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Research article

Effect of Adaptive Paced Cardiolocomotor Synchronization During Running: A Preliminary Study

Bill Phillips , Yi Jin[Author Information](#)[Publish Date](#)[How to Cite](#)[Email link to this article](#)

ABSTRACT

Cardiolocomotor synchronization (CLS) has been well established for individuals engaged in rhythmic activity, such as walking, running, or cycling. When frequency of the activity is at or near the heart rate, entrainment occurs. CLS has been shown in many cases to improve the efficiency of locomotor activity, improving stroke volume, reducing blood pressure variability, and lowering the oxygen uptake (VO_2). Instead of a 1:1 frequency ratio of activity to heart rate, an investigation was performed to determine if different harmonic coupling at other simple integer ratios (e.g. 1:2, 2:3, 3:2) could achieve any performance benefits. CLS was ensured by pacing the stride rate according to the measured heartbeat (i.e., adaptive paced CLS, or forced CLS). An algorithm was designed that determined the simplest ratio (lowest denominator) that, when multiplied by the heart rate will fall within an individualized, predetermined comfortable pacing range for the user. The algorithm was implemented on an iPhone 4, which generated a 'tick-tock' sound through the iPhone's headphones. A sham-controlled crossover study was performed with 15 volunteers of various fitness levels. Subjects ran a 3 mile (4.83 km) simulated training run at their normal pace on two consecutive days (randomized one adaptive pacing, one sham). Adaptive pacing resulted in faster runs run times, with subjects running an average of $26:03 \pm 3:23$ for adaptive pacing and $26:38 \pm 3:31$ for sham ($F = 5.46$, $p < 0.05$). The increase in heart rate from the start of the race as estimated by an exponential time constant was significantly longer during adaptive pacing, $\tau = 0.99 \pm 0.30$, compared to sham, $\tau = 1.53 \pm 0.34$ ($t = -6.62$, $p < 0.01$). Eighty-seven percent of runners found it easy to adjust their stride length to match the

pacing signal with seventy-nine percent reporting that pacing helped their performance. These results suggest that adaptive paced CLS may have a beneficial effect on running performance and may be useful as a training aid.

Key words: CLS, pacing, coupling, entrainment

Key Points

- Sham-controlled crossover study using 15 experienced runners running 3 miles (4.83 km).
- Adaptive CLS pacing resulted in statistically significant 35 second average decrease in run-time ($p < 0.05$).
- Increase in heart rate during the run was significantly slower during adaptive pacing ($p < 0.01$).

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