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Changes in Triathletes' Performance and Body Composition During a Specific Training Period for a Half-Ironman Race

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The number of recreational athletes completing a Half-Ironman triathlon has increased exponentially in recent years. However, there is a lack of research on how to train for this kind of an event. The purpose of this study was thus to analyse triathletes' changes in performance and body composition following a triathlon-specific training period. Fourteen male amateur triathletes completed a 7-week period of general training and a 13-week period of specific training for a Half-Ironman triathlon. Anthropometric measures and performance tests were carried out to assess the effects of the specific training program. Results showed that the pre-test value of VO_{2max} for cycling was inversely correlated not only with the percentage of change in cycling performance, but also with the percentage change in several variables of running performance. In swimming, inverse correlations were observed between the time of the first 800 m test and the time percentage change for this test, but not with the percentage change in the performance of other segments of the race. Moreover, the somatotype component of endomorphy and the fat mass percentage of the first anthropometry were highly correlated with the percentage change in VO_{2max} in the run segment. These results highlight the importance of providing individualised training, considering that the same training program had a different impact on recreational triathletes belonging to the same group. Amateur athletes with higher initial performance levels probably need a greater amount of training to achieve improved adaptation.

Key words: *endurance training, triathlon, anthropometry, performance.*

Introduction

Over the last decade, recreational athletes have shown growing interest in long distance events (Malchrowicz-Mośko et al., 2019). Among these types of events, the Half-Ironman distance triathlon (1.9 km swim, 90 km bike and 21.1 km run) is currently very popular among recreational triathletes. As an illustration, Ironman® 70.3 events (half the Ironman distance) attracted around 120,000 triathletes in 2015. Only 1% of these participants raced in the elite category, while the remaining 99% raced in the age group category, related to the amateur and recreational triathlon (WTC, 2016).

High values of maximum oxygen uptake (VO_{2max}) and the ventilatory threshold (VT) 2 have been linked to performance levels in ultra-endurance races (Whyte et al., 2000). Furthermore, other performance factors such as core temperature, feeding, hydration and even muscle cramps during the race have been related to performance in long-distance events (Laursen, 2011; Michalczyk et al. 2016,).

Body composition is also related to performance in endurance sports, including triathlons. An excess of body weight is especially

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disadvantageous in the run segment (Deitrick, 1991; Sleivert and Rowlands, 1996). In cycling, the effects of body weight are directly linked to the cycling course's topography. Steep hills increase the effect of gravity on the triathletes, so light triathletes may have an advantage (Swain, 1994). Descriptive studies have reported that high-level triathletes have a fat mass percentage of approximately 11% (Santos et al., 2015). Deitrick (1991) compared "heavy weight triathletes" with "typical triathletes". This research showed that higher body fat levels were linked to lower running economy and VO_{2max} values, shorter treadmill performance times in an incremental run to exhaustion, and lower power/weight ratios on the bicycle ergometer. In long distance triathletes, lower rates in the somatotype endomorphy component, as well as higher rates in the ectomorphy component have resulted in significantly better performance in the Ironman race (Kandel et al., 2014). Thus, excess fat mass seems to reduce performance in triathlons, above all in the cycling and running segments (Sleivert and Rowlands, 1996).

Endurance training induces changes in physiological performance factors and body composition of both sedentary people and athletes (Carbuhn et al., 2010; Silvestre et al., 2006; Maciejewska et al., 2017; Gronek et al., 2017). Some studies have found changes in body composition after a long distance triathlon competition (Knechtle et al., 2008; Sharwood et al., 2004). Other studies have described the intensity and physiological responses in triathlons, including long distance events (Laursen et al., 2007; Sharwood et al., 2004). Furthermore, data exist on the relationship between specific periods of training for an Ironman race and performance (Esteve-Lanao et al., 2017; Muñoz et al., 2014; Neal et al., 2011). However, following a literature review, to our knowledge, there are no studies which provide precise descriptions of changes in performance and body composition after a specific training period for a Half-Ironman triathlon race.

Thus, this article presents a descriptive study of changes in physiological values as well as body composition induced by a specific training period, and their relationship with success factors in triathlon performance. Our hypothesis was that the initial level of performance of each subject would condition the subsequent adaptations induced by the training period.

Methods

Participants

Fourteen male amateur triathletes volunteered to participate in the study. The main goal of the training period was to prepare for a Half-Ironman distance event in Alicante, Spain. They were all trained by the same coach (RC), taking part in a supervised training program based on the same periodization model. The inclusion criteria were: having less than two years of previous training for triathlon events and completing at least 95% of the total training load. All participants provided written informed consent to take part in this study, which was approved by the Alicante University Ethics Committee. Data of the final sample are shown in Table 1.

Design

Before starting the 13-week specific training program for a Half-Ironman race, all triathletes took part in a 7-week period of general training. Most of the workouts in this period were of low intensity and the training volume progressively increased in the three triathlon segments over these weeks. The goal of this training period was to increase fitness levels to prepare the triathletes for the workouts of the specific period. The anthropometric measurements and performance tests took place in the last week of this general period and in week 12 of the specific training period. Both pre-tests and post-tests were performed for a week, with at least 48 hours of rest between tests. Three main training zones were defined for this study: Zone 1 (at or below VT1), Zone 2 (between VT1 and VT2) and Zone 3 (at or beyond VT2) (Skinner and McLellan, 1980). These training zones were subdivided into further training zones for daily workouts. Participants thus trained based on eight training zones (Cejuela and Esteve-Lanao, 2011) in order to be more precise in some workouts and to use the "objective load scale" (ECOs) to control the training load. Briefly, the ECOs were calculated by multiplying the total duration of a training session (in minutes) with a scoring value between 1 and 50, depending on the heart rate-based training zone (1-8) and by a factor of 1.0, 0.75 or 0.5 for running, swimming or cycling, respectively (Cejuela and Esteve-Lanao, 2011).

Estimation of body composition

An anthropometric method was used to estimate the triathletes' body composition. All measurements were taken in the same tent, at ambient temperature (22 ± 1°C) and by the same researcher who was a Level 3 anthropometrist of the International Society for the Advancement of Kinanthropometry (ISAK). Measurements followed the protocols of Ross and Marfell-Jones (1991) and were taken three times for each subject. The equipment used included a Holtain skinfold calliper (Holtain Ltd. U.K), a Holtain bone breadth calliper (Holtain Ltd., U.K), scales, a stadiometer and anthropometric tape (SECA LTD., Germany). Data on physical characteristics were collected in the following order: age, body mass and stature. The following measurements were also taken: biepycondilar humerus, bi-styloid and biepicondylar femur breadths, arm relaxed, arm flexed and tense, mid-thigh and calf girths, sub-scapular, biceps, triceps, suprailiac, supraspinale, front thigh, medial calf and abdominal skinfolds.

Muscle mass was calculated using the Lee et al.'s equation (2000) and fat mass using the Withers et al.'s equation (1987). Bone mass was evaluated with the Döbeln equation, modified by Rocha (1975). Finally, the somatotype was estimated with the Heath-Carter equations (Carter, 2002).

Performance tests

Incremental tests to volitional exhaustion were used to determine training zones in cycling and running. A ramp protocol was applied for cycling on rollers, starting at 50 watts (W) and increasing 5 W every 12 s (Muñoz et al., 2014). Participants used their own bike for the power wheel (powertap®) test. The running test was performed on a 400 m certified track. Participants started at 10 km/h and increased the speed of 0.3 km/h every 200 m (Brue, 1985). Both tests were conducted using a gas-exchange analyzer (Cosmed® K4b 2, Italy). The following variables were measured during the tests: oxygen uptake (VO_2), pulmonary ventilation (VE), ventilatory equivalent of oxygen (VE/VO_2), ventilatory equivalent of carbon dioxide (VE/VCO_2) as well as end-tidal partial pressure of oxygen ($P_{ET}O_2$) and carbon dioxide ($P_{ET}CO_2$).

Maximal oxygen uptake (VO_{2max}) was recorded as the highest VO_2 value obtained for any continuous 1-min period. VT1 was determined based on the criteria of an increase in both VE/VO_2 and $P_{ET}O_2$ with no increase in VE/VCO_2, whereas VT2 was determined using the criteria of an increase in both VE/VO_2 and VE/VCO_2 and a decrease in $P_{ET}CO_2$. Two independents observers identified VT1 and VT2. In case of disagreement, the opinion of a third researcher was sought (Doherty et al., 2003). The heart rate (HR) was continuously monitored during the test using radiotelemetry (Polar Electro®, Finland). The maximal aerobic power or velocity was determined during the test as well as the velocity and power linked with the ventilatory thresholds. Training zones were calculated individually for each athlete using different intensity variables (range of HR and power or velocity).

Swimming training zones were calculated based on an 800 m test in a 25 m pool. Participants had to cover the distance in the shortest time possible. A difference greater than 5% in the part-time of each 100 m was not allowed. The medium pace during the test was considered to be the VT2 pace and 120% of the medium pace was associated with the VT1 pace (Sweetenham and Atkinson, 2003).

The test took place in the last week of the general training program and in week 12 of the specific training program. Both pre- and post-tests were performed for a week, with at least 48 hours of rest between following tests.

Main characteristics of the specific training period

General training data is shown in Figure 1. The 13 weeks of the specific training program were divided into three mesocycles. The first and second mesocycles were composed of 4 weeks of training and the third mesocycle of 5 weeks of training. Peaks of training volume were prescribed at the end of the first and second mesocycles (at weeks 4 and 8). A peak of the training load was prescribed at week 8 for swimming, at weeks 3 and 4 for cycling, and at weeks 6 and 7 for running. Specific transition sessions, usually bike-run transitions, were included almost every week during this training period. During the first week of each mesocycle, participants completed a week with a lower training load to recover (weeks 1, 5 and 9). The third mesocycle included a tapering period of 3 weeks and a post-test (week 12). The training period concluded with a Half-Ironman triathlon (week 13). The training plan was composed of 106 training sessions (28 dedicated to swimming, 34 to

cycling and 44 to running). The total training volume was about 155 training hours. The distribution of the training load in each segment was 28% for swimming, 38% for cycling and 34% for running. Concerning training intensity distribution, a large percentage of the training volume was in Zone 1 (80%). The rest of the training volume was distributed equally between Zone 2 (11%) and Zone 3 (9%).

Strength training program

The strength-training program consisted of 36 workouts (14 in the general training period and 22 in the specific training period). Workouts were progressive using resistance-training machines. Recommendations by Klion and Jacobson (2014) were followed when selecting the strength exercises, combining exercises involving both the upper and lower body muscles. In addition, core stability exercises were carried out during each workout. These sessions were commonly conducted twice a week, usually under the supervision of one of the coaches.

Control of training loads

Triathletes were filling personal training logs with the information recorded in their HR monitors, on the amount of time spent in each training zone. Swimming sessions and intensity workouts for the run segment were always supervised by one of the coaches (SS, RC or LF). In addition, a power meter for bike workouts was used and speed was controlled in high intensity run workouts.

Statistical analysis

A descriptive analysis based on means and standard deviation of height, body mass, BMI, triathlon training experience (years), VO_{2max} run (ml/kg/min) and VO_{2max} cycling (ml/kg/min) was performed.

We adapted the concept of sigma convergence (Barro and Sala-i-Martin, 2004) to the evolution of disparities in anthropometry and performance as a consequence of training, and, given the nature of the indicator of the percentage variation rate, we used the dispersion rate with respect to the median IMe as a measure of dispersion.

Thus, convergence was considered to occur if the value of the IMe after training decreased compared to the value of the IMe before training, that is, when the dispersion with respect to the median of the variables declined with training. This "adaptation" of the convergence concept was used to check if the sample was more homogeneous after training, decreasing dispersion among triathletes.

In order to analyse temporary convergence, that is, the evolution during training, we used the percentage variation rate that synthesized the time evolution of anthropometric variables and performance variables after training.

This percentage variation rate allowed for comparisons between triathletes and to estimate whether triathletes who started with worse anthropometric variable values evolved better after training, both in terms of the same variables and performance variables. That is, a temporary convergence was found if triathletes who started in a worse condition compared to others before training, improved, in percentage terms, more quickly than triathletes who started out in a better condition before training.

To analyse temporary convergence, we calculated the Spearman coefficient of correlation (ϱ) between anthropometric and performance variable values before training and the corresponding values of the percentage variation rate.

Results

Figures 2 and 3 show the percentage change rates in anthropometric and performance values. Almost all triathletes reduced their body mass, fat mass and muscle mass following the training period. The endomorphy component dropped while the ectomorphy component increased for almost all participants. Opposite data were found for one participant.

All triathletes improved most of their performance variables. Only one triathlete did not improve his power at VO_{2max} in cycling. One participant decreased his speed at VO_{2max} intensity in running and three participants maintained the same value. One participant did not improve his speed at VT2 intensity and three participants did not improve it at VT1 intensity. The VO_{2max} value in running increased for six participants, but dropped or remained unchanged for the rest of them. In swimming, all triathletes improved their time in the 800 m test except for one athlete.

As shown in Tables 2 and 3, there was a high correlation between weight in the first anthropometry and speed, and between body mass

(ϱ = 0.631) and changes in VO_{2max} in the run (ϱ = 0.712). There was a high correlation between the fat mass percentage of the first anthropometry and VO_{2max} in cycling (ϱ = 0.712). There was a significant correlation between the pre-endomorphy somatotype component and VO_{2max} in the bike (ϱ = 0.716). The same was found for the pre-mesomorphy component, which correlated with VO_{2max} in the bike (ϱ = 0.537). There was an inverse correlation between the pre-ectomorphy somatotype component and VO_{2max} in the bike (ϱ = -0.623). However there was no significant correlation between the somatotype component and VO_{2max} in evaluated running.

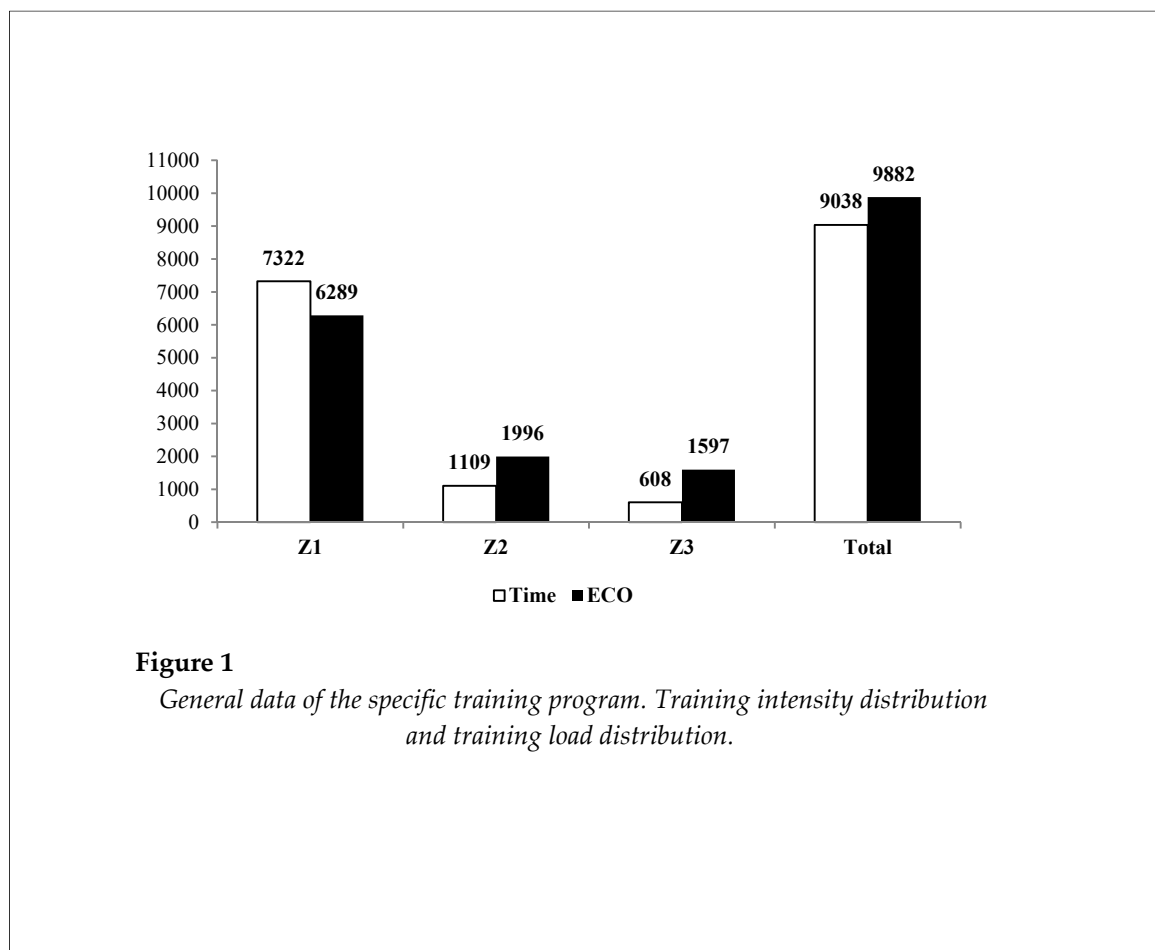|	**Table 1**
Sample data	
N	14
Body height (cm)	174.4 ± 5.3
Body mass (kg)	71.8 ± 4.5
BMI	23.7 ± 1.0
Triathlon training experience (years)	2.4 ± 0.8
VO_{2max} run (ml/kg^{-1}/min^{-1})	55.7 ± 4.5
VO_{2max} cycling (ml/kg^{-1}/min^{-1})	53.4 ± 4.5

Figure 1

General data of the specific training program. Training intensity distribution and training load distribution.
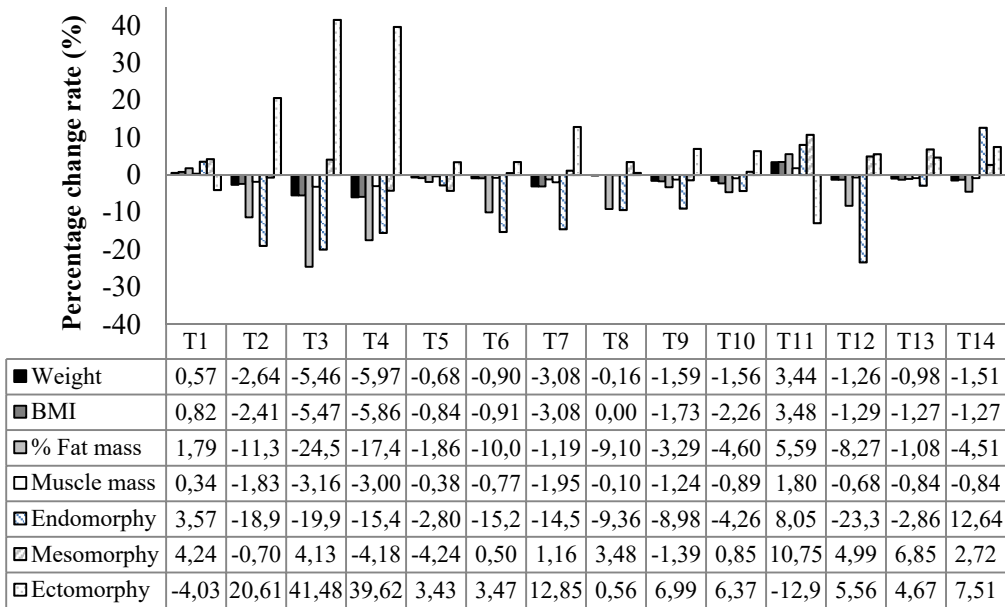
Figure 2

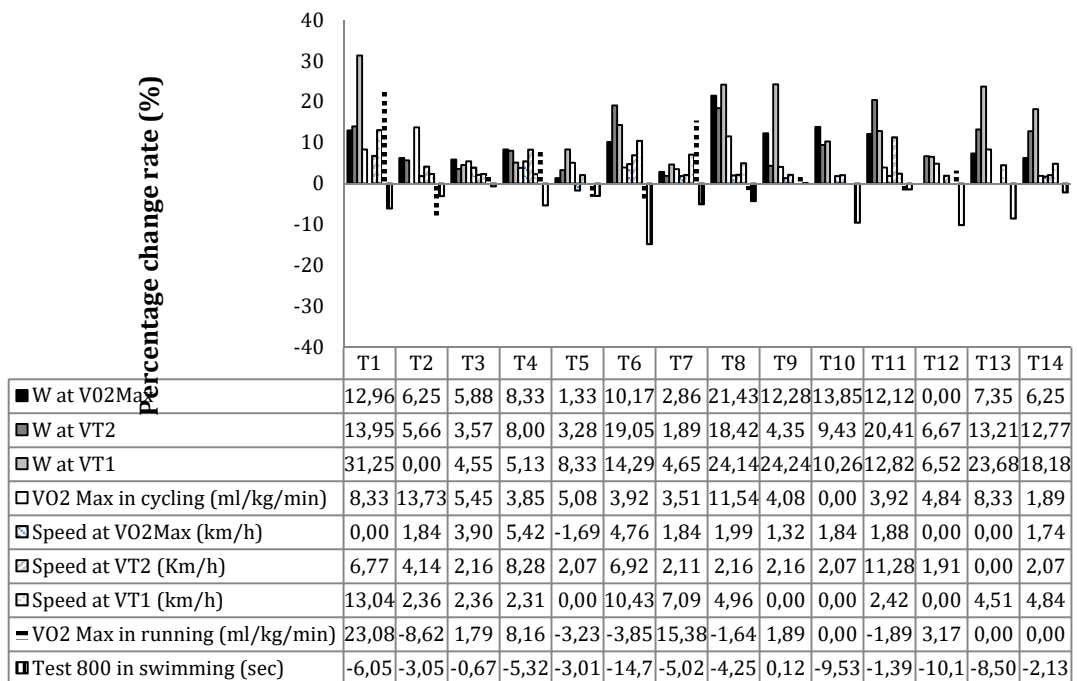*Percentage change rate of anthropometric variables.*
T = triathlete

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
■ Weight	0,57	-2,64	-5,46	-5,97	-0,68	-0,90	-3,08	-0,16	-1,59	-1,56	3,44	-1,26	-0,98	-1,51
■ BMI	0,82	-2,41	-5,47	-5,86	-0,84	-0,91	-3,08	0,00	-1,73	-2,26	3,48	-1,29	-1,27	-1,27
▨ % Fat mass	1,79	-11,3	-24,5	-17,4	-1,86	-10,0	-1,19	-9,10	-3,29	-4,60	5,59	-8,27	-1,08	-4,51
▢ Muscle mass	0,34	-1,83	-3,16	-3,00	-0,38	-0,77	-1,95	-0,10	-1,24	-0,89	1,80	-0,68	-0,84	-0,84
▨ Endomorphy	3,57	-18,9	-19,9	-15,4	-2,80	-15,2	-14,5	-9,36	-8,98	-4,26	8,05	-23,3	-2,86	12,64
▨ Mesomorphy	4,24	-0,70	4,13	-4,18	-4,24	0,50	1,16	3,48	-1,39	0,85	10,75	4,99	6,85	2,72
▢ Ectomorphy	-4,03	20,61	41,48	39,62	3,43	3,47	12,85	0,56	6,99	6,37	-12,9	5,56	4,67	7,51

Figure 3

Percentage change rate of performance variables.
T = triathlete

	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
■ W at VO2Max	12,96	6,25	5,88	8,33	1,33	10,17	2,86	21,43	12,28	13,85	12,12	0,00	7,35	6,25
▨ W at VT2	13,95	5,66	3,57	8,00	3,28	19,05	1,89	18,42	4,35	9,43	20,41	6,67	13,21	12,77
▨ W at VT1	31,25	0,00	4,55	5,13	8,33	14,29	4,65	24,14	24,24	10,26	12,82	6,52	23,68	18,18
▢ VO2 Max in cycling (ml/kg/min)	8,33	13,73	5,45	3,85	5,08	3,92	3,51	11,54	4,08	0,00	3,92	4,84	8,33	1,89
▨ Speed at VO2Max (km/h)	0,00	1,84	3,90	5,42	-1,69	4,76	1,84	1,99	1,32	1,84	1,88	0,00	0,00	1,74
▢ Speed at VT2 (Km/h)	6,77	4,14	2,16	8,28	2,07	6,92	2,11	2,16	2,16	2,07	11,28	1,91	0,00	2,07
▢ Speed at VT1 (km/h)	13,04	2,36	2,36	2,31	0,00	10,43	7,09	4,96	0,00	0,00	2,42	0,00	4,51	4,84
▬ VO2 Max in running (ml/kg/min)	23,08	-8,62	1,79	8,16	-3,23	-3,85	15,38	-1,64	1,89	0,00	-1,89	3,17	0,00	0,00
▥ Test 800 in swimming (sec)	-6,05	-3,05	-0,67	-5,32	-3,01	-14,7	-5,02	-4,25	0,12	-9,53	-1,39	-10,1	-8,50	-2,13

Table 2

Temporal convergence. Spearman correlation coefficients between performance and anthropometric variables before training and the percentage change rate of the bike performance variables.

	Bike power (W) at VO_{2Max}	Bike power (W) at VT2	Bike power (W) at VT1	VO_{2Max} bike (ml/kg/min)
Weight pre	0.202	0.146	-0.328	0.237
BMI pre	-0.126	-0.225	-0.163	0.426
% Fat mass pre	0.139	0.152	0.116	**0.716**[**]
Endomorphy pre	0.026	0.125	-0.037	**0.546**[*]
Mesomorphy pre	-0.031	-0.345	0.209	**0.537**[*]
Ectomorphy pre	0.108	0.292	0.191	**-0.623**[*]
Muscle mass (kg) pre	-0.293	-0.073	-0.481	-0.531
Bike power (W) at VO_{2Max} pre	**-0.800**[**]	-0.502	**-0.593**[*]	-0.153
Bike power (W) at VT2 pre	**-0.766**[**]	**-0.678**[**]	**-0.691**[**]	0.001
Bike power (W) at VT1 pre	**-0.767**[**]	**-0.725**[**]	**-0.773**[**]	-0.022
VO_{2max} bike (ml/kg/min) pre	**-0.782**[**]	-0.372	-0.378	0.075
Speed at VO_{2max} (km/h) pre	**-0.654**[*]	-0.368	-0.361	-0.184
Speed at VT2 (Km/h) pre	-0.509	-0.389	-0.337	-0.032
Speed at VT1 (km/h) pre	-0.493	-0.508	-0.418	-0.084
VO_{2max} run (ml/kg/min) pre	-0.207	-0.155	-0.082	0.511
Test 800 swim (s) pre	**0.561**[*]	0.468	0.429	-0.341
Convergence				
I_{Me} pre[a]	0.089	0.103	0.123	0.065
I_{Me} post[b]	0.065	0.084	0.092	0.075
Difference	**-0.023**	**-0.018**	**-0.03**	**0.011**

* p < 0.05. ** p < 0.01.

[a] Dispersion index with respect to the median of the performance variables before training.

[b] Dispersion index with respect to the median of the performance variables after training.

Table 3

Temporal convergence. Spearman correlation coefficients between performance and anthropometric variables before training and the percentage change rate of the run performance variables and swimming 800 m test.

	Speed at VO$_{2max}$ (km/h)	Speed at VT2 (km/h)	Speed at VT1 (km/h)	VO$_{2max}$ run (ml/kg/min)	800 m swim test (s)
Weight pre	-0.263	0.246	0.631*	0.712*	-0.017
BMI pre	-0.204	-0.027	-0.114	0.137	0.183
% Fat mass pre	-0.051	0.016	0.271	-0.373	0.099
Endomorphy pre	0.113	0.095	0.267	-0.254	-0.037
Mesomorphy pre	-0.384	-0.069	0.067	-0.06	0.525
Ectomorphy pre	0.033	-0.091	0.007	-0.104	-0.332
Muscle mass (kg) pre	0.277	-0.073	-0.34	0.077	0.099
Bike power (W) at V0$_{2max}$ pre	-0.32	-0.569*	-0.417	-0.02	-0.035
Bike power (W) at VT2 pre	-0.359	-0.529	-0.607*	0.025	0.013
Bike power (W) at VT1 pre	-0.245	-0.332	-0.598*	0.067	0.168
VO$_{2max}$ bike (ml/kg/min) pre	-0.243	-0.616*	-0.155	0.038	-0.084
Speed at VO$_{2max}$ (km/h) pre	-0.498	-0.577*	-0.439	0.071	-0.104
Speed at VT2 (km/h) pre	-0.433	-0.730**	-0.542*	0.07	-0.226
Speed at VT1 (km/h) pre	-0.348	-0.614*	-0.746**	0.16	-0.177
VO$_{2max}$ run (ml/kg/min) pre	-0.465	-0.568*	-0.463	-0.336	-0.109
800 m swim test (s) pre	0.171	0.033	0.418	0.276	-0.701**
Convergence					
I$_{Me}$ pre[a]	0.045	0.039	0.035	0.075	0.1
I$_{Me}$ post[b]	0.04	0.03	0.021	0.072	0.072
Difference	-0.005	-0.008	-0.014	-0.003	-0.028

* p < 0.05. ** p < 0.01.

[a] Dispersion index with respect to the median of the performance variables before training.

[b] Dispersion index with respect to the median of the performance variables after training.

A high inverse correlation was found between maximum aerobic cycling power (W) in the first test and the percentage of change of this value ($\varrho = -0.800$). Maximum aerobic cycling power in the first test was also correlated with the change percentage in cycling power at VT1, but not with the percentage of change in cycling power at VT2. However, there was a high inverse correlation between maximum aerobic cycling power in the first test and the percentage of change in the running speed at VT2 ($\varrho = -0.569$). Cycling power at VT2 in the first test was inversely correlated with the percentage of change in maximum aerobic power ($\varrho = -0.766$), in power at VT2 ($\varrho = -0.678$) and in power at VT1 ($\varrho = 0.691$). Additionally, this value was inversely correlated with the percentage of change in running speed at VT1. The same inverse correlations were observed between power at VT1 in the first test and the percentage of change in maximum aerobic cycling power ($\varrho = -0.767$), in cycling power at VT2 ($\varrho = -0.725$), in cycling power at VT1 ($\varrho = -0.773$) and in running speed at VT1 ($\varrho = -0.598$). VO$_{2max}$ value that triathletes obtained in the first cycling test was highly correlated with the percentage of change in VO$_{2max}$ in the bike and with the running speed at VT2 ($\varrho = -0.616$).

There was a high inverse correlation between maximum aerobic running speed and the percentage of change in maximum cycling aerobic power ($\varrho = -0.654$). This value also highly correlated with the percentage of change in running speed at VT2 ($\varrho = -0.577$). The value of running speed at VT2 that triathletes obtained in the pre-test was inversely correlated with the percentage of change in running speed at VT2 ($\varrho = -0.614$) and in running speed at VT1 ($\varrho = -0.746$), but not with the percentage of change in maximum aerobic power speed. Similar results were observed with the initial value of running speed at VT1 which was inversely related to the percentage of change in running speed at VT2 ($\varrho = 0.614$) and in running speed at VT1 ($\varrho = -0.746$). In addition, the value of VO$_{2max}$ in the run in the initial test was inversely correlated with changes in the speed at VT2 ($\varrho = -0.568$).

Finally, triathletes' time in the first 800 m swimming test was inversely correlated with the percentage of change in this test ($\varrho = -0.701$).

Discussion

The objective of this study was to analyse changes in body composition and performance variables after a specific training period for a Half-Ironman race. As expected, participants improved their performance variables after training. These results agree with those of other studies that found improvements in performance (both physiological and physical) in recreational athletes related to successful performance in different endurance sports (Muñoz et al., 2013), including triathlon events (Muñoz et al., 2014; Neal et al., 2011), after a training period.

Almost all triathletes increased VO2max values for cycling. Training effects were less significant, however, in VO2max for running. Training volume may have affected these results: despite the fact that the training load was balanced in each segment, participants completed more total training hours in cycling than running. Previous studies have shown that increasing training volume significantly improves VO2max in endurance sports (Fiskerstrand and Seiler, 2004). Training frequency is also a factor that could have influenced these results. Most of the participants only trained cycling once or twice a week before the study and they did not do so regularly. However, they completed three or four cycling training sessions weekly during the specific training period. The frequency of running workouts during the specific training period was similar to that which the participants performed in previous training periods. In fact, several studies have used the increase of training frequency as a strategy to continue improving performance and avoid adaptation of the athlete (Tnønessen et al., 2014, 2015). Perhaps, if there had been a greater number of running sessions, the improvements in this segment would have been superior. Yet, it was decided that the participants made a maximum of four running workouts per week because previous studies have reported that most injuries in triathlon events were related to running (Korkia et al., 1994; Vleck and Garbutt, 1998). More training volume was completed in cycling because it is the segment that accounts for a greater percentage of time in a long distance triathlon (Kandel et al., 2014). In addition, a higher level of performance in this segment may be related to the final result of the race because it will reduce fatigue during the

running segment (Wu et al., 2014).

The weekly average of training volume completed to prepare for the half-Ironman race (≈800 min) was similar to the volume described in other studies with recreational long-distance triathletes (Esteve-Lanao et al., 2017; Kandel et al., 2014) or cyclists (Rüst et al., 2012). On the other hand, this volume is higher in comparison with training volume of recreational runners (≈300 min) (Esteve-Lanao et al., 2017; Zillmann et al., 2013), but smaller when compared with the weekly volume completed by an elite triathlete (≈1200 min) (Mujika, 2014). With regard to the weekly average of training loads, it was similar to that reported in the training period for an Ironman race in triathletes with the same level of performance (≈850 ECOs), but higher in comparison with the weekly average of training loads for a marathon (≈500 ECOs) (Esteve-Lanao et al., 2017).

Training intensity distribution was in line not only with studies about long-distance triathlon events (Esteve-Lanao et al., 2017; Muñoz et al., 2014), but also with studies about other endurance sports (Billat et al., 2001; Fiskerstrand and Seiler, 2004). Most of training (≈80%) was prescribed at or below VT1. This strategy is an approach known as polarized training, which has been presented as the perfect model of training intensity distribution for endurance sports (Seiler and Kjerland, 2006; Seiler and Tønnessen, 2009).

Triathletes with the worst performance during the pre-test obtained a higher percentage of improvement after the training period in most of the variables considered. Participants with lower values of bike power at VO2max and ventilatory thresholds obtained greater improvements in values related to cycling performance, but also in different values related to the run segment, especially speed at ventilatory thresholds. However, as far as swimming performance was concerned, participants with a worse time in the 800 m swimming pre-test were the only ones to obtain a greater percentage of improvement in the swimming test, though this did not apply to the other two segments. This result can be explained by the so-called "cross training" phenomenon (Millet et al., 2002): previous studies have shown how cycling training improves running performance and vice versa (Mutton et al., 1993), but swimming appears to be a highly specific activity that neither gains from, nor provides

benefits for other activities (Millet et al., 2002).

According to our data, the majority of triathletes improved their body composition values, reducing their percentage of body fat and weight. Some previous studies (Margaritis et al., 2003; Palazzetti et al., 2004; Puggina et al., 2011) have also examined the effect of a specific training period on body composition in long-distance triathletes and their results are similar to those found in our research. Puggina et al. (2011) observed significant effects on the reduction of the body fat percentage after a 12-week triathlon training program for a Half-Ironman race. In other studies on long-distance triathletes, no significant differences in weight were found after 6 weeks of training, but a significant increase in the percentage of fat mass was observed (Margaritis et al., 2003). Nevertheless, Palazzetti et al. (2004) found a significant reduction in the BMI and the fat mass percentage after an 8-week training period.

Triathletes with a higher percentage of fat mass, lesser ectomorphy and higher endomorphy values obtained a higher percentage of improvement of VO2max in the bike. This result agrees with findings of previous studies, which have shown that a reduction in fat mass and a lesser endomorphy component value were related to higher values of relative VO2max (Kriketos et al., 2000; Vanderburgh and Katch, 1996) . Although this fat mass correlation was not found with VO2max in the run, results showed that triathletes with high weight values before starting the specific training period obtained a higher percentage of improvement in VO2max in the run and speed at VT1. Several studies have shown that body composition is related to higher performance in endurance sports (Knechtle et al., 2010; Landers et al., 2000), especially in sports where athletes must transport their body weight (Saunders et al., 2004). Thus, for each kg of extra weight in the trunk, aerobic demand increases by 1%, and for each additional kg in the legs, aerobic demand increases by 10% (Myers and Steudel, 1985).

As these results show, the initial level of performance significantly conditions the adaptations generated by training. Recent research (Skovereng et al., 2018) has also shown that there are statistically significant differences between the initial level of performance and VO2peak and subsequent adaptations following a 12-week high intensity interval training program in trained

cyclists. Yet, these authors note that the small and moderate effects indicate a limited influence on training practice. The main strength of this study is that it describes the characteristics and adaptations of a training program for a previously undescribed race. A known limitation is the small sample size, since it is difficult to exhaustively control a larger number of participants in a long-term training process. Despite this limitation, statistically significant correlations were found in several variables. In the future, it would be important to continue with this line of research in order to determine the role of the initial level of performance in the adaptations induced by training.

Practical implications

The increase of participation in endurance sports has produced the appearance of large training groups. As a general rule, coaches prescribe the same training program for the whole group. Yet, coaches should understand that adaptations for a training period are conditioned by the initial level of physical fitness in each segment and previous training experience. For this reason, although all triathletes are classified as amateur athletes, it is important that coaches individualize training loads by segment to maximize adaptations.

Conclusions

As a general rule, triathletes with low initial values in the first test were those who increased their performance the most after the specific training period. However, triathletes with the best results in the first test did not improve their performance significantly. Changes in body composition were also higher in triathletes with higher endomorphy values. These results confirm the importance of training individualization. Despite the fact that all participants were considered to be amateur triathletes, higher training volume or training intensity may be necessary to obtain greater adaptations in triathletes with higher initial fitness levels.

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