Some Metabolic Responses To Reduced Breathing Frequency during Constant Load Exercise

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Swimming VS. Dry land activities

strictly technique-dependent breathing
Front crawl swimming

USUAL BREATHING

taking breaths every second stroke cycle

REDUCED BREATHING

taking breaths every fourth, fifth, sixth or eighth stroke cycle
Front crawl swimming

USUAL BREATHING

REDUCED BREATHING

taking breaths every fourth, fifth, sixth or eight stroke cycle

DURING FINISH AT COMPETITION RACES
HYPOXIC TRAINING

SIMILAR CONDITIONS AS AT ALTITUDE TRAINING

USUAL BREATHING

REDUCED BREATHING

taking breaths every fourth, fifth, sixth or eight stroke cycle
Restricting the frequency of breathing during swimming is a training technique imposed by coaches on their athletes. This technique, called controlled frequency breathing (CFB), restricts the number of breaths from the normal breathing (NB) pattern of 1 breath every 2 or 3 strokes to a pattern of 1 breath every 6, 7, or 8 strokes. It was originally believed that CFB training would limit oxygen delivery to working skeletal muscle and produce metabolic adaptations characteristic of training at altitude (4, 13). CFB is commonly used during training with the belief that it will improve performance.

Theoretically, CFB would limit air exchange at the lungs, thus reducing oxygen concentrations in pulmonary circulation and oxygen availability to the tissues. This would allow a swimmer to train at a moderate intensity but to mimic the limited oxygen availability that occurs at high altitude.

Recently some of the training techniques which I have used have been further developed, rediscovered and promoted as "hypoxic" training (hypoxic = less than the ordinary or norm). I first discovered "less oxygen training" (oxygen debt) when I was a sprinter (up to 440 yards) and a hurdler in track. Then my coach would give us repeats wherein we would hold our breath for fixed intervals. We would hold our breath for 6 to 10 steps, then breath, etc. I applied this procedure to swimming and have been very successful in developing sprinters through the years.

We are all aware of oxygen debt and lactic acid build-up. So the next step is to increase one’s level of resistance to oxygen debt and lactic acid concentration in the muscles and blood. What we want is a better way than to force the body to exist with less oxygen.

My swimmers are forced to train doing repeats, i.e. 10 x 100 breathing every third arm cycle, thereby breathing less air and getting less oxygen at cellular level. I observed many years ago that their heart beats/minute (i.e. pulse rate) would increase nearly 10% over doing the same series allowing them to breathe when they pleased, which was normally every arm cycle. Training at high altitudes may also be the answer. (per Dr. Councilman, Indiana University...
Restricting the frequency of breathing during swimming is a training technique imposed by coaches on their athletes. This technique, called controlled frequency breathing (CFB), restricts the number of breaths from the normal breathing (NB) pattern of 1 breath every 2 or 3 strokes to a pattern of 1 breath every 6, 7, or 8 strokes. It was originally believed that CFB training would limit oxygen delivery to working skeletal muscle and produce metabolic adaptations characteristic of training at altitude (4, 13). CFB is commonly used during training with the belief that it will improve performance.

Theoretically, CFB would limit oxygen exchange at the lungs, thus reducing oxygen extraction in pulmonary circulation and delivery to the tissues. This would increase lactic acid accumulation and increase the lactate threshold. The reduction in oxygen availability would presumably force the swimmer to train at a level suited to the restricted aerobic capabilities of the swimmer. This may improve performance at that intensity by decreasing muscle damage and lactate accumulation.
Background

- hypoventilation
- hypercapnia
- hypoxia

Dicker, Lofthus, Thornton, Brooks (1980). *MSSE*
Matheson, McKenzie (1988). *JSMPF*
Sharp, Williams, Bevan (1991). *IJSM*
Yamamoto, Mutoh, Kobayashi, Miyashita (1987). *EJAP*
Yamamoto, Takei, Mutoh, Miyashita (1988). *EJAP*
Kapus, Ušaj, Kapus, Štrumbelj (2002). *Kinesiologia Slovenica*
Kapus, Ušaj, Kapus, Štrumbelj (2003). *Kinesiologia Slovenica*
SWIMMING

BICYCLE EXERCISE

on land

water
hold breath using almost all lung capacity

expiration + inspiration

RBF
10 min$^{-1}$

4 seconds

2 seconds
The purpose of the study to compare metabolic responses (ventilatory, gas exchange and oxygen saturation) during the constant load bicycle exercise with two different breathing conditions (spontaneous breathing and RBF)
METHODS
Subjects and procedures

- 8 male subjects (age 25 ± 1 years, height 181 ± 3 cm, weight 80 ± 7 kg and Vo2peak 44.26 ± 2.93 ml/kg/min)

1. Incremental bicycle exercise with RBF

   - 2 minutes
   - 30 W
2. constant load test with RBF at peak power output
2. constant load test with RBF at peak power output

3. repeat (identical protocol) constant load test with spontaneous breathing
Instruments

breathing parameters
\( (V_E, V_T, V_{O_2}, P_{ETCO_2}, P_{ETO_2}) \)
Instruments

$O_2$ saturation
capillary blood samples ([LA], Po₂, Pco₂)
<table>
<thead>
<tr>
<th>Subjects</th>
<th>power output (W)</th>
<th>Tmax (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>240</td>
<td>420</td>
</tr>
<tr>
<td>2</td>
<td>180</td>
<td>317</td>
</tr>
<tr>
<td>3</td>
<td>210</td>
<td>358</td>
</tr>
<tr>
<td>4</td>
<td>150</td>
<td>1158</td>
</tr>
<tr>
<td>5</td>
<td>150</td>
<td>1032</td>
</tr>
<tr>
<td>6</td>
<td>210</td>
<td>354</td>
</tr>
<tr>
<td>7</td>
<td>180</td>
<td>408</td>
</tr>
<tr>
<td>8</td>
<td>210</td>
<td>479</td>
</tr>
</tbody>
</table>

$565 \pm 332$ s
Higher $V_T$
marked hypoventilation
no significant differences in \( \text{Vo}_2 \)
lower $P_{ETO_2}$

SB vs. B10
higher $P_{ETCO_2}$
O$_2$ desaturation

SB vs. B10
<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>SB</td>
<td>B10</td>
</tr>
<tr>
<td><strong>pH</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>warm-up</td>
<td></td>
<td>7.40 (0.02)</td>
<td>7.43 (0.04)</td>
</tr>
<tr>
<td>2. minute during the exercise</td>
<td></td>
<td>7.38 (0.02)</td>
<td>7.34 (0.01) **</td>
</tr>
<tr>
<td>4. minute during the exercise</td>
<td></td>
<td>7.36 (0.04)</td>
<td>7.29 (0.02) **</td>
</tr>
<tr>
<td><strong>Po$_2$ (kPa)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>warm-up</td>
<td></td>
<td>11.1 (1.0)</td>
<td>11.3 (0.9)</td>
</tr>
<tr>
<td>2. minute during the exercise</td>
<td></td>
<td>11.3 (0.8)</td>
<td>9.6 (0.7) **</td>
</tr>
<tr>
<td>4. minute during the exercise</td>
<td></td>
<td>11.5 (0.9)</td>
<td>9.2 (1.0) **</td>
</tr>
<tr>
<td><strong>Pco$_2$ (kPa)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>warm-up</td>
<td></td>
<td>5.2 (0.5)</td>
<td>5.3 (0.6)</td>
</tr>
<tr>
<td>2. minute during the exercise</td>
<td></td>
<td>5.8 (0.6)</td>
<td>6.4 (0.4) *</td>
</tr>
<tr>
<td>4. minute during the exercise</td>
<td></td>
<td>5.7 (0.7)</td>
<td>6.8 (0.5) **</td>
</tr>
</tbody>
</table>

**SB vs. B10**
<table>
<thead>
<tr>
<th>[LA•] (mmol/l)</th>
<th>SB</th>
<th>B10</th>
</tr>
</thead>
<tbody>
<tr>
<td>warm-up</td>
<td>1.3 (0.3)</td>
<td>1.3 (0.3)</td>
</tr>
<tr>
<td>1. minute during the exercise</td>
<td>1.3 (0.3)</td>
<td>1.4 (0.4)</td>
</tr>
<tr>
<td>3. minute during the exercise</td>
<td>3.1 (1.0)</td>
<td>3.5 (0.9)</td>
</tr>
<tr>
<td>5. minute during the exercise</td>
<td>4.5 (1.8)</td>
<td>5.1 (1.9)</td>
</tr>
<tr>
<td>2. minute after the exercise</td>
<td>4.6 (2.5)</td>
<td>5.4 (3.1)</td>
</tr>
<tr>
<td>4. minute after the exercise</td>
<td>4.1 (2.5)</td>
<td>4.7 (2.8)</td>
</tr>
</tbody>
</table>

No significant differences in [LA•]
Results of this study confirmed results of previous study about changes in $V_E$, CO$_2$ and O$_2$ during exercise with RBF.

It seemed that this degree of breathing reduction did not influence on aerobic metabolism due to unchanged Vo$_2$ and [LA$^-$].
Results of this study confirmed results of previous study about changes in $V_E$, $CO_2$ and $O_2$ during exercise with reduced breathing.

It seemed that this degree of breathing reduction did not influence on aerobic metabolism due to unchanged $Vo_2$ and $[LA^-]$. 
Thank you for your attention