, p = .19, d = .27 for cycling and 164 ± 7 bpm and 164 ± 8 bpm, p = 1.0, d = .0) for running pre and post-intervention tests, respectively (Figures 1 and 2). The CON group showed a significant decrease in running performance time (29.4 ± 4.0 min to 27.1 ± 2.7 min, p = .04, d = .53) while the cycling time and HR_{av} did not significantly change (34.5 ± 2.6 min to 33.7 ± 3.2 min, p = .11, d = .27 and 148 ± 16 bpm to 147 ± 16 bpm, p = .5, d = .06, respectively). Also, the HR_{av} in the running test remainded unchanged (159 ± 16 bpm to 161 ± 13 bpm, p = .28, d = .14). However, P_{av} was increased from 170 ± 31 W to 183 ± 40 W (p = .07, d = .59). There were no significant interactive effects obtained between groups (F(1,12) = .50, p = .49; Figure 1 and 2). No significant changes were observed in this group for RPE_{av} in CTT (from 6 ± 1 to 6 ± 1, p = .42, d = .0) or RTT (from 6 ± 2 to 7 ± 2, p = .25, d = .50).

Discussion

Our objective was to investigate how 1 and 2 min intervals of cycle HIIT sets influence these variables on moderately trained triathletes who reduced their weekly training volume. Maximum aerobic capacity is a strong physiological indicator associated with endurance performance [2,9,18,22,26]. Endurance athletes such as cyclists, runners and triathletes, typically have a high VO_{2max} and an elevated VT [2,27]. Therefore, the improvement of both variables in endurance sports is a fundamental objective of training. Previous researchers concluded that HIIT helped the enhancement of anaerobic and aerobic metabolism response to the energy demand, increasing energy status in the muscle and improving ATP availability in recreational active athletes[9] Additionally, a recruitment of fast fibres which aid to increase oxidative capacity of muscle, the improvement of capillarisation and oxidative enzyme activity and plasma volume indicated an enhancement of aerobic metabolism capacity [9,15]. Otherwise, highly trained athletes endurance performance might improve due to the increase of skeletal muscle buffering capacity. However, central and peripherical adaptations to HIIT needs further investigation, such as, neuromuscular and endocrinological adaptations, expression on muscle cation pumps, expression on fibre type and myoglobin levels [9].

It has been concluded that the time trained at or near VO_{2max} is essential to effectively improve the aerobic capacity [28-30]. After four weeks of HIIT training, VO_{2max} significantly increased by 6.7%, despite an overall reduction in training volume and training load. This was in agreement with previous researchers who observed an increase in aerobic capacity after a HIIT training program [1,8]. Etxebarria et al. [1] observed a 7.3% and 7.5% increase for short (10, 20 and 40 s efforts) and long HIIT (5 min efforts) respectively, after three weeks performing a either short or long cycling HIIT twice a week. Similarly, Gojanovic et al. [8] found a positive change after four weeks of running HIIT twice a week using intervals between 3 and 4 min 45 s at VO_{2max} for duration equal to 60% of time to exhaustion. VO_{2max} improved 3.5% in a control group who performed the sessions on a treadmill and 1.9% for a group who used a lower-body positive pressure treadmill. However, Acevedo and Goldfarb [6] concluded that eight weeks of HIIT did not enhance VO_{2max} in competitive long distance runners. The novel finding in the current study was that VO_{2max} presented similar improvements to previous research despite the weekly training time being reduced by 43% with the addition of two short-duration HIIT sessions in the overall training program.

A range of studies have investigated the optimum duration, intensity and recovery stimulus to achieve a greater improvement in aerobic capacity. Some authors have used short intervals (from 15 to 30 s) [1,8,16], whereas, in Etxebarria et. al [1] and Mallol et al. [31] 5 min intervals were employed during their respective intervention training programs. All studies concluded that there is an improvement in aerobic capacity using HIIT as a complement to usual training protocols, without total volume and load reduction [1,8,30]. Mallol et al. [31] showed that a triathlete amateur group who performed four weeks of running HIIT twice a week, decreased their maximal speed during a maximal run test on the treadmill. Although HR and average velocity during a cycle ergometer TT test was considerably lower, probably due to a residual fatigue from the intensified training period. Accordingly, in the current study, we tried to use shorter efforts at higher intensity in order to observe the athlete's responses to 1 and 2 min duration intervals.

Other important indicators of an athlete's aerobic conditioning are the VT (VT_1 and VT_2). In our investigation we focused on power at these points, in order to observe if four weeks of HIIT could improve the aerobic capacity. The results showed the HIIT group improved significantly at both time points. Namely, athletes could maintain greater average power levels during a maximal cycle ergometer test after four weeks of HIIT training at similar intensities. These findings were in agreement with Laursen et al. [5] who observed improvement of 6% in PVT_1 and 7% in PVT_2. However, the highly trained cyclists in Laursen's study [5] reduced their normal training program by two hours while the participants in this study reduced their training volume by and average of 4.7 hours per week. The percentage of VO_2 at which the VT occurred remained unchanged from an average of 70.3 to 71% p = .84 for VT_1 and from 84 to 85.6%, p = .58 for VT_2. The CON group showed improvements in aerobic threshold at VT_1. As expected due to the high volume of endurance training they completed.

HIIT participants maintained their performance in the simulated triathlon test following a 43% reduction in training duration with a 23% reduction in training load (RPE-min). All variables measured: cycling time, P_{av}, HR_{av} and running times remained unchanged. Previous literature observed improvements in running performance (time) after a cycling HIIT program with no total training volume reduction [1,20]. Etxebarria et al. [1] concluded that the change of 5 km running times after four weeks of long sets HIIT sessions was small (4.9 ± 4.7%) decreasing the total time (from 21.25 ± 2.47 min to 20.21 ± 2.31min). Likewise, Mutton et al. [20] observed decreases in 5000 m and 1609 m TT (1.7 min and 18-21 s, respectively) and VO_{2max} improvements in runners using either running only or running plus cycle training. Similarly, Mikesell et al. [19] and Murphy et al. [32] observed equal improvements in running performance when comparing both training groups. Other investigators have shown improvements in cycling TT performances following cycling HIIT programs, without significant volume reduction in training volume [17,18]. Lindsay et al. [17] observed a decrease of 3.5% for completion of a 40 km TT in professional cyclists after four weeks of HIIT program. All participants had a moderate/base-intensity background before aproximately 15% of the total weekly training volume was replaced by HIIT training.

In the current investigation, the CON group improved running performance after four weeks of high volume and low-moderate intensity. This shows that to improve running performance, rather than simply maintenance over a four week period, high volume training emerges as the superior approach over HIIT, even though the high intensity training resulted in enhancements of VO_{2max} and VT_s. Whereas, the HIIT group maintained time, power, HR and speed variables in running and cycling performances (simulated triathlon) despite the reduction in training load. HIIT group performances remainded unchanged maybe due to other factors which weren't measured in the current research, such as, running economy, fatigue accumulated after HIIT sessions, motivation and psychological variables. These findings suggest that the use of this method of training during specific volume reduced periods such as periodistation, and off-season, might help to achieve and/or maintain high physiological and fitness levels, such as VO_{2max} and power at ventilator thresholds while the performance is maintained.

Practical Applications

The use of cycling HIIT training sessions over four weeks appears to maintain cycling and running performances during tapering, between seasons or during a period of training modification such as injury which requires a reduction of volume and/or sport mode modification. Further, this method improved VO_{2max}, PVT_1 and PVT_2 in the volume reduction periods. Additionally, cycling HIIT using a cross training methodolgy may be a useful adjunct for maintaining running performance in triathletes, using different mechanisms which can be targeted by different intensities, sport modality and volume training stress. Nevertheless, it is clear that improvements in running and cycling performance in moderately trained triathletes requires a threshold volume of training to be achieved rather than via reduced volume in combination with a HIIT stimulus.

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Conflict of interest

No known conflicts of interest are associated with this publication, and there has been no significant financial support for this work that could have influenced its outcome**.**

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Figure 1A.

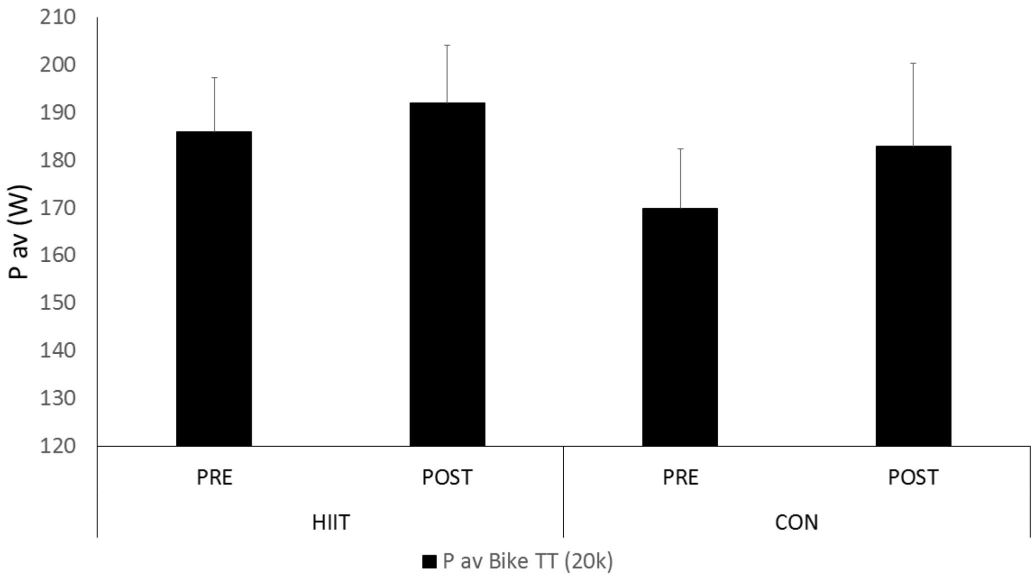


Figure 1B.

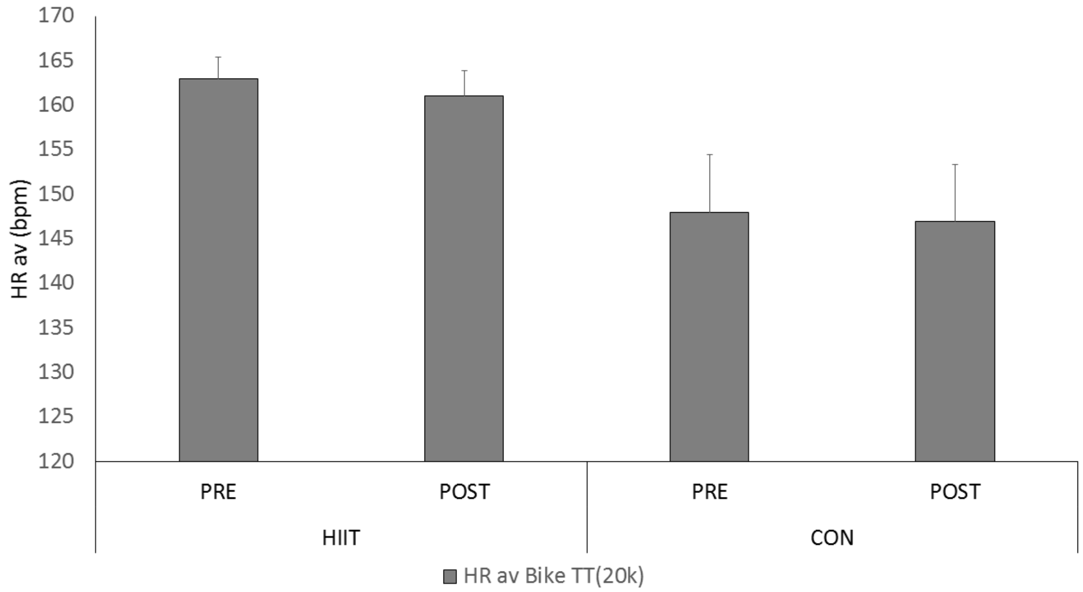


Figure 1C.

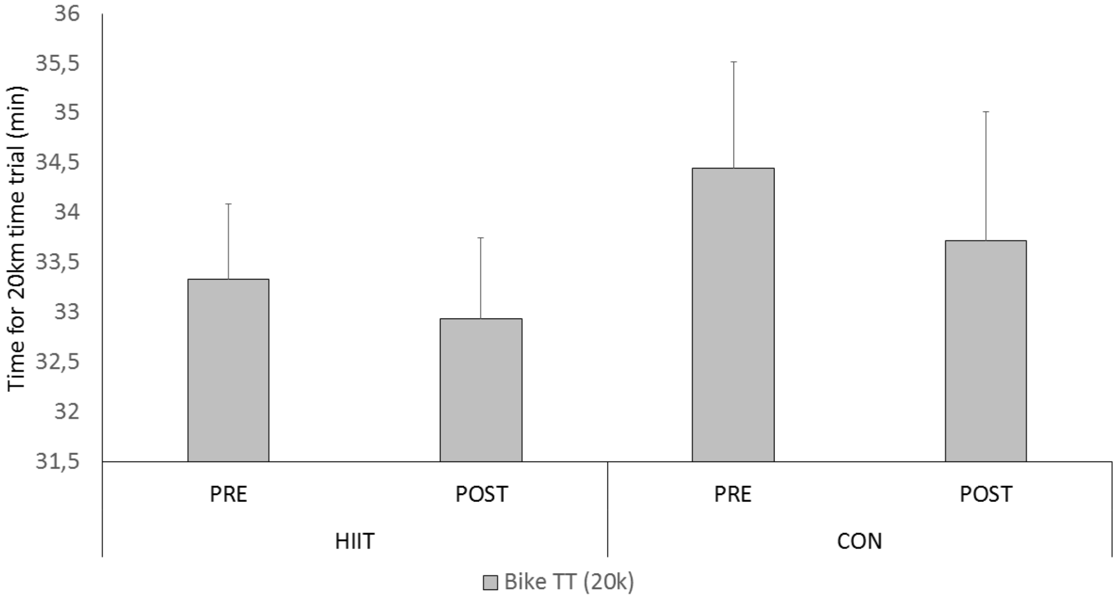
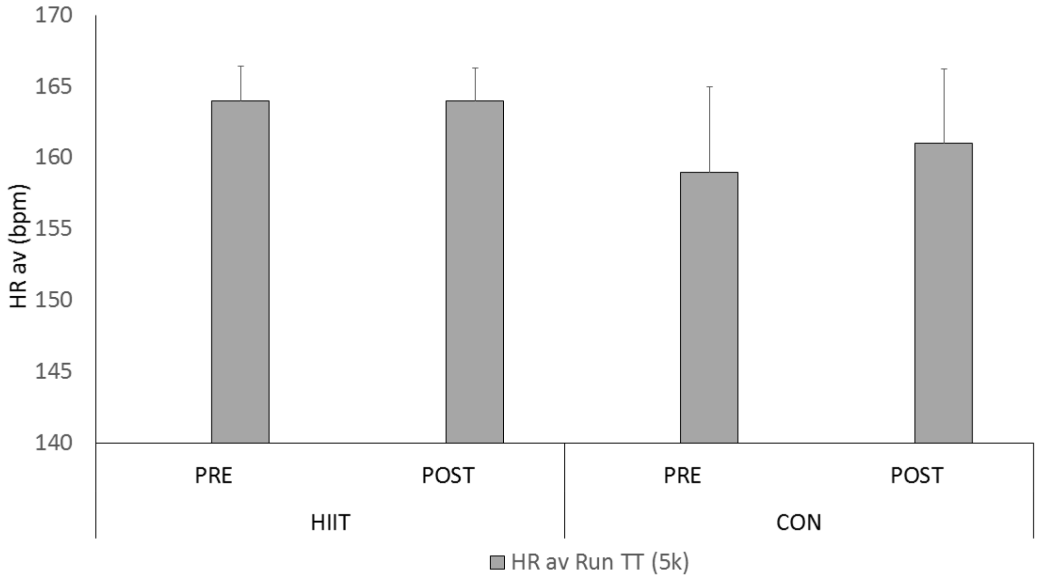


Figure 1. Differences between Intervention (HIIT) and Control group (CON) during for pre and post-tests on P_{av}. (1A), HR_{av} (1B) and time for 20 km cycling time trial (1C).

P_{av} = average Power; HR_{av} = average heart rate in cycling test

Figure 2A.



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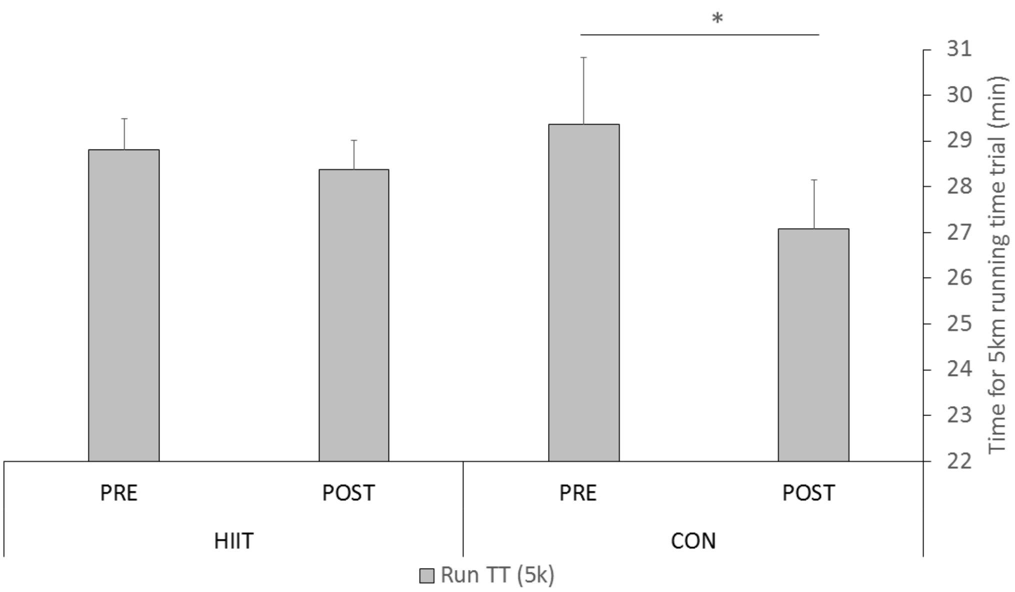

Figure 2. Differences between Intervention (HIIT) and Control group (CON) for HR_{av} running (2A) and time for 5 km running time trial (2B). * $p < .05$ significant difference between tests.

HR_{av} = average Heart Rate in running test

Table 1. Participants characteristics (n = 16)

	Intervention (HIIT) group	Control (CON) group
Age (yr)	42.9 ± 12.1	37.2 ± 13.3
Gender	4 female + 4 male	4 female + 4 male
Height (cm)	171.0 ± 10.9	174.3 ± 9.7
Body mass (kg)	70.8 ± 9.7	76.0 ± 15.2
BMI (kg.m^{-2})	23.8 ± 1.7	24.7 ± 2.0

BMI = body mass index.

Table 2. Comparison of usual weekly and intervention training time for both the HIIT group and CON group.

	Intervention (HIIT) group				Control (CON) group			
	Usual week	Intervention week	Dif. (%)	d	Usual week	Intervention week	Dif. (%)	d
Training volume (min)	648.3 ± 178.7	365.4 ± 105.9**	-43.6	-2.7	509.5 ± 195.6	492.8 ± 201.9	-3.3	-.1
RPE-min (AU)	2163.8 ± 910.6	1654.4 ± 779.7*	-23.5	-.7	2859.8 ± 1442.8	2259.8 ± 1193.8	-21.0	-.5

HIIT = High intensity interval training, CON = control group, Dif. = mean differences, d = Cohen effect size value. * $p < .05$, ** $p < .01$ significant differences with usual week.

Table 3. Training contents distribution and differences in training load (RPE-min, AU) between groups during intervention weeks.

	Total Training sessions		Total Swimming sessions		Total Cycling sessions		Total Running sessions		Training load (RPE-min)			
	HIIT	CON	HIIT	CON	HIIT	CON	HIIT	CON	HIIT	CON	Dif. (%)	d
Week 1	6	8	1	2	3	3	2	3	1347.7 ± 715	2055.7 ± 1184.5	52.5	.6
Week 2	7	8	2	2	3	3	2	3	1886.2 ± 748.6	2416.3 ± 1536.8	28.1	.3
Week 3	6	7	2	2	3	3	1	3	1609.7 ± 933.2	2042 ± 1086.8	26.9	.4
Week 4	7	8	2	2	3	3	2	3	1773.9 ± 937.2	2525.3 ± 1274.3	42.4	.6

HIIT = High intensity interval training group, CON = control group, Dif. = mean differences, d = Cohen effect size value.

Table 4. Differences in Intervention (HIIT) and Control (CON) group for pre and post-tests in VO_{2max}, power at 1st (PVT_1), 2nd (PVT_2) ventilatory threshold and peak power (PPO) during cycle-ergometer maximal.

	Intervention (HIIT) group				Control (CON) group				p (between groups)
	Pre	Post	Dif. (%)	d	Pre	Post	Dif. (%)	d	
VO_{2max} ($mL·kg^{-1}.min^{-1}$)	42.4 ± 5.2	45.2 ± 6.0*	6.7	.5	43.1 ± 4.5	42.8 ± 3.9	-.8	-.1	.05 µ
PVT_1 (W)	148.3 ± 31.7	174.9 ± 26.1**	18.0	1.0	154.0 ± 31.6	179.7 ± 27.4**	16.7	.9	.91
PVT_2 (W)	195.8 ± 43.7	227.5 ± 32.1**	16.2	1.0	227.3 ± 36.2	236.5 ± 39.7	4.0	.2	.03 µ
PPO (W)	242.3 ± 52.0	278.6 ± 58.0*	15.0	.6	275.2 ± 45.8	290.0 ± 52.8	5.4	.3	.24

HIIT = High intensity interval training, CON = control group, Dif. = mean differences, d = Cohen effect size value. * p < .05, ** p < .01 significant differences with pre. µ p < .05 significant interaction between groups