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Original research

Bike and run pacing on downhill segments predict Ironman triathlon relative success

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ABSTRACT

Objectives: Determine if performance and physiological based pacing characteristics over the varied terrain of a triathlon predicted relative bike, run, and/or overall success.
Poor self-regulation of intensity during long distance (Full Iron) triathlon can manifest in adverse discontinuities in performance.
Design: Observational study of a random sample of Ironman World Championship athletes. High performing and low performing groups were established upon race completion.
Methods: Participants wore global positioning system and heart rate enabled watches during the race. Percentage difference from pre-race disclosed goal pace (%off) and mean HR were calculated for nine segments of the bike and 11 segments of the run. Normalized graded running pace (accounting for changes in elevation) was computed via analysis software. Step-wise regression analyses identified segments predictive of relative success and HP and LP were compared at these segments to confirm importance.
Results: %Off of goal velocity during two downhill segments of the bike (HP: $-6.8 \pm 3.2\%$, $-14.2 \pm 2.6\%$ versus LP: $-1.2 \pm 4.2\%$, $-5.1 \pm 11.5\%$; $p < 0.020$) and %off from NGP during one downhill segment of the run (HP: $4.8 \pm 5.2\%$ versus LP: $33.3 \pm 38.7\%$; $p = 0.033$) significantly predicted relative performance. Also, HP displayed more consistency in mean HR (141 ± 12 to 138 ± 11 bpm) compared to LP (139 ± 17 to 131 ± 16 bpm; $p = 0.019$) over the climb and descent from the turn-around point during the bike component.
Conclusions: Athletes who maintained faster relative speeds on downhill segments, and who had smaller changes in HR between consecutive up and downhill segments were more successful relative to their goal times.

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1. Introduction

Optimal pacing is integral to successful performance during endurance exercise. However, self-regulation of exercise intensity during long distance triathlon racing (swim 3.86 km, cycle 180.20 km, run 42.20 km), known by its' eponym "Ironman" through the World Triathlon Corporation (WTC) is complicated due to the combination of the extreme duration, variations in altitude on the bike and run courses, and the range of the abilities in the athletes competing. Although these are only some of the variables triathletes contend with on race day, they should be accounted for when prescribing a pacing strategy for each athlete's best possible performance.

Literature on pacing suggests that maintaining a consistent intensity (i.e., even pacing) is best during endurance exercise greater than 2 min.[1] In practice, long distance triathletes apply positive pacing where exercise intensity decreases by 1–2% each hour during the cycling and running components.[2] It is most likely that the departure from even pacing is due to central self-regulation of pace in response to: (a) sensory feed-back alterations in central drive to working muscles[3–5] and (b) anticipation of the perceived duration of cycling and/or running needed to finish the race while maintaining homeostasis and without causing musculo-skeletal injury.[6] Separately, coaches suggest racing with a negative pacing strategy so that the second half of the bike and run components are completed in less time than the first halves.[7] The discrepancies between research based, coach recommended, and observed pacing strategies highlight the value in determining which pacing behaviors within the bike and run components differentiate between those athletes that are successful compared to those that suffer from adverse discontinuities in performance.[8]

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The geography of the course also challenges self-regulation of intensity. It has been demonstrated in cycling[9–11] and running[12,13] investigations that dynamic pacing, permitting for increased intensity on uphill segments followed by decreased intensity on downhill segments is best over varied terrain. When applied to long distance triathlon, it may be advantageous to incorporate previous single sport research with the theoretical best practices into a dynamic, yet overall even pacing strategy for the bike and run components. This technique would allow for relatively brief and small fluctuations in exercise intensity in response to up- and downhill segments with a quick return to pre-selected goal intensities.

Age, gender, and previous best finish times have been statistically linked to Ironman performance.[14–16] However, absolute performance and race success differ. Age-group competitions within the race allow non-professional triathletes to compete within each five-year age span. Winning times for these groups ranged from 8:54 for the male 40–44 age group to 16:59 for the female 75 and older age group at the 2012 race.[17] Both athletes were successful, even though one athlete performed at nearly twice the velocity of other. Therefore, the percentage that an athlete deviates from their pre-race goal time offers a relative view of athlete's success. Factors such as $\dot{V}O_{2\,max}$, age, and gender play a role in absolute performance, while optimal pacing as a function of the athlete's pre-race goal times may be more important for relative performance as it allows an individual to acutely achieve their personal best.[14–16]

Therefore, the purpose of this investigation was to determine if pacing during different segments of the bike and run course predicted relative success when compared to triathletes' pre-race goal times for each component. Following this we sought to determine if differences between relative high and low performers existed within any of the identified bike or run segments. Given the previous literature we hypothesized that the race segments containing hills would be related to relative performance. The results will help to determine how pacing over different segments of the Ironman World Championship triathlon bike and run courses influence an athlete's ability to achieve their goal time.

2. Methods

Forty triathletes (29 males, age 45 ± 11 y, height 176 ± 6 cm, weight 71.8 ± 6.4 kg, body mass index 23 ± 2 and 11 females, age 43 ± 11 y, height 167 ± 6 cm, weight 59.2 ± 4.7 kg, body mass index 21 ± 2) participated in this investigation at the Ironman Long-Distance World Championship Triathlon located in Kona, HI in October of 2012. Athletes are classified as highly trained because all participants had qualified for this race by placing highly in their respective age group at a separate full or half Ironman triathlon within the past year. Participants were recruited by investigators located at the practice swim start and in the race exposition area. Only athletes that planned to complete the course in less than 14 h were recruited to allow time for post-race measurements. Athletes were excluded if they were not able to attend a familiarization session at least one day prior to race day in order to practice use of the HR monitor. Also, athletes with chronic or recent injuries that were still planning to race were excluded due to the possibility of their inability to complete the entire event. Prior to participation, in accordance with all human research ethical guidelines, athletes were briefed on all risks and benefits of participation in the current investigation and allowed to ask any questions. Next, participants read and signed an informed consent form that had been approved by the University of Connecticut Institutional Review Board, within the Office of Research Compliance, approval number H12–218.

At least one day prior to the race, participants met with investigators to practice using the global positioning system (GPS) and heart rate (HR) enabled watch (Global Trainer, Timex Group USA, Inc. Middlebury, CT; GT) watch. Also, at this visit participants answered questions about their goal finish times for each component and total race time. The purpose of asking pre-race goal time was to establish a baseline for relative success for each athlete. As the subject population consisted of highly trained athletes that had qualified for this event by placing highly within their age group in another Ironman event earlier in the same year the assumption was that all athletes had a consistent perception of their personal capabilities and were able to achieve their goal.

On the morning of the race all participants met investigators to activate their GPS/HR enabled watch. The display of the watch was customized to each athlete to display the information that they normally used while racing. Prior to entering the water for the floating swim start participants were instructed to start the chronograph and lock all buttons on the GT due to probable contact during the >1900 person mass swim start. The swim time used for analysis was that from the official Ironman web site. Participants pressed the lap button at the beginning and end of the bike and at the beginning of the run. Upon completion of the race the participant pressed the stop button.

For all participants, percent off goal time (%off) was calculated for swim, cycle and run duration, and total race duration using an equation for percent error and similar to that of Ely and colleagues.[18]

$$\frac{\text{actual duration} - \text{goal duration}}{\text{goal duration}} \quad (1)$$

Next, absolute %off goal velocity was calculated for all segments of the cycling component ($\%off_{BIKE}$) on the course using Eq. (2). For the remainder of this investigation the term "component" refers to the complete swim, bike, or run portions of the race, and the term "segment" refers to individual sections within the bike ($n = 9$) and run ($n = 11$), which were previously established by WTC with timing mats.

$$\frac{\text{goal velocity} - \text{actual velocity}}{\text{goal velocity}} \quad (2)$$

Goal velocity ($km\,h^{-1}$) was equal to the mean velocity for the 180 km course that would have been needed to achieve each athlete's goal bike time. The order of goal and actual values was reversed (compared to Eq. (1)) so that a negative value represents a velocity faster than goal and positive represents a velocity slower than goal.

Absolute %off run pace was also calculated for the run segments ($\%off_{RUN}$) km using Eq. (3).

$$\frac{\text{actual pace} - \text{goal pace}}{\text{goal pace}} \quad (3)$$

Thus, for all calculations a negative value for a component or segment represents completion is less than goal time (i.e., faster) while a positive value represents completion in more than goal time (i.e., slower).

To more precisely measure athlete exercise intensity and account for changes in course elevation, Global Trainer files were next analyzed with TrainingPeaks WKO+ v3.0 (Peaksware LLC, Boulder, CO) software to provide average HR for segments of the bike and run components and normalized graded pace (NGP) for the run component. NGP is defined as, "the adjusted pace reported from GPS data that reflects the changes in grade and intensity that contribute to the physiological cost of running on varied terrain" and it is derived via a proprietary algorithm that has been developed by Peaksware LLC. This algorithm takes into account the grade of the segment in question and the athlete's functional threshold pace which we determined based on each individual's previous best solo marathon time. For example if the absolute pace

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