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# Training-Intensity Distribution During an Ironman Season: Relationship With Competition Performance

**Iker Muñoz, Roberto Cejuela, Stephen Seiler, Eneko Larumbe, and Jonathan Esteve-Lanao**

***Purpose:*** To describe training loads during an Ironman training program based on intensity zones and observe training–performance relationships. ***Methods:*** Nine triathletes completed a program with the same periodization model aiming at participation in the same Ironman event. Before and during the study, subjects performed ramp-protocol tests, running, and cycling to determine aerobic (AeT) and anaerobic thresholds (AnT) through gas-exchange analysis. For swimming, subjects performed a graded lactate test to determine AeT and AnT. Training was subsequently controlled by heart rate (HR) during each training session over 18 wk. Training and the competition were both quantified based on the cumulative time spent in 3 intensity zones: zone 1 (low intensity; <AeT), zone 2 (moderate intensity; between AeT and AnT), and zone 3 (high intensity; >AnT). ***Results:*** Most of training time was spent in zone 1 (68% ± 14%), whereas the Ironman competition was primarily performed in zone 2 (59% ± 22%). Significant inverse correlations were found between both total training time and training time in zone 1 vs performance time in competition ($r$ = –.69 and –.92, respectively). In contrast, there was a moderate positive correlation between total training time in zone 2 and performance time in competition ($r$ = .53) and a strong positive correlation between percentage of total training time in zone 2 and performance time in competition ($r$ = .94). ***Conclusions:*** While athletes perform with HR mainly in zone 2, better performances are associated with more training time spent in zone 1. A high amount of cycling training in zone 2 may contribute to poorer overall performance.

***Keywords:*** training zones, triathlon, endurance, training volume, training periodization

Triathlon races can be conducted over a wide range of race conditions (temperature, humidity, sea tides, road profiles, etc). Thus, it is not suitable to compare personal-best times between triathletes.[1] This is distinct from what happens in pool swimming, track cycling, or route races, where it is possible to have standard conditions.[1,2] As such, it is difficult to establish relationships between training loads and competition performances for triathletes, particularly in ultraendurance events[3] (half-Ironman or Ironman distance) unless subjects all compete in the same race.

Ironman distance (3.8 km-swim, 180-km bike, 42.2-km run) is currently very popular for recreational experienced triathletes. In spite of plentiful training recommendations, there is a lack of evidence guiding training-intensity distribution for this particular event. A predominantly easy training approach, considered to be the most logical way, is to train the distance,[3] but many coaches counter that "faster is better" and argue against so-called junk miles or low-intensity training.[4] In separate controlled studies, in both cycling and running, superior benefits have been found when athletes followed an intensity distribution with less threshold-intensity training and high amounts of low-[5] or low/high-intensity training.[6]

Since there is a lack of scientific data about how training for an Ironman distance should be distributed across intensity, the purpose of this study was to describe training loads during an Ironman training program according to physiological zones and observe training–performance correlations in a group of triathletes who participated in the same Ironman triathlon event.

## Methods

### Participants

A total of 13 recreational-level triathletes started the study. They lived and trained in the area around Madrid, Spain. Their main goal for the season was to prepare for an Ironman distance triathlon to be held in Klagenfurt, Austria, on July 4, 2010. They all trained with the same coach (J. E-L.) in a supervised program following the same periodization model. The only difference between programs was related to total volume, which was set according to time availability and performance level. Three different versions of this common program were designed and prescribed, with the only difference being total volume, but keeping constant the main variables

Muñoz, Larumbe, and Esteve-Lanao are with the European University of Madrid, Madrid, Spain. Cejuela is with the Dept Section of Physical Education and Sports, University of Alicante, Alicante, Spain. Seiler is with the Faculty of Health and Sport Sciences, University of Agder, Kristiansand, Norway.

described herein. Training experience in endurance sports was similar between subjects (~8 y). In spite of having had a preferred activity in the past (ie, swimming, cycling, running, or a mixture of them), they had all trained exclusively for triathlon since at least 2 years before the study. They were all familiar with long-distance triathlon. Subjects' descriptive characteristics are shown in Table 1.

## Main Characteristics of Training and Periodization

Before starting the preparation cycle-training program, all triathletes participated in the same 25-week winter program (21–23 wk of winter-season training plus a 2- to 4-wk transition period). During the winter program, all participants trained at the same training intensity and followed the same training methods using a reverse-periodization program design, specially focused on road-running race competitions with basic strength (2 sessions/wk), swimming (2 sessions/wk), and cycling training (1 session/wk). During the transition period, basic endurance training was maintained, increasing the cycling and swimming volumes from the previous tapering for road-running races. One weekly session of resistance training was also included to maintain basic maximal strength levels. During the following 18-week training macrocycle (data included in this study), triathletes recorded every training-session load. This macrocycle was the specific program for the Ironman distance race. This was the main competitive goal of the season for all these triathletes.

Three programs were designed according to 3 different arbitrary performance levels (based on physiological performance, experience, and availability for time to train). However, global training-intensity distribution (based on heart-rate [HR] time in zone) was set to be ~77%, ~20%, and ~3%, respectively, in zones 1, 2, and 3, in every program. This included the entire training load (swimming, cycling, and running time). This distribution was a little higher in zone 2 for swimming (~30%), while lower for running (~15%). Zone 3 was minimal in running (~1%). Peak training volumes for each sport were 9 to 12 km/wk for swimming, 330 to 390 km/wk for cycling, and 55 to 78 km/wk for running.

This 18-week macrocycle combined a traditional periodization model (first emphasis on volume, later on intensity) for swimming with a reverse-periodization model for running and cycling (opposite trend, with the highest volumes relatively at the end, before tapering). Global load was designed to alternate every 2 weeks of hard-training load with an easy, lower-load week (six 3-wk mesocycles). The peak training volumes were prescribed at week 7 for swimming, at week 9 for cycling, and at week 12 for running. Almost every week after week 7, long-distance transition sessions were included (generally bike-to-run transitions, with only 1 session for swim-to-bike transition at wk 11). Both duration and intensity were increasing progressively during those workouts, with the criteria of increasing first in cycling and later in the running event. Hydration and nutritional guidelines were followed during these sessions, based on personal interview with a sport-nutrition specialist, including the calculation of sweating rate. Time of day was set early in the morning, but given the climate conditions (springtime, Madrid metropolitan area, 20–30°C), HR drift might have occurred during these sessions, according to perceptual personal observations of the coach.

Strength training was based on maximal strength development with moderate loads during the initial 11 weeks. It consisted of progressive workouts starting with resistance-training machines. Loads progressed from 2 to 4 sets per muscle group, 25 to 28 repetitions, and 40% to 75% of estimated 1-repetition maximum through

**Table 1 Descriptive Characteristics of the Final Sample (Mean ± SD), N = 9**

| | Total | Women (n = 3) | Men (n = 6) | *P* |
|---|---|---|---|---|
| Age (y) | 41.1 ± 8.7 | 41.0 ± 2.6 | 42.8 ± 9.9 | 1.000 |
| Weight (kg) | 68.3 ± 8.1 | 58.9 ± 0.8** | 72.7 ± 4.0 | .020** |
| Height (cm) | 172.4 ± 8.2 | 167 ± 7.0 | 176 ± 5.5 | .092 |
| Body-mass index (kg/m$^2$) | 23.0 ± 2.2 | 21.2 ± 1.6 | 23.4 ± 1.6 | .071 |
| Triathlon training experience (y) | 3.7 ± 1.2 | 3.7 ± 1.5 | 3.7 ± 0.8 | 1.000 |
| Study performance (h) | 11.7 ± 1.7 | 12.1 ± 0.1 | 11.4 ± 1.8 | .439 |
| Study performance (% of time vs gender's winner) | 141 ± 20 | 127 ± 7 | 148 ± 27 | .197 |
| Study performance (% of time vs gender's age-group winner) | 126 ± 12 | 125 ± 2 | 126 ± 16 | .606 |
| Total training load (TRIMPs) | 18,092 ± 3529 | 16,255 ± 442 | 19,010 ± 4100 | .121 |
| Competition load (TRIMPs) | 1061 ± 200 | 976 ± 196 | 1102 ± 206 | .302 |
| Swimming time (competition) | 1.15 ± 0.18 | 1.22 ± 0.23 | 1.11 ± 0.15 | .298 |
| Cycling time (competition) | 5.90 ± 0.57 | 6.08 ± 0.19 | 5.80 ± 0.69 | .121 |
| Running time (competition) | 4.36 ± 0.79 | 4.54 ± 0.37 | 4.27 ± 0.96 | .439 |

Abbreviations: TRIMP, training impulse.

**$P < .01$.

submaximal testing calculations. Those exercises were replaced at week 4 by multijoint exercises. Loads were gradually increasing in a similar fashion as mentioned before. Resistance training was gradually combined with specific strength methods in every sport (paddles for swimming, hills or harder gears for cycling, light weighted belts for running) between weeks 5 and 15. By the end of the macrocycle, some basic maintenance resistance-machine training was conducted with moderate loads (60–70% of estimated 1-repetition maximum), low number, explosive-velocity repetitions.

No differences were applied to the programs in strength training. These sessions were commonly conducted twice a week, always under the supervision of the coach. The training load was included in the training logs, but it was not quantified for this study.

No speed training or any other workouts beyond maximal-aerobic-power zone were prescribed.

## Baseline Physiological Testing and Training Zone Settings

Two weeks before starting the 18-week macrocycle, during the transition period, graded exercise tests were used to determine training zones. Two metabolic thresholds were defined, following previously described procedures.[5,7] Swimming tests were performed as a graded multistage test consisting of 7 repetitions of 200 m with 2-minute rests.[8] HR (beats/min) and blood lactate (bLA; mMol/L) samples from the ear lobe were analyzed with a portable lactate analyzer (Lactate Pro, Arkray Inc, Amstelveen, The Netherlands). Threshold criteria were defined as follows: blood lactate 0.5-mMol/L increase for aerobic threshold (AeT), >1.0-mMol/L increase for anaerobic threshold (AnT), and 8 to 9 mMol/L for maximal aerobic velocity.[9,10]

Cycling and running tests were conducted with a gas-exchange analyzer ($VO_{2000}$, Medical Graphics, St Paul, MN, USA). A ramp-protocol test was conducted for cycling on an ergometer (Sensormedics, Yorba Linda, CA, USA) starting at 50 W and increasing 5 W every 12 seconds.[11] The test ended when ventilatory equivalent for carbon dioxide ($VE/VCO_2$) and pulmonary ventilation (VE) were clearly shown to have passed the respiratory-compensation threshold (herein referred to as AnT). A 5-minute rest was given between the cycling test and a running test on a treadmill (Technogym Run Race 1400 HC, Gambettola, Italy). Starting velocity was set at 8 km/h, increasing by 0.5 km/h every 30 seconds until volitional exhaustion.[5] The following variables were measured: oxygen uptake ($VO_2$), VE, ventilatory equivalent for oxygen ($VE/VO_2$), $VE/CO_2$, and 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-minute period during the running test. Standardized criteria were used for $VO_{2max}$ achievemente.[12] The AeT was determined using the criteria of an increase in both $VE/VO_2$ and $P_{ET}O_2$ with no increase in $VE/VCO_2$, whereas the AnT was determined using the criteria of an increase in both $VE/VO_2$ and $VE/VCO_2$ and a decrease in $P_{ET}CO_2$.[7,11] Two independent observers identified AeT and AnT. If there was disagreement, the opinion of a third investigator was obtained.[7,11] HR was continuously monitored during the tests using radiotelemetry (Accurex Plus, Polar Electro Oy, Finland).

Power and speed training zones were increased during the program according to rating of perceived exertion and HR initial training zones. A second metabolic test took place during weeks 9 and 10 to update the initial zones. The same criteria were applied for setting thresholds-based training zones. Performance data from these metabolic tests are shown in Table 2. Since there were several dropouts, only the data from the final subjects are included.

Three main training zones were defined for this study: zone 1 (at or below AeT), zone 2 (beyond AeT and below AnT), and zone 3 (at or beyond AnT). For daily training workouts, these zones were subdivided in narrower ranges (dividing each zone for being more precise in some workouts and adding a maximal-aerobic-power zone for some swimming workouts). Training logs were designed to calculate training load based on the so-called Lucía TRIMPs score, referred to herein as TRIMPs, which corresponds to value each minute performed in zone 1 per 1, each minute in zone 2 per 2, and each minute in zone 3 per 3.[5,7] Triathletes were filling personal training

**Table 2 Performance Data From the Metabolic Tests (Mean ± SD), N = 9**

| Event | Variable | Test 1 (weeks 1 and 2) | Test 2 (weeks 9–10) |
|---|---|---|---|
| Swim | AeT (speed, m/s) | 0.87 ± 0.06 | 0.92 ± 0.06 |
| | AnT (speed, m/s) | 0.95 ± 0.08 | 1.05 ± 0.11 |
| Bike | AeT (power, W) | 173 ± 30 | 242 ± 47 |
| | AnT (power, W) | 227 ± 42 | 277 ± 36 |
| Run | AeT (speed, km/h) | 10.7 ± 1.1 | 13.1 ± 1.9 |
| | AnT (speed, km/h) | 11.7 ± 0.8 | 14.0 ± 1.4 |
| | $VO_{2max}$ ($mL \cdot kg^{-1} \cdot km^{-1}$) | 52.7 ± 5.2 | 55.0 ± 5.7 |

Abbreviations: AeT, aerobic threshold; AnT, anaerobic threshold; $VO_{2max}$, maximal oxygen uptake.

logs with the information recorded in their HR monitors, in terms of the amount of time spent per training zone.

Inclusion criteria were the following: to complete and record 95% of total training sessions and complete and perform continuously, without any relevant health, tactical, or technical problems, the full distance in competition, performing as best as possible.

## Statistical Analysis

Pearson *r* correlations were quantified between training load and competition variables. Mann-Whitney test for independent samples was applied to compare gender differences in descriptive variables. Paired *t* test was used to compare relative time spent in each zone between training and competition. Significance level was set at $P = .05$ for all calculations.

# Results

## Participant Dropout

Four triathletes did not record training data properly (fewer than 95% of training sessions). Thus, 9 subjects met all criteria and were included in the statistical analysis. There were no differences between men and women in terms of relative level. This level was expressed as the percentage of time versus their gender winner on the whole race. Only body weight was higher in men than in women ($t_6 = 5.661$, $P = .001$). Table 1 shows the results from the final subjects included in the study.

## Correlations Between Metabolic Tests and Triathlon Performance

Significant correlations were found between AeT and AnT speed and power in both test 1 and test 2 in swimming and running events. Significant correlations with Ironman performance were found for running data from test 1 and cycling AnT power in test 2 (see Table 3).

## Time Spent in Metabolic Zones in Training and Competition

Most of the training time was conducted in zone 1 (68% ± 14%, 28% ± 13%, and 4% ± 3% respectively, for zones 1, 2, and 3). However, most competition time was found in zone 2 (38% ± 27%, 58% ± 25%, and 4% ± 6%, respectively, for zones 1, 2 and 3). We found a significant difference between percentage of time in zones 1 ($t_8 = -2.737$, $P = .045$) and 2 ($t_8 = 2.675$, $P = .028$), with no differences in zone 3 ($t_8 = -0.248$, $P = .810$). Swimming training-intensity distribution was 64% ± 16%, 34% ± 16%, and 2% ± 2%; cycling was 68% ± 15%, 27% ± 12%, and 5% ± 3%; and running was 70% ± 17%, 28% ± 16%, and 2% ± 4%. Training-load distributions (TRIMPs) among the 3 disciplines were 18%, 47%, and 35%, respectively.

Competition intensity distribution per sport in zones 1, 2, and 3 was 30% ± 31%, 56% ± 34%, and 15% ± 34% in swimming; 22% ± 26%, 74% ± 24%, and 4% ± 6% in cycling; and 62% ± 40%, 38% ± 40%, and 0% ± 0% in running.

## Correlations Between Training and Competition

Correlations between total training (swim + bike + run) and the Ironman distance competition are presented in Table 4. There was a significant inverse correlation between total training time and competition performance time ($r = -.688$, $P = .040$). There was no significant correlation between competition performance and total load (TRIMPs; $r = -.305$, $P = .425$).

**Table 3 Pearson Correlations of Metabolic Tests With Sport Performance and Ironman Race Performance**

| | | Ironman Sport Performance | | | |
|---|---|---|---|---|---|
| **Metabolic test** | **Sport tested** | **Swim** | **Bike** | **Run** | **Ironman race performance** |
| Aerobic-threshold pace/power test 1 | Swim | –.954** | | | –.564 |
| | Bike | | –.139 | | –.404 |
| | Run | | | –.864** | –.718* |
| Anaerobic-threshold pace/power test 1 | Swim | –.887** | | | –.604 |
| | Bike | | –.446 | | –.353 |
| | Run | | | –.927** | –.835** |
| Aerobic-threshold pace/power test 2 | Swim | –.888** | | | –.534 |
| | Bike | | –.254 | | –.660 |
| | Run | | | –.300 | –.217 |
| Anaerobic-threshold pace/power test 2 | Swim | –.861** | | | –.664 |
| | Bike | | –.561 | | –.731* |
| | Run | | | –.784* | –.650 |

$^*P < .05$. $^{**}P < .01$.

**Table 4 Pearson Correlations of Total Training Load With Sport Performance and Ironman Race Performance**

| | Ironman Sport Performance | | | |
|---|---|---|---|---|
| | Swim | Bike | Run | Ironman race performance |
| Total time | –.604 | –.868** | –.473 | –.688* |
| Time in zone 1 | –.670* | –.927** | –.808** | –.919** |
| Time in zone 2 | .249 | .220 | .697* | .532 |
| Time in zone 3 | –.162 | .145 | .513 | .338 |
| % time in zone 1 | –.566 | –.811** | –.931** | –.934** |
| % time in zone 2 | .614 | .819** | .924** | .939** |
| % time in zone 3 | .174 | .544 | .686* | .636 |
| Total TRIMPs | –.419 | –.609 | –.034 | –.305 |
| Load in zone 1 (TRIMPs) | –.508 | –.936** | –.938** | –.930** |
| Load in zone 2 (TRIMPs) | .245 | .719* | .251 | .532 |
| Load in zone 3 (TRIMPs) | –.523 | .536 | .107 | .307 |

Abbreviations: TRIMP, training impulse.

*$P < .05$. **$P < .01$.

There were significant inverse correlations between competition time and zone 1 training in total time ($r$ = –.919, $P$ = .040), percentage of training time ($r$ = –.934, $P$ = .001), and total load ($r$ = –.930, $P$ = .001).

There were significant positive correlations between competition time and percentage of total training time in zone 2 ($r$ = .939, $P$ = .001). That is, greater time spent in zone 2 during training was associated with slower competition performance.

When analyzing these correlations within each discipline, similar findings were found, reaching statistical significance in cycling and running. Table 4 shows more detailed information.

Correlations between training load per sport and the particular performance during the Ironman are presented in Table 5.

Total training time was inversely correlated with every sport performance, reaching statistical significance in cycling ($r$ = –.898, $P$ = .001).

Inverse correlations were found in every sport between total time in zone 1 and competition times, reaching significance in cycling ($r$ = –.949, $P$ = .001) and running ($r$ = –.916, $P$ = .001). These training–performance correlations were very similar with percentage of time and training load in zone 1.

There were significant correlations between competition times and percentage of total training time in zone 2 both in swimming ($r$ = .289, $P$ = .451), cycling ($r$ = .896, $P$ = .001), and running ($r$ = .848, $P$ = .001).

## Correlations Between Zone 1 and Zone 2

Significant correlations were found between zones 1 and 2 in every sport and in total accumulated training ($P$ = .001). However, there were no correlations between the total training times spent in zones 1 and 2 in any sport or in total training ($P$ > .05; see Table 6).

**Table 5 Pearson Correlations of Training Load per Sport With Sport Performance**

| | Sport | | |
|---|---|---|---|
| Variable | Swim | Bike | Run |
| Total training time | –.303 | –.898** | –.459 |
| Training time in zone 1 | –.346 | –.949** | –.916** |
| Training time in zone 2 | .042 | .455 | .461 |
| Training time in zone 3 | .400 | .354 | .199 |
| % training time in zone 1 | –.237 | –.896** | –.844** |
| % training time in zone 2 | .289 | .896** | .848** |
| % training time in zone 3 | –.326 | .728* | .207 |
| Total training TRIMPs | –.247 | –.592 | .065 |
| Load in zone 1 TRIMPs | –.400 | –.942** | –.918** |
| Load in zone 2 TRIMPs | .019 | .454 | .471 |
| Load in zone 3 TRIMPs | –.400 | .333 | .205 |

Abbreviations: TRIMP, training impulse.

*$P < .05$. **$P < .01$.

In addition, there were significant correlations between percentage of cycling training time in zones 1 and 2 versus running performance. Cycling training in zone 1 was related to the competition running performance ($r$ = –.925, $P$ = .001). On the other hand, cycling training in zone 2 correlated inversely with running performance ($r$ = .912, $P$ = .001). When considering total time in zones instead of percentage of time, these

**Table 6 Pearson Correlations Between Total Training Time in Zones 1 and 2**

| | | Sport | | | |
|---|---|---|---|---|---|
| **Variable** | **With variable** | **Swim** | **Bike** | **Run** | **Total training** |
| Time in zone 1 | Time in zone 2 | –.044 | –.539 | –.154 | –.321 |
| % time in zone 1 | % time in zone 2 | –.992** | –.993** | –.973** | –.988** |

**$P$ < .01.

correlations were high but not significant ($r$ = –.778, $P$ = .14, and $r$ = .811, $P$ = .008, respectively).

## Discussion

The key finding of this study was that intensity distribution was correlated with performance in the Ironman triathlon such that greater absolute and relative loading of training in intensity zone 1 was positively correlated with performance, while greater relative training load performed in intensity zone 2, or between-thresholds intensity, was negatively correlated with triathlon performance. That is, a training distribution focusing on accumulating a larger volume of low-intensity training, but not more between-thresholds-intensity training, was associated with better performance.

During ultraendurance events (>4 h long), performance depends on the athlete's ability to maintain a submaximal intensity for a long time. Several studies have shown that it is unrealistic to maintain the intensity of AnT for more than ~225 min.[13,14] Others argue that this limit during a continuous bout is ~60 minutes, even when the athlete is highly trained and strongly motivated.[10] In any case, the average intensity of an Ironman-distance triathlon is expected to be clearly below AnT in spite of being 3 different disciplines. What we do not know is whether the average intensity is also below the AeT. It likely depends somewhat on performance level. The triathletes in the current study were recreational level. Based on our HR recordings, brief work periods of ≥AnT intensity were only observed during the swimming event, which was ~58 to ~89 minutes in this group. HR recordings collected during the whole triathlon suggest an overall intensity distribution based on time in HR zones of 37% zone 1, 59% zone 2, and 4% zone 3, using laboratory-based testing values as a reference. However, this calculated distribution does not take into account a potential change in the relationship between metabolic intensity and HR that occurs during a prolonged endurance event. Even if dehydration is controlled with regular fluid intake, fatigue and core-temperature elevation can be expected to result in some HR drift that is not observed during normal laboratory testing.[3,15] The relationship of cycling power and running velocity with $VO_2$ likely also changes as efficiency decreases during extended exercise.[15] Thus, some but not all of the HR drift is "compensated for" by a true increase in oxygen utilization at a given submaximal intensity. Taken together, we argue that metabolic intensity maintained by the athletes in the current study may be overestimated by normal time-in-zone interpretation of HR recordings. Therefore, the true distribution of metabolic intensity ($VO_2$) during the triathlon is likely somewhat more weighted toward zone 1 then the calculated distribution. Accepting this, HR encroached most on zone 2 in swimming and cycling (~56% and ~74%) but less in running (~38%, being mostly accounted by 2 of the fastest runners). In spite of the presumed overestimation, these data are in accord with what was previously discussed by Laursen and Rhodes[3] in terms of suggesting the higher HR drift in the middle part of the race, during the cycling event.

Nevertheless, it does appear that a small portion of the event is performed above the lactate threshold (15% in swimming, 4% cycling, and 0% running, all according to HR-based zones). Despite this, more lactate-threshold-intensity training during the 18 weeks before racing was negatively associated with performance.

The specificity principle of training has been challenged in recent years with a growing trend toward high-low-intensity volume training, combined with a substantial amount of zone 3 training.[4,16–18] This distribution of training away from the lactate-threshold-intensity region has been called polarized training. A practical interpretation of both descriptive and experimental studies supporting this intensity distribution is that excessive threshold training can lead to both training monotony and stagnation, as well as failure to execute higher-intensity training with sufficient quality. It has been suggested that a polarized-training model reduces sympathetic stress[17] and may reduce the risk of overtraining.[19,20] While we did not find a true polarization of training intensity since zone 3 training loads were very low, we did observe that intensity distribution away from zone 2 was associated with better performance. Further studies might be conducted with a higher percentage of time in zone 3 versus zone 2 to test a true polarized approach.

Zone 1 and zone 2 training percent ranged from 39% to 89% in zone 1 and 9% to 55% in zone 2. Since they did not accumulate the same training volume during the 18-week macrocycle (ranging from 137 to 297 h in the included triathletes), total training hours in zones 1 and 2 showed the largest differences. Zone 1 training ranged from >220 to ~53 hours, whereas zone 2 ranged from ~114 to ~23. The total volume of zone 3 training was small and quite similar between subjects (4% ± 2%). Consequently, a very strong inverse correlation was found between the proportion of training time spent in zones 1 and 2. That is, athletes who trained more in zone 2 compensated by training even less in zone 1. However, in terms of absolute volume, these correlations were nonsignificant. This means that the relationships found between total volumes in a given zone with performance are not attributable to the mere default of time in the opposite zone.

The athletes were prescribed training that strongly emphasized zone 1 training volume (~77%), moderate amounts of zone 2 training (~20%), and small amounts of zone 3 training in the form of intervals (~3%). Most of the run and swim sessions were observed by the coach. The most common deviation from the training prescription was that athletes cycled at higher intensity when they were not supervised by a coach. Zone 1 training became zone 2 training many times. About 64% of the overall zone 2 training was found to take place during cycling training.

Even assuming an overestimation due to HR drift, it appears that a substantial portion of the bike competition is performed in zone 2, between AeT and AnT. Consequently, we might expect that more specific training in this higher-intensity zone would be performance enhancing. Surprisingly, the current data suggest the opposite, which was also the case for running.

More interesting, we observed significant correlations between percentage of cycling training time in zones 1 and 2 versus running performance. They supported cycling training in zone 1 for the competition running performance, but not cycling training in zone 2 for the running performance. We did not find the same degree of correlations in performance with swimming training distribution. We suggest that both training specificity (open-water swimming-competition model vs pool training) and tactical factors (saving energy for the later events) might be partially explaining this. As reported elsewhere,[3] swimming made up ~10% of total competition time, so especially in recreational triathletes, a preservative strategy might have occurred (personal reports given to the coach by most of our triathletes).

## Practical Applications and Conclusions

While the Ironman triathlon seems to be performed mainly in zone 2 (swimming and cycling phases), most of the training might be conducted in zone 1 in cycling and running disciplines for better performance. Performing about 75% to 80% of all training sessions at an intensity below the AeT might maximize performance combined with a certain degree of moderate to intense training. Determining to what extent this important rate should be addressed to race pace or to a polarized distribution would establish an interesting design for future studies in ultraendurance events.

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