Acute Carbohydrate Ingestion Affects Lactate Response in Highly Trained Swimmers

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**Purpose:** Effects of acute carbohydrate ingestion on blood lactate (BLa) response to graded exercise was examined in highly trained male and female swimmers.

**Methods:** Twenty-three swimmers performed the United States Swimming Lactate Protocol, a graded interval test (5 × 200 on 5 min), following ingestion of carbohydrate sports drink (CHO) and placebo (PLA).

**Results:** There was no difference in heart rate ($P = .55$), swim velocity ($P = .95$), or ratings of perceived exertion ($P = .58$) between beverages. There was a significant main effect for gender ($P = .002$) on BLa during all swim stages and recovery. In females, BLa was 27% to 50% higher for CHO during the first ($P = .009$) and second ($P = .04$) swim stages. Predicted BLa at selected swim velocity was higher ($P = .048$) for CHO versus PLA in females at 1.27 m·s$^{-1}$ and higher ($P < .02$) for men at 1.4 m·s$^{-1}$. Mean ($\pm$ SD) BLa was significantly ($P = .004$) greater for CHO (2.7 $\pm$ 1.2) compared with PLA (2.0 $\pm$ 1.1 mmol·L$^{-1}$) during the second test stage and when normalized relative to velocity ($P = .004$). Peak BLa after the final swim (9.6 $\pm$ 3.1 vs. 9.0 $\pm$ 3.2 mmol·L$^{-1}$, $P = .36$) was not different between CHO and PLA.

**Conclusions:** Acute CHO ingestion alters the BLa: swim velocity relationship during moderate intensity swims of an incremental swim test, particularly for females. Therefore, pretest beverage ingestion should be standardized during the administration of BLa testing to prevent potential erroneous interpretations regarding athlete’s training status.

**Keywords:** athlete testing, sports drink, nutrition, exercise performance

Measurement of blood lactate concentration (BLa) during exercise has been of interest to exercise physiologists, coaches, and athletes for many years, particularly, since BLa has often been associated with fatigue. BLa increases with exercise intensity, but not in a linear relationship. The “breakpoint” above the initial slope that occurs at a submaximal exercise intensity has classically been defined as the lactate threshold (LT); however, other operational definitions have been put forth. These include the absolute value for onset of blood lactate accumulation (OBLA) at 2 or 4 mmol·L$^{-1}$; a 1 mmol·L$^{-1}$ increase in BLa above baseline; or maximal
lactate steady state (MLSS), the highest BLa and workload that can be maintained over time without additional accumulation. LT is often used in the field to establish optimal training intensities and evaluate an athlete’s progress during a training cycle in the sport of swimming.

Endurance training can improve LT by lowering BLa at a set exercise intensity or swim velocity. There are, however, intervening variables unrelated to training status which could also potentially affect LT. Dietary manipulation of muscle glycogen stores by either carbohydrate (CHO) loading or depletion can affect OBLA and/or LT. Swimmers consuming a mixed diet of 54% CHO compared with 39% CHO for three days exhibited slower swim performance and lower BLa at 85 and 100% of maximum velocity. In contrast, other investigators report no effect on LT when muscle glycogen stores are elevated or lowered. Moreover, CHO ingestion during exercise is not reported to significantly affect BLa, although the effect on LT per se was not directly examined.

The acute effect of preexercise CHO ingestion on BLa has not been thoroughly examined. Moreover, pretest guidelines regarding acute CHO ingestion before LT determination in elite athletes (who routinely participate in these tests) are not specific. Rotstein et al reported preexercise CHO (42 g in 600 mL of sport drink) had no effect on anaerobic threshold determination when using a lactate minimum test (LMT) in competitive distance runners. This is the only study, to our knowledge, that investigated acute effects of CHO ingestion on LT. It is known that preexercise substrate availability regulates the type of fuel oxidation during exercise. However, there are somewhat contradictory findings regarding potential acute effects of CHO ingestion on BLa during exercise. Koivisto et al found no difference in BLa following preexercise glucose ingestion vs. placebo but fructose ingestion elevated BLa 20 to 25%. Another investigator observed higher BLa following fructose and fructose/glucose ingestion versus placebo. It would seem plausible that elevated blood glucose from high glycemic CHO (eg, sports drinks) before exercise could potentially increase CHO oxidation and thereby alter glycolytic flux and BLa.

The purpose of our study was to determine if acute preexercise CHO ingestion impacts BLa response to a standardized field test in highly trained swimmers. We hypothesized that CHO ingested immediately before a swim test would not affect performance but would alter BLa relative to velocity. The practical application of such results could delimit potential intervening variables that might affect the validity of BLa testing in athletes.

**Methods**

**Subjects**

Twenty-three (12 male, 11 female) competitive swimmers from local colleges and swimming clubs participated in the study. All subjects were swim training a minimum of 2 h per day (6 d per week) for at least 3 y. Subjects’ ability ranged from nonscholarship collegiate athletes to elite, world-class swimmers. All subjects were at a minimum top competitors within their state, 10 swimmers (women, men) had United States Junior National time standards and five swimmers were world class competitors (including a current American record holder). Most swimmers (7
men, 5 women) were considered middle distance swimmers (competing primarily in events between 100 and 400 m), with 3 men and 3 women considered sprinters (primarily 50 to 100 m), and 2 men, 4 women were distance swimmers (specialists in 400 m and above). Mean (± SD) physical characteristics are presented in Table 1. Subjects’ fastest 200 freestyle time performed in the past year (in a short course yard pool, the competitive distance for American collegiate swimmers) was 110.9 ± 5.0 and 104.1 ± 5.1 s for females and males, respectively. Informed written consent was obtained from all subjects as approved by the Institutional Review Boards at Georgia Institute of Technology and University of Georgia. All subjects were currently involved in 6 to 10 swim practices per week of at least 2 h in duration. The study was conducted during April and May following short course championship season after the peak conditioning training phase.

Table 1  Mean (± SD) physical characteristics of subjects

<table>
<thead>
<tr>
<th></th>
<th>Females</th>
<th>Males</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>19.9 ± 0.8</td>
<td>20.2 ± 1.7</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>169.6 ± 7.0</td>
<td>187.4 ± 8.4</td>
</tr>
<tr>
<td>Body Mass (kg)</td>
<td>65.2 ± 8.3</td>
<td>87.6 ± 8.2</td>
</tr>
<tr>
<td>Swim Training (y)</td>
<td>12.0 ± 2.4</td>
<td>9.4 ± 3.5</td>
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**Research Design**

A double-blind, crossover design was used with subjects serving as their own controls. Subjects’ diet and training were standardized for 2 d before each experimental trial as documented by food and activity logs. Dietary intake was analyzed using software published by United States Department of Agriculture (MyPyramidTracker, OMB Number 0584 to 0535). Mean dietary intake (Table 2) was not different before PLA and CHO trials in terms of total calories (males $P = .79$, females $P = .43$) or carbohydrate intake (males $P = .94$, females $P = .82$). Swim training in individual subjects for 2 d before testing was not different for CHO and PLA trials (6792 ± 5010 and 7240 ± 4386 m of swimming, respectively). Swim set intensity and dryland exercise (running, weight lifting) were noted but not quantified.

**Experimental Procedure**

Each subject performed two experimental trials in randomized order with an average of 5 (± 2.5) days apart. All tests were conducted in the morning after an overnight fast. Thirty minutes before each swim protocol, subjects consumed a volume equivalent to 12 mL·kg$^{-1}$ of body mass of either 6% sucrose/glucose sports drink (CHO; Gatorade, Pepsico Company) or artificially sweetened placebo (PLA) with similar fruit-punch flavor (sugar-free Kool-Aid with sucralose). Thereafter, no beverages were consumed during the exercise test or recovery. Both investigator and subjects were blinded to the beverage received.
Figure 1 illustrates the test protocol schematic. The Lactate/Heart Rate Test Protocol designed by United States (USA) Swimming Association (Colorado Springs, CO) was used. This test consists of an intermittent, five-stage incremental interval swim test, followed by 30 min of recovery. Before the test, subjects performed 20 min of a standardized warm-up of their choice consisting of swimming, kicking, and pulling, which was repeated for both test conditions. Subjects completed five 200 freestyle swims at increasing intensity on a 5-min interval (inclusive of passive rest sitting at poolside). Subjects were tested in indoor short course 25 yard pools except for five swimmers tested at one 50-m pool. However, the pool configuration was the same and water temperature was within 1°C for each subject’s trials. Each stage progressed in swim intensity (from ≈75% to 100% effort) and described in Figure 1 relative to the mean % of peak heart rate (HR) achieved following each stage. Since it was not possible to control swimmers’ speed for both drink conditions, velocity was calculated based on total time to perform each stage (m⋅s⁻¹).

Times were recorded to the nearest 0.1 s on a digital stopwatch by an experienced timer. Immediately following warm-up and each swim stage, HR was measured via telemetry (Polar Electro, Finland). HR was only recorded at the end of the 20 min warm-up swim and calculated to be 52% of the HR peak value obtained during the last swim stage (Figure 1). Female subjects wore the HR chest strap underneath their suit. However, the strap would not stay in place for males during swims; therefore, it was placed onto their chest immediately following each swim stage. HR was sampled for 15 s and the peak value recorded. Ratings of perceived exertion (RPE) were recorded using the 15-point Borg Scale. Blood samples (5 µL) were obtained from a towel-dried ear lobe with a lancet and blood dropped directly onto the test strip. A LactatePro LT-1710 (Arkray, Inc. Kyoto, Japan) hand-held analyzer was used and has been validated for clinical and field settings with high repeatability and a coefficient of variation ≤3%. The same unit was used on replicate tests for each individual. BLa was measured after the 20 min warm-up (time point of 0 min) and immediately following each swim stage. Following the 5th swim stage, BLa and HR were measured at 0, 3, 5, 13, 23 and 30 min during passive recovery (seated on the pool deck) as dictated in the USA Swim protocol. Average swim velocity

Table 2  Mean (± SD) daily dietary intake before swim trials

<table>
<thead>
<tr>
<th></th>
<th>Females PLA</th>
<th>Females CHO</th>
<th>Males PLA</th>
<th>Males CHO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Calories (kcal)</td>
<td>1958 ± 658</td>
<td>1979 ± 878</td>
<td>3256 ± 1073</td>
<td>3219 ± 1250</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>277 ± 104</td>
<td>266 ± 155</td>
<td>374 ± 155</td>
<td>371 ± 157</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>89 ± 42</td>
<td>94 ± 31</td>
<td>140 ± 50</td>
<td>142 ± 70</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>61 ± 29</td>
<td>64 ± 33</td>
<td>136 ± 61</td>
<td>132 ± 58</td>
</tr>
<tr>
<td>Carbohydrate (g/kg BM)</td>
<td>4.5 ± 2.0</td>
<td>4.4 ± 3.0</td>
<td>4.5 ± 2.1</td>
<td>4.6 ± 2.0</td>
</tr>
<tr>
<td>Protein (g/kg BM)</td>
<td>1.4 ± 0.6</td>
<td>1.5 ± 0.6</td>
<td>1.7 ± 0.7</td>
<td>1.8 ± 0.9</td>
</tr>
<tr>
<td>Fat (g/kg BM)</td>
<td>1.0 ± 0.5</td>
<td>1.0 ± 0.6</td>
<td>1.6 ± 0.8</td>
<td>1.6 ± 0.8</td>
</tr>
</tbody>
</table>
Statistical Analysis

Power calculations were conducted with G* Power Software, version 3.03 (Heinrich-Heine-University, Düsseldorf, Germany) using a repeated measures ANOVA, within-factors approach. Based on previously collected data in our laboratory, the correlation between repeated measures of blood lactate was 0.7. Using an alpha level of 0.05 and effect size of 0.25, a sample size of 12 subjects resulted in an estimated power of 0.76.

A two-way ANOVA with repeated measures, with one between- and one within-factor was used to examine the effect of beverage and gender during swim test stages and recovery. ANOVA was also used to examine those time points corresponding to below and above LT for beverage and trial number (order) effects. Post hoc tests were performed using the Bonferroni correction for multiple comparisons.

Paired $t$ tests were used to analyze between-trial differences in nutrient intake, peak lactate, and predicted BLa relative to swim velocity at the moderate intensity swim stages. Since identical swim velocity could not be achieved across the stages,
each individual’s predicted BLa was determined at specific swim velocities achieved before LT using linear regression analysis. All values were means expressed ± SD. An alpha level of 0.05 was used to indicate statistical significance. The SPSS version 12.0 software (Chicago, IL, USA) was used for all analyses.

Results

Swimming Velocity

Peak velocity for the total group was 1.49 ± 0.09 m·s⁻¹ during both CHO and PLA. Mean peak swim velocity was significantly slower ($P = .000$) for female (1.43 ± 0.07 m·s⁻¹) compared with male swimmers (1.55 ± 0.06 m·s⁻¹). Swim velocity at each stage was not different between nutritional treatments ($P = .95$) nor affected by test order ($P = .65$). Thus, swim performance was not different across the swim stages for the drink treatments.

Blood Lactate

In Figure 2, BLa is plotted relative to the calculated swim velocity achieved at each swim stage for females and males. However, since the impact of CHO on BLa before LT was of interest and swim velocities varied among individuals at the different swim stages, each subject’s predicted BLa at a selected swim velocity was also computed for the first two to three swim stages (the linear portion of the relationship for each subject). For females, predicted BLa was significantly ($P = .048$) different (by 35%)

![Figure 2](image_url) — Mean (± SD) blood lactate (BLa) concentration relative to swim velocity for the two beverage conditions, carbohydrate (CHO) and placebo (PLA) by gender. Significant beverage difference ($P < .05$) for mean (± SD) predicted BLa at the velocity of 1.27 m·s⁻¹ and 1.4 m·s⁻¹ for females and males, respectively, are illustrated with triangles.
or an absolute level of 0.6 mmol·L⁻¹) at a swim velocity of 1.27 m·s⁻¹ (Figure 2). For males, predicted BL_a was significantly higher \((P = .02)\) for CHO compared with PLA by 22% or 0.6 mmol·L⁻¹ at 1.4 m·s⁻¹. Regression lines for both genders were similar with respect to intercept \((P = .46 \text{ and } 0.59)\) and slope \((P = .34 \text{ and } 0.48)\).

There was no main effect for beverage on BL_a across all swim stages and recovery \((P = .226)\). There was a main effect for gender \((P = .002)\) with lower BL_a during all post-swim time points (inclusive of recovery) for females. BL_a was lower by an absolute difference ranging from 0.9 to 3.4 mmol · L⁻¹ or 37 to 45% during the five swim stages compared with males and remained lower by 2.1 to 4.2 mmol · L⁻¹ or 36 to 46% throughout 30 min of passive recovery (Figure 3, panel A). There was also a significant interaction effect for gender \(\times\) time \((P \leq 0.0001)\). No significant differences by trial order were found for BL_a in all subjects \((P = .12)\) or within gender-specific groups (males \(P = .25\), females \(P = .26\)).

Since significant gender differences were observed, we also analyzed individual swim stages by both total group and gender (Figure 3, Panel A). Absolute BL_a for

![Figure 3](image)

**Figure 3** — A.: Mean (± SD) blood lactate (BL_a) concentration over each swim stage and throughout recovery time for the two beverage conditions, carbohydrate in bold line (CHO) and placebo in dashed (PLA) for males (M) and females (F). Significant beverage differences \((P < .05)\) are indicated by an asterisk after swim bouts 1 and 2 for females only. At swim stage 2, CHO was also higher \((P = .004)\) than PLA for all subjects (data not shown). B.: Mean (± SD) heart rate (HR) during the five-stage swim protocol and 30-min recovery for carbohydrate (CHO) and placebo (PLA) conditions by gender (males, M and females, F).
Carbohydrate Ingestion Affects Lactate

The total group was greater by 35% \((P = .004)\) for CHO during stage two (min 10) of the test \((2.7 \pm 1.2 \text{ mmol}\cdot\text{L}^{-1})\) compared with PLA \((2.0 \pm 1.1 \text{ mmol}\cdot\text{L}^{-1})\). Moreover, during swim stage two, the computed BLa normalized to swim velocity was also significantly \((P = .004)\) greater by 26.7% with CHO compared with PLA. However, peak BLa after the final swim \((9.6 \pm 3.1 \text{ vs. } 9.0 \pm 3.2 \text{ mmol}\cdot\text{L}^{-1}, P = .36)\) and throughout 30-min recovery \((P = .96)\) were not different between CHO and PLA. For females, BLa was significantly greater by 27% during the first \((1.4 \pm 0.5 \text{ vs. } 1.1 \pm 0.5 \text{ mmol}\cdot\text{L}^{-1}, P = .009)\) and by 50% during the second swim stages \((2.1 \pm 0.9 \text{ and } 1.4 \pm 0.6 \text{ mmol}\cdot\text{L}^{-1}, P = .04)\) for CHO compared with PLA. There was not a significant beverage effect for males \((P = .83)\), although BLa tended to be higher by 23% \((P = .06)\) for CHO during the second swim stage \((\text{CHO, } 3.2 \pm 1.3 \text{ compared with PLA, } 2.6 \pm 1.2 \text{ mmol}\cdot\text{L}^{-1})\).

It was expected and observed that those who classified themselves as distance swimmers \((n = 6, 4 \text{ female, } 2 \text{ male})\) had significantly lower BLa \((P < .003)\) compared with sprinters \((n = 6, 3 \text{ females, } 3 \text{ males})\) throughout the five swims \((by 1.2 \text{ to } 2.9 \text{ mmol}\cdot\text{L}^{-1})\). To probe whether the slightly greater weighting of female distance swimmers influenced results, all distance swimmers were removed and the analysis repeated with 7 females, 10 males. The gender effect (lower BLa for females) remained significant \((P = .002)\) and BLa with CHO \((2.6 \pm 0.8 \text{ mmol}\cdot\text{L}^{-1})\) during stage two was also higher \((P = .026)\) compared with PLA \((1.6 \pm 0.7 \text{ mmol}\cdot\text{L}^{-1})\) for females.

**Other Physiological Variables**

HR (Figure 4) was not different between CHO and PLA \((\text{males } P = .87, \text{ females } P = .73)\) although tended to differ \((P = .13)\) by gender. After 30 min of recovery, female HR averaged \(\approx 8 \text{ beats}\cdot\text{min}^{-1}\) lower than males. Mean \((\pm \text{SD})\) RPE during

![Figure 4](image-url) — Individual responses for blood lactate (BLa) relative to swim velocity for two world-ranked females: a sprint freestyle (sprint) and distance (dist) freestyle swimmer after placebo (P) or carbohydrate (C) ingestion.
exercise was similar ($P = .45$) between drink conditions, increasing from 10.8 ± 1.5 after the first stage to 19.4 ± 1.0 after the final swim stage. RPE was 12.8 ± 1.2 at stage two, a value considered predictive of LT with leg exercise. RPE also did not differ ($P = .58$) between genders.

Variability between test trial order for swim velocity and HR was calculated to account for potential training effects since our testing occurred during subjects’ early phase of long course training. Test–retest repeatability of swim velocity was 1.3% based on trial order for stage one and two. Within subject differences for HR based on trial order was negligible (≈1%) except during stage two for males (−4.4% lower in trial 2 compared with trial 1). Thus, if %HR difference along with BLa were negative when comparing trials 2 vs. 1, a possible training effect might have explained differences in BLa for men. However, %BLa difference for CHO relative to PLA was 29% greater for men during stage two.

**Discussion**

Physiological tests in the field are used for various sports (eg, competitive swimming) to assess training status. Whether these tests have external validity relies, in part, on the test administration and reduction/elimination of extraneous intervening variables. Acute CHO ingestion is not widely known to affect BLa during exercise; however, we observed that sports drink ingestion affects BLa relative to swim velocity in trained swimmers, particularly in the early stages of a graded field test. Although the absolute magnitude of this effect was small (less than 1 mmol·L$^{-1}$), the difference occurred at an exercise intensity often associated with LT based on BLa and RPE. Moreover, this effect was particularly noteworthy for females who exhibit higher BLa with preexercise CHO in the moderate intensity swims. This difference could not be explained by the slightly greater distribution of female distance swimmers in the sample. Whether this is a true gender-specific metabolic effect remains an issue requiring further investigation.

These findings are in contrast to at least one investigation that examined acute CHO ingestion on run speed at LMT. Male distance runners consumed 7% CHO beverage (21 g of CHO) 30 min before the test and again before the incremental run portion of LMT. Thus, CHO dosage was similar to our female subjects, but only 2/3 that of males. LMT also varied from a traditional graded exercise test in that following moderate intensity running (75% of 10-km race pace), two sprints were performed at 130% $V_{O_{2max}}$ to elevate BLa. An incremental test of 5-min stages was then performed and terminated after three consecutive BLa increases. Although blood glucose was higher, no effect of CHO on LMT speed was reported. However, these authors concluded that their study did not exclude the possibility that CHO ingestion before exercise could elevate BLa when initiating exercise in a normolactemic state (as in the current study).

Increases in BLa at submaximal speeds due to acute CHO ingestion could invalidate assumptions related to training status. A right and/or downward shift in the BLa relative to swim velocity curve could be interpreted as improved metabolic adaptation to endurance training while a left and/or upward shift might suggest “deterioration in fitness.” Thus, the observed upward BLa shift of nearly 1 mmol·L$^{-1}$ at a specific velocity, due to sports drink ingestion, could invalidate assumptions related to athletes’ training status. Using a seven-stage 200-m swim
test, eight male and four female world-ranked swimmers displayed similar absolute reductions in BLa at LT (0.4 to 0.7 mmol-L\(^{-1}\)) as fitness improved over several months of training.\(^2\) In another case study of an elite swimmer, step-test data provided valuable information since the athlete was competing at his best when swim economy, lactate removal, and aerobic metabolism were most developed for low to moderate-speed swimming.\(^2\) Therefore, in our highly trained swimmers, this small but significant difference at submaximal swim speeds is practically meaningful.

The finding that female swimmers had lower BLa and appeared to be more affected by acute CHO ingestion compared with males is of interest. Our test–retest % differences in BLa based on test order were within +1.3% compared with men; thus, a potential intervening variable such as training status is not likely. The proportion of predominantly distance compared with sprint swimmers by gender may have partially contributed to lower mean BLa in women since, except for one world-class sprint female, peak BLa were all < 8 mmol-L\(^{-1}\). However, even the removal of distance swimmers from the data set preserved the gender-specific BLa response. So, it does not appear that the swimmer specialty can fully explain the gender-specific effect. Menstrual cycle phase influences on BLa reported previously\(^2\) merit future investigation as to whether additional pretest control of CHO intake are necessary to improve reliability for women in LT protocols.

BLa differences due to dietary influences have important practical implications in both laboratory and field testing. Chronic glycogen depletion (due to low daily CHO intake and/or high volume training) results in lower BLa at the same workload.\(^8\)\(^-\)\(^12\)\(^,\)\(^2\)\(^2\) Thus, published protocols for the physiological assessment of swimmers typically specify a high-carbohydrate, low-fat diet on the day of testing.\(^1\)\(^4\) The only recommendation related to preexercise nutrient intake is the abstinence from food and beverages containing caffeine or alcohol 2 h prior. Adequate hydration with either water or a sports drink is “encouraged.” Our data suggest these two hydration options ought to be standardized and not recommended interchangeably. If pretest hydration does occur with a sports drink, the same drink should be used systematically thereafter (or limit to water) to improve the sensitivity of the test.

Previous studies suggest that the relationship between BLa and work load may be as much an indicator of CHO deficiency as that of endurance capacity.\(^8\) Foster et al\(^2\) suggested, for testing purposes, the glycogen state of athletes might be corrected by “normalizing” the BLa profile relative to a maximal value obtained during a test since both peak and submaximal BLa should be similarly reduced in a glycogen depleted state. However, since our peak values were unaffected by acute CHO ingestion, such a normalization method would not be effective. It is also possible that a fasted state before testing produced a different BLa response to this bolus (averaging 60 and 48 g of CHO for men and women, respectively), since blood glucose responses may mirror that of lactate.\(^2\)\(^6\)

The type of CHO consumed preexercise may also be a mitigating factor. A high versus low glycemic meal consumed 3 h before exercise elevated BLa (3.2 vs. 2.7 mmol-L\(^{-1}\)) during exercise at 70% \(V_{\text{O2max}}\).\(^2\)\(^7\) Using a 90% \(V_{\text{O2max}}\) running test (12 x 800 m), de Sousa et al\(^2\)\(^6\) reported 35% higher BLa with acute CHO ingestion (maltodextrin-glucose-fructose solution) versus placebo (11.4 vs. 8.4 mmol-L\(^{-1}\)). Moreover, Jentjens et al\(^1\)\(^8\) observed higher BLa following fructose/glucose ingestion versus lower dose glucose alone or placebo. In contrast, Tsintzas et al\(^2\)\(^9\) reported preexercise CHO (5.5% solution of 1.7% glucose, 1.1% fructose, 0.6% maltose,
1.9% polymers) ingested 10 min before running at 70% VO2max did not affect BLa. Koivisto et al\textsuperscript{17} also found no difference in BLa during exercise when 75 g of glucose was ingested before exercise versus placebo but 20 to 25% higher BLa with similar dose of fructose. The beverage used in our study was a sucrose/glucose solution. Thus, although there is potential for acute CHO ingestion to impact BLa during exercise, it may be that certain CHO forms have differential effects. Whether pure fructose or a blend containing fructose has more of an effect is not well understood.

It might be argued that alternate tests would yield different conclusions as other protocols (2, 3, or 7 × 200 m) and those measuring different constructs (critical velocity, LT, OBLA) have been used for competitive swimmers.\textsuperscript{1,30} For example, the concept of critical velocity might be correlated with a higher absolute accumulation of BLa (4 mmol·L\textsuperscript{−1}). Such a BLa level was not achieved until after the 3rd swim stage in our protocol and was unaffected with CHO. Moreover, BLa clearance, another measure of interest in competitive swimming, was not affected by CHO ingestion. Thus, we acknowledge these results are only generalizable to moderate-intensity swims in a step-test similar to that used in the current study.

Practical Applications

Although group data are important for research, the primary purpose of BLa testing is to examine individual athletes. Our study indicates that to produce valid BLa results for individuals, acute pretest nutritional practices (ie, sports drink ingestion) need to be controlled since resultant changes in BLa might obscure expected results related to training status, especially during the moderate-intensity swims. Figure 4 illustrates the effect of CHO in two world-ranked female swimmers, one distance specialist (1500 m freestyle) and sprinter (50/100 m freestyle). For the sprinter, there appears to be little difference until the higher intensity swims (after the 3rd test stage) where the “break point” occurred at a slower velocity. The distance swimmer had no alteration in break point, but tended to have higher BLa throughout the swim set following CHO. So, although pretest CHO ingestion significantly altered BLa relative to swim velocity, effects on individual swimmers may not occur in an entirely predictable pattern.

Although acute sports drink ingestion altered BLa in the “moderate” intensity swims, it did not affect peak BLa or clearance. Either water or CHO beverages can be ingested before testing, but should be noted and standardized thereafter in future test sessions. Otherwise, failure to control pretest CHO could lead to results that undermine a coach’s interpretation of appropriate training pace or status.

Conclusions

Preexercise CHO ingestion can alter the BLa relative to swim velocity curve, particularly in the moderate intensity swims and may be more apparent in female swimmers. Whether this is a gender-specific metabolic effect cannot be completely discerned from this study. To produce reliable and valid BLa testing results, the acute preexercise nutritional intake (eg, CHO fluid) should be standardized to improve the validity of athlete testing.
Acknowledgments

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References
