Effect of Short Rest Intervals on Running Performance Following a Cycling Exercise Bout

by Michelle StanWiens and Werner W.K. Hoeger

Abstract

The National Governing Body of USA Triathlon imposes a three-minute “time-out” penalty for elite racers who illegally draft during the bike portion of a triathlon. The purpose of this investigation was to determine if an added time-out penalty between a 30-minute bike ride and a 10-km run provided sufficient recovery time to actually become a benefit. Ten (n = 10) volunteer trained female subjects performed two bike/run (BR) trials separated by four to seven days. Each BR trial consisted of a 30-minute bike ride performed at an exercise heart rate of 80% of cycling $V_{\text{O}2\text{max}}$, followed by a 10-km treadmill run at 0% grade during which subjects adjusted the treadmill speed at will. Subjects performed the trials in a random order using a 45-second (BR45s) rest interval and a three-minute (BR3m) rest interval between exercise bouts. A mixed models design showed that there was no significant difference ($p > .05$) between observed and target exercise heart rates at 80% of cycling $V_{\text{O}2\text{max}}$ during the bike portions of the trials (BR45s = 158 b·min⁻¹ ± 0.05, BR3m = 158 b·min⁻¹ ± 0.04). Repeated measures ANOVA showed that 10-km performance was significantly ($p < .05$) faster for the BR3m trial (47.85 min ± 5.0) as compared to the BR45s trial (48.68 min ± 5.4). These data support the hypothesis that a three-minute rest interval following a 30-minute bike bout performed at 80% of cycling $V_{\text{O}2\text{max}}$ produces significantly faster 10-km run times as compared to a shorter 45-second recovery period between these exercise modalities.

Introduction

The sport of triathlon is commonly recognized as an endurance event of varying lengths comprised of swimming, biking, and running in sequence. The popularity of the sport has grown dramatically in recent years evidenced by an increase in membership from 15,937 in 1993 to more than 70,000 members in 2006. The number of sanctioned events exceeded 1,800 races in 2006 (USA Triathlon, 2007).

In a triathlon, the transition is a short period of rest during which the athlete quickly changes gear for the next phase of the event. The assumption that the shortest transition is most beneficial to triathlon performance is at the heart of the current penalty system used by the World Triathlon Corporation, Governing Body of the Hawaii Ironman Triathlon race. For elite racers, the penalty for illegal drafting during the bike portion of the triathlon is a four-minute penalty administered in two parts: (a) one minute is added to the elapsed time and (b) a three-minute time penalty during the bike-run transition. The three-minute time penalty, enforced between the bike-run, in essence becomes a rest period between these two phases of the race. Typically, during this penalty period, athletes are sitting, standing, or stretching.

For peak performance, athletes rely on carbohydrates to contribute most of the energy needed to sustain high-intensity exercise (Costill, 1988). Following exercise, and depending on the intensity of exercise, a rest interval or recovery period of varying length (i.e., seconds, minutes, hours, or days) is required to remove blood lactate and restore adenosine triphosphate, phosphocreatine, and/or glycogen depleted during exercise (Brooks, Fahey, & White, 1996; McArdle, Katch, & Katch, 2007). In the case of aerobic exercise, no significant blood lactate accumulation or phosphocreatine depletion occur. For optimal recovery, the most critical component following high-intensity and/or prolonged aerobic endurance events is the replenishment of muscle glycogen (Wilmore & Costill, 2004). This replenishment comes primarily from carbohydrate intake during or following exercise and the recovery rate is faster in trained athletes (McArdle et al., 2007).

Studies detailing the effects of rest periods on human performance indicate that long-term recovery bouts improve subsequent performance. (MacDougall, Ward, Sale, & Sutton, 1977; Maehlum, Felig, & Wahren, 1978). Most of the research in the area of exercise recovery has focused on the benefits of long-term recovery on subsequent glycogen repletion (Blomstrand & Saltin, 1999; Burke et al., 1996; Burke, Collier, & Hargreaves, 1993; Casey, Short, Hultman, & Greenhaff, 1995), but a review of the literature in the area of high-intensity aerobic endurance exercise revealed no findings on the effects of a rest interval of less than five minutes on subsequent athletic performance.

Using multiple maximal sprint cycling tests of 5-second duration with either 10- or 30-second recovery periods between sprints, Glaister, Stone, Stewart, Hughes, & Moir (2005) found higher measures of maximum and mean power output following 30-second recovery periods. Additionally, significantly lower measures of fatigue, heart rate, respiratory exchange ratio, oxygen uptake, blood lactate, and ratings of perceived exertion were found with the 30-second recovery periods. The researchers concluded that the length of recovery affects performance when performing repeated cycling sprint intervals, and although the exact mechanism of this response is unknown, these results should be considered when developing and evaluating performance capabilities of multiple sprint athletic events. The possibility exists that performance may also increase in a second bout of exercise when using different relatively short-duration recovery periods (i.e., less than 5 minutes) between two bouts of high-intensity aerobic endurance events. Thus the purpose of this investigation was to determine the effect of a 45-second and a three-minute rest interval on 10-kilometer (km) running performance following a 30-minute cycling exercise bout performed at an exercise heart rate equivalent to 80% of maximal oxygen uptake ($V_{\text{O}2\text{max}}$).

Methods

Ten (n = 10) volunteer aerobic endurance trained female subjects members of a women’s triathlon training group participated in three
exercise sessions, an initial bike maximal oxygen uptake (V0\textsubscript{2max}) test and two bike/run (BR) trials. Table 1 provides a summary of basic subject characteristics.

Table 1. Subject Characteristics

<table>
<thead>
<tr>
<th>Variable</th>
<th>M ± SD</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>30.9 ± 5.7</td>
<td>19.0 – 37.0</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>171.1 ± 3.7</td>
<td>165.0 – 178.0</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>58.6 ± 4.9</td>
<td>49.1 – 65.9</td>
</tr>
<tr>
<td>V0\textsubscript{2max} (ml·kg\textsuperscript{-1}·min\textsuperscript{-1})</td>
<td>54.4 ± 4.8</td>
<td>46.9 – 62.8</td>
</tr>
<tr>
<td>EHR at 80% of V0\textsubscript{2max} (b·min\textsuperscript{-1})</td>
<td>157.8 ± 8.4</td>
<td>141.0 – 168</td>
</tr>
</tbody>
</table>

Each BR trial consisted of a 30-minute stationary bike ride at an exercise heart rate (EHR) equivalent to 80% of V0\textsubscript{2max} followed by a 10-km run at self-selected speeds and 0% grade on a motor-driven treadmill. For the purposes of this study, “self-selected speeds” meant that subjects freely adjusted running speeds at any time during the run to achieve the best possible performance in the 10-km run. The participants were aware of the distance covered, as shown on the treadmill control panel, but were not aware of the elapsed time.

One BR trial was performed with a 45-second rest interval between the bike ride and the 10-km run (BR45s), a rest period long enough for subjects to change into running shoes. The other trial allowed for a three-minute rest interval (BR3m) between the bike and the run during which subjects also changed into running shoes. The two BR trials were conducted in a random, counterbalanced order. Participants were allowed to consume only water, ad libitum, during all exercise sessions.

Two days prior to all testing, participants were asked to refrain from intense physical activity above a “somewhat hard” intensity level according to the rate of perceived exertion scale (Borg, 1982). Subjects were also asked to maintain similar diets (i.e., energy and nutrient intake) during the two days prior to the two BR trials and refrain from food intake two hours prior to testing.

The three testing sessions were spaced four to seven days apart. Testing was conducted at the same time of the day for each subject. All tests began with a 10-minute warm-up. This warm-up consisted of a two-minute walk on the treadmill at 4.0 km·h\textsuperscript{-1} followed by three-minute jog at 9.7 km·h\textsuperscript{-1}. Following the treadmill warm-up, participants completed a sequence of static stretching exercises for 4.5 minutes, with each stretch being held for approximately 20 seconds.

The exercise variables measured in this study were V0\textsubscript{2max}, EHR associated with 80% of V0\textsubscript{2max}, EHR during each minute of the 30-minute bike ride, and final 10-km treadmill run time. Each subject’s V0\textsubscript{2max} was assessed on a Monark bicycle ergometer using techniques of open circuit spirometry. Metabolic measurements were determined using a TrueMax 2400 ParVo Medics metabolic measurement cart. EHR at 80% of V0\textsubscript{2max} was determined by finding the EHR associated with 80% of V0\textsubscript{2max} during the initial maximal bike test.

For the bike portion of the two BR trials, the EHR was used to control exercise intensity. The resistance on the bicycle ergometer was continually adjusted to keep each subject at the EHR associated with 80% of V0\textsubscript{2max}. In this manner all subjects cycled for 30 minutes at the same intensity level, thereby entering the run portion at approximately the same level of fatigue. EHR during the cycling portion of each trial was monitored via telemetry using a wireless Polar heart rate monitor and recorded every minute during the trial. A Quinton Q-50, Series 90 motorized treadmill was used for the run portion of the trials. To assess the effect of the two different rest periods (45 sec vs. 3.0 min) on 10-km running performance, subjects were allowed to run at self-selected speeds during the two 10-km runs. The final 10-km run time was recorded immediately upon completion of the run.

A repeated measures ANOVA design was used to analyze the 30-km performance (run time) between the BR45s and BR3m trials. A randomized order and counterbalanced design ensured that the order of treatment did not affect the results of the study. The order of the tests was also analyzed with a repeated measures ANOVA design to confirm the lack of learning effect from the first to the second test.

To confirm that all subjects met the experimental conditions concerning EHR intensity during the 30-minute bike bouts, a mixed models design was used to analyze variability between the actual exercise heart rate (AEHR) and the target exercise heart rate (TEHR) at 80% of V0\textsubscript{2max}. Only AEHRs taken from minutes 5 to 30 were used in the analysis. AEHR data from minutes 1 to 4 were excluded from the analysis because during the initial five minutes of the bike ride, exercise heart rates gradually increased to the TEHR.

Approval from the Boise State University Institutional Review Board for the Protection of Human Subjects in Research was obtained prior to the start of this study and all subjects signed and informed consent form before participating in the study.

Results

Results of the 10-km treadmill run times for the BR45s and BR3m trials are given in Table 2. Results of the repeated measures ANOVA indicated that the 10-km run time was significantly faster (p ≤ .05) following the three-minute rest interval (BR3m time = 47.85 min) versus the trial with only 45 seconds between the bike and the run (BR45s time = 48.68 min) portions of the trial.

Results from the second repeated measures ANOVA conducted to ascertain that there wasn’t a learning effect from BR trial 1 to

Table 2. 10-Kilometer Treadmill Run Time (min)

<table>
<thead>
<tr>
<th>Trial</th>
<th>n</th>
<th>M ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>BR45s</td>
<td>10</td>
<td>48.68 ± 5.42</td>
</tr>
<tr>
<td>BR3m</td>
<td>10</td>
<td>47.85* ± 5.02</td>
</tr>
</tbody>
</table>

*BR45s = Bike/run with 45 seconds rest between exercise modalities
BR3m = Bike/run with a three-minute rest interval between exercise modalities

Significantly different from BR45s (p ≤ .05)
trial 2 (BR45s and BR3m were performed in a random order), indicated that there was no significant difference \((p > .05)\) in 10-km performance from trial 1 to trial 2, (48.33 min vs. 48.20 min). Table 3 provides the times for the two 10-km treadmill run trials.

### Table 3. 10-Kilometer Treadmill Run Time (min)

<table>
<thead>
<tr>
<th>Trial</th>
<th>n</th>
<th>M ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trial 1</td>
<td>10</td>
<td>48.33 ± 5.5</td>
</tr>
<tr>
<td>Trial 2</td>
<td>10</td>
<td>48.20 ± 5.0</td>
</tr>
</tbody>
</table>

* Not significantly different from Trial 1 \((p > .05)\)

Results from the mixed model analysis comparing AEHR and TEHR from minutes 5 through 30 for both the BR45s and BR3m trials indicated that there was no significant difference \((p > .05)\) between the AEHR and the TEHR \((158 \text{ b·min}^{-1})\) in all cases. Table 4 provides the bike EHR data for both the BR45s and BR3m trials.

### Table 4. Actual Exercise Heart Rate (AEHR) and Target Exercise Heart Rate (TEHR) Results for Cycling Portion of the BR45s and BR3m Trials

<table>
<thead>
<tr>
<th>Trial</th>
<th>n</th>
<th>AEHR M ± SD</th>
<th>TEHR M ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>BR45s ((\text{b·min}^{-1}))</td>
<td>10</td>
<td>158 ± 8.72</td>
<td>158 ± 8.89</td>
</tr>
<tr>
<td>BR3m  ((\text{b·min}^{-1}))</td>
<td>10</td>
<td>158 ± 8.75</td>
<td>158 ± 8.89</td>
</tr>
</tbody>
</table>

\(^1\text{BR45s = Bike/run with 45 seconds rest between exercise modalities}

\(^2\text{BR3m = Bike/run with a three-minute rest interval between exercise modalities}

*Significantly different from BR45s \((p \leq .05)\)

**Discussion**

The result of this study indicate that 10-km run time is affected by the length of the rest interval following a 30-minute bike ride at an EHR equivalent to 80% of \(\text{VO}_{2\text{max}}\). As with improved anaerobic performance in subsequent intervals following a longer rest period \((5 \text{ vs. } 30 \text{ seconds})\) during multiple cycling sprints (Glaister et al., 2005), this study found that 10-km performance was 49.8 seconds faster on the BR45s trial \((48.68 \text{ min ± 5.4})\) as compared to the BR45s trial \((48.68 \text{ min ± 5.4})\).

The exact mechanism for improved performance between high-intensity aerobic events interspaced by short recovery periods has not been investigated. Recovery from strenuous steady state exercise requires resynthesis of high-energy phosphates, replenishment of body fluids and oxygen in the blood and in myoglobin, removal of blood lactate, heat dissipation, and reduction of thermogenic hormone levels (McArdle et al., 2007). Although little lactate accumulation occurs at an oxygen consumption below 60% of \(\text{VO}_{2\text{max}}\), the subjects in this study rode the bike at 80% \(\text{VO}_{2\text{max}}\); an intensity level that may have caused some increases in lactate. It is also feasible that blood glucose rose slightly through gluconeogenesis, a process known to increase as a result of intense exercise. All of the aforementioned factors could begin to be positively influenced in a brief three-minute recovery period, long enough to improve performance in a subsequent bout of high-intensity endurance exercise.

Based on these findings, an “imposed” four-minute \((240 \text{ s})\) penalty in shorter events such as investigated in this research, in essence becomes only a 2-minute 25-second penalty \((240 \text{ s – 45 s transition – 50 s improved performance})\). The 50-second improvement in 10-km performance, however, does not completely overcome the time lost due to the imposed penalty, but it may affect the athlete’s final placement within an event and may not provide sufficient penalty to deter participants from illegally drafting during races.

Additional research is necessary to determine the effects of different duration “time-out” penalties on longer duration races; including some with the swim portion of the triathlon. If the findings of the current study hold true for longer races and even in the Iron-length triathlons, the time penalty imposed on athletes for illegal drafting during the cycling portion of the triathlon should really be added to the final finish time instead of providing the athlete with the added benefit of a longer rest period that subsequently may enhance running performance.

**Ms. Michelle StanWiens is the founder and director of performancethigh.com and Dr. Werner W.K. Hoeger is a faculty member at Boise State University, Idaho (USA)**

**References**