RESEARCH ARTICLE

DOI: 10.54392/ijpefs2628

International Journal of
PHYSICAL EDUCATION, FITNESS AND SPORTS

# The Impact of High-Cadence Cycling on Running Performance in Healthy Adults

**Matthew Ott [a], Jason Simpson [a], Nuno Oliveria [a], Paul Donahue [a], Tanner A. Thorsen [a, *]**

[a] School of Kinesiology & Nutrition, The University of Southern Mississippi, Hattiesburg, 39401, USA

* Corresponding Author E-mail: tanner.thorsen@usm.edu

DOI: https://doi.org/10.54392/ijpefs2628

Received: 05-03-2026; Revised: 12-06-2026; Accepted: 18-06-2026; Published: 26-06-2026

**Abstract:** Understanding the effects of high-cadence cycling on subsequent running performance and spatiotemporal parameters is vital for determining whether a brief, low-impact cycling stimulus can acutely enhance running performance in healthy adults. However, research on cycling-to-running transfer has primarily focused on triathletes, and its applicability to healthy adults remains largely unexplored. This study aimed to examine the acute effects of high-cadence cycling on subsequent 800-meter running performance and spatiotemporal parameters in healthy adults. Thirty healthy adults completed two testing visits. In the first visit, participants performed an 800 m run at a maximal workout pace. In the second visit, participants completed a 10-minute bout of high-cadence cycling, then immediately repeated the 800-meter run. Time, average cadence, velocity, step length, and step time were compared between visits. Significant improvements were observed in total time, cadence, velocity, and step time, while step length did not change significantly. Participants were also classified into cadence-dominant or step-length-dominant strategy groups, and running outcomes were compared within each strategy group. Total 800 m time decreased during the cycle-run protocol in both running strategies, but only the step length group achieved statistical significance. Cadence increased significantly in the cadence strategy group, and step length increased significantly in the step length strategy group. These findings indicate that an acute bout of HCC may improve 800-meter running performance and alter running strategy in healthy adults. Furthermore, the variability in responses suggests that while HCC serves as a potential rhythmic primer, runners retain individualized movement strategies when translating to faster running speeds post-cycling.

**Keywords:** Length-Time Difference, Running Cadence, Cycling Cadence, Step Length.

## 1. Introduction

Cycling is a commonly used exercise modality that provides controllable cardiovascular and musculoskeletal demand while imposing relatively low impact on the lower extremities (Thorsen *et al.,* 2020; Thorsen *et al.,* 2024). Compared with many weight-bearing activities, cycling reduces joint loading while allowing the ankle, knee, and hip to move through a greater range of motion than walking. Its accessibility, mechanical consistency, and ability to control cadence and work rate have made it practical for both performance and clinical applications. Importantly, studies across a variety of populations have shown that cycling can positively influence gait mechanics, including gait velocity and cadence (Gottschall & Palmer, 2000, 2002; Keating *et al.,* 2025; Thorsen *et al.,* 2024). Since gait velocity is strongly associated with functional mobility, quality of life, and movement efficiency, exercise strategies that can acutely enhance gait may have important implications for rehabilitation and performance outcomes (Lama *et al.,* 2024; Middleton *et al.,* 2015; VanSwearingen *et al.,* 2011).

Among the factors that influence gait velocity following cycling, cadence has emerged as a leading contributor. Previous research has demonstrated that increases in gait velocity following cycling are associated mainly with cadence-driven changes during walking, including shorter stance and swing times, rather than changes in spatial parameters such as step length or step width (Thorsen *et al.,* 2024). Alterations in cycling cadence have been proposed to increase peripheral afferent signals, which may trigger central processing changes believed to enhance motor function control (Gottschall & Palmer, 2002). In walking, these cadence-

related changes may be reflected biomechanically through increased propulsive ground reaction forces, greater joint angular velocity during the swing phase, and increased positive power production of the lower extremity during stance (Thorsen *et al.,* 2024). Conversely, little to no improvement in gait performance was observed when maintaining a constant cycling cadence or increasing the work rate (Keating *et al.,* 2025). Collectively, these findings suggest that high-cadence cycling (HCC) may serve as a practical acute stimulus for improving gait mechanics.

Despite these findings, responses to cycling interventions do not appear to be uniform across individuals. Recent work by Lama (2024) demonstrated that some participants experienced meaningful improvements in gait velocity following cycling, whereas others showed little to no change (Lama *et al.,* 2024). This variability in responsiveness suggests that the improvements in gait after cycling may depend on the individual's sensitivity to the high cadence stimulus. Although gait velocity improves in some individuals post cycling, the extent and consistency of the response remain unclear. Thus, individual response variability raises an important question of whether HCC protocols provide sufficient stimulus to transfer to other tasks, such as running.

Task improvement following cycling exercise has indeed been examined in running, particularly in triathletes performing cycling-to-running "brick" training protocols (Bernard *et al.,* 2003, 2006; Etxebarria *et al.,* 2014; Price et al., 2020). Gottschall and Palmer (2000) investigated post-cycling changes in running mechanics and found that 30 minutes of cycling before running decreased initial stride length and increased stride frequency (Gottschall & Palmer, 2000). These findings were similar to the cadence-driven changes previously observed in walking post-cycling. In a follow-up study by Gottschall and Palmer (2002), the effects of cycling cadence on subsequent running performance and kinematics in triathletes were examined (Gottschall & Palmer, 2002). They reported that after 30 minutes of cycling at 110 rpm, triathletes ran 4% faster than after cycling at 90 rpm and 7% faster than after cycling at 70 rpm before a 3200 m run (Gottschall & Palmer, 2002). Notably, running cadence after cycling at higher cadences appeared to reflect the preceding cycling rhythm, suggesting a carryover effect that may be influenced by spinal central pattern generators.

Most research on cycling-to-running transfer has focused particularly on triathletes, whose training backgrounds make them more adapted to transitions between cycling and running (Bernard *et al.*, 2003, 2006; Etxebarria *et al.,* 2014; Gottschall & Palmer, 2000, 2002; Price *et al.,* 2020; Suriano & Bishop, 2010). Therefore, it remains unclear whether the cadence-related effects of HCC observed after cycling are specific to highly trained individuals or whether they also occur in healthy adults who are less accustomed to cycling-running transitions. The present study extends Gottschall & Palmer's findings by examining whether a shorter bout of HCC can improve subsequent running performance in healthy adults. In addition, recent work by Thorsen and colleagues demonstrated cadence-driven improvements in walking mechanics after cycling; it remains unknown whether similar adjustments transfer to running, a faster and mechanically distinct gait task. Thus, the present study advances prior work by evaluating whether HCC acutely improves 800 m running performance and whether these changes are expressed through spatiotemporal variables.

Therefore, the purpose of this study was to examine the acute effects of HCC on subsequent running performance in healthy adults. Specifically, this study compared 800 m running time, velocity, cadence, step time, and step length between a run condition and a cycle-run condition (CR). We hypothesized that CR would improve 800 m running performance through faster running time and increased cadence.

## 2. Methods

### 2.1 Experimental Approach

A within-subject, repeated-measures design was used to examine acute changes in running performance and spatiotemporal parameters following HCC. Testing occurred on separate visits. The Run established baseline metrics during an 800 m run. The CR (48-72 hours later) involved a 10-min high-cadence cycling bout followed by an 800 m run. Running metrics were compared between visits, and the rate of perceived exertion (RPE) was reported.

### 2.2 Participants

An a priori power analysis was conducted for a one-sided dependent samples t-test with a moderate effect size (dz = 0.5, α = .05, β = .80) and indicated a total sample of 27 participants (G*Power 3.1.9.7) (Faul *et al.,* 2007). To account for recruiting and attrition, a sample of 34 healthy adults within the local community were recruited for this study (21.9 ± 2.31 years, 1.73 ±

0.1 m, 72.12 ± 10.68 kg). However, 4 participants failed to complete all testing visits, leaving a final sample of 30 participants. All volunteers provided written informed consent before formally enrolling in the study. The study protocol was approved by the University of Southern Mississippi Institutional Review Board (#25-0505).

## 2.3 Inclusion Criteria

Standardized pre-participation instructions were distributed electronically via email to each participant prior to data collection. Participants were instructed to abstain from vigorous physical activity, alcohol, and caffeine for 48 hours before each of the 2 testing visits. Non-adherent participants were rescheduled or excluded from the study. Inclusion criteria included healthy adults who run aged 18-30 years. To meet the definition of a healthy adult who runs, each participant had to routinely run for exercise and enjoyment at least 5 km per week (Dingenen *et al.*, 2020). This threshold was selected to better identify participants who regularly run, while maintaining a recreationally active sample rather than competitive endurance athletes. This criterion was intended to ensure basic running familiarity was met while avoiding a highly trained sample. Additional inclusion criteria included no current or past lower extremity musculoskeletal injuries in the preceding 6 months. This criterion minimized bias arising from injury-related biomechanical changes in running and cycling, thereby reducing variance and strengthening internal validity. In addition, participants were included if they answered "No" to all general health questions on the Physical Activity Readiness Questionnaire (PAR-Q+) (Warburton *et al.*, 2011). Additional inclusion criteria included a body mass index (BMI) score < 30 kg/m2 and a shoe size of U.S. 6-11 (men) or 7.5-11 (women).

## 2.4 Procedures

### *2.4.1 Run*

Before the participants began, they were asked to perform a 5-10-minute dynamic warm-up. The dynamic warm-up consists of marching high knees, A-skips, butt-kicks, side shuffles, carioca, front & lateral leg swings, bodyweight squats, jumping jacks, and one jogged lap. After the warm-up, the correct instrumented insoles were placed in the participant's shoes and calibrated. Participants then ran an 800 m time trial on an indoor 200 m track at their maximal workout pace. A standardized cue, "3, 2, 1, go", was utilized at the starting line of the track to initiate the run. Participants reported RPE after completing the run. An 800 m run was selected because it is long enough to assess sustained running performance and spatiotemporal organization. As well as short enough to allow participants to complete the run at their best effort without accumulating excessive fatigue.

### *2.4.2 Cycle-Run*

The CR was performed at least 48-72 hours after the run to mitigate fatigue-related effects. During CR, the same dynamic warm-up was repeated, and then the instrumented insoles were placed in each participant's shoe before the cycle-run test. Participants were then fitted to a mechanically braked cycle ergometer (828e, Monark, Vansbro, Sweden). Saddle height was adjusted to 25° to 30° of knee flexion with the crank at bottom-dead-center, verified using a hand-held goniometer (Holmes *et al.*, 1994). Participants then completed one cycling bout lasting 10 min at a normalized work rate of 0.75 W/kg and a cadence of 100 + 2 RPM. When the cycling bout was complete, participants would immediately return to the track and run 800 m at their maximal workout pace, using the same starting cue to initiate the run. RPE was recorded after the cycling bout and the 800 m run.

## 2.5 Instrumentation

Participants completed both 800 m runs on a 200 m indoor track. Lap times were recorded each lap using a handheld stopwatch. Instrumented insoles recorded temporal metrics and ground reaction forces during the 800 m run (100 Hz, Loadsol Pro Novel Electronics, St. Paul, MN, USA).

## 2.6 Experimental Design

A within-subject, two-condition (repeated-measures) design was used to assess the acute effect of high-cadence cycling (HCC) on subsequent overground running performance in healthy adults (Figure 1).

## 2.7 Data Analysis

Lap time was recorded for each of the four 200 m laps during the 800 m run, and total time was calculated as the sum of the four laps. Output from the instrumented insoles were exported for analysis into a custom MATLAB script to estimate cadence and step time (2024a MATLAB, MathWorks, Natick, MA, USA).

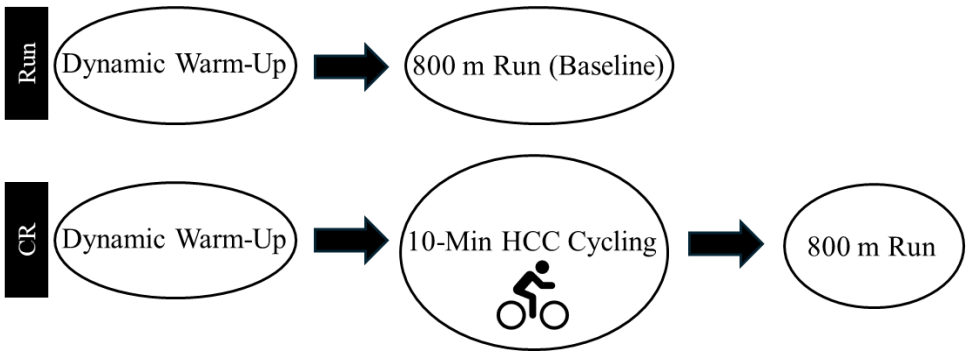


**Figure 1.** Study Protocol. Within-subject design across two visits. Run: 800 m run to establish baseline metrics. CR (48-72 h later), 10-min high-cadence cycling bout, then an 800 m run.

Running velocity was calculated as the average velocity of each lap, calculated as the quotient of lap distance (200 m) and lap time. Step length was calculated as the quotient of velocity and cadence. To characterize running strategy, the Length-Time-Difference (LTD) was calculated from the relative change in step length and step time from the Run to the CR using the equations presented by Baudendistel *et al.* (2021) (equation 1).

$$LTD\ (\%) = \frac{(step\ length\ CR - step\ length\ Run)}{(step\ length\ Run)} + \frac{(step\ time\ CR - step\ time\ Run)}{(step\ time\ Run)} \quad (1)$$

Although originally developed to characterize preferred-to-fast walking transitions, the LTD framework is applicable to running as running velocity is determined by the interaction between step length and step time. As a simple comparative ratio, LTD characterizes an individual's speed-strategy phenotype based on how an individual achieves increased velocity; either through longer steps or shorter step times.

## 2.8 Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics (version 31.0.0.0, IBM Corp., Armonk, NY, USA). Descriptive statistics were calculated for all variables and are reported as mean + standard deviation. Normality of the data was assessed using the Shapiro-Wilk test. Statistical significance was set a priori as $p < .05$. Bonferroni adjustments were made to account for family-wise error, resulting in an adjusted $p = .01$. Dependent-samples t-tests were used to compare both Run and CR for the total 800 m time, average velocity, average cadence, average step length, and average step time, with 95% confidence intervals calculated for the mean difference between Run and CR. Cohen's d was calculated to quantify the effect size for paired comparisons. Effect size for the dependent-samples t-test was reported using Cohen's d and interpreted by magnitude: 0.20 (small), 0.50 (medium), 0.80 (large) (Cohen, 2013).

Participants were additionally classified into cadence-strategy or step-length strategy groups based on LTD. Dependent-samples t-tests were used to compare results from the Run and CR for total 800 m time, average velocity, average cadence, average step length, and average step time within the running strategy group. Cohen's d was calculated to quantify the effect size for paired comparisons. Effect size for the dependent-samples t-test was reported using Cohen's d and interpreted by magnitude: 0.20 (small), 0.50 (medium), 0.80 (large) (Cohen, 2013).

# 3. Results

## 3.1 HCC Intervention

Thirty healthy adults completed both visits and were included in the final analysis (21.9 ± 2.31 years, 1.73 ± 0.1 m, 72.12 ± 10.68 kg, 23.88 ± 2.29 kg/m², M = 21, F = 9). Table 1 presents the results of the HCC intervention. Following CR, total 800 m time and step time decreased, while running velocity and cadence increased. Average step length did not change significantly (Table 2).

Table 1. Paired-samples t-test results for the total 800 m performance and average spatiotemporal variables are presented as mean + SD. Bold indicates statistical significance.

## 3.2 LTD Between-Group Comparison

Fourteen participants were classified as using a cadence-dominant strategy with a mean LTD of -3.89 % + 2.22, and 16 participants were classified as a step length-dominant strategy with a mean LTD of 4.84% ± 5.92 (Figure 2). Total 800 m time decreased during the CR in the Step Length Strategy group (Table 2). Running velocity increased during the CR in both groups, with the step length strategy achieving statistical significance (cadence; p = .190, step length;

p = .030, Table 2). Running cadence increased significantly in the cadence strategy group from the Run to CR (p = .001, Table 2). Running step length increased significantly in the step length strategy group during the CR (p = .012, Table 2). Step time significantly decreased in the cadence strategy group in the CR (p = .004, Table 2).

## 4. Discussion

The purpose of this study was to assess the acute effects of HCC on subsequent running performance in healthy adults. We hypothesized that HCC would improve 800 m running performance, as evidenced by faster running time and cadence during the CR.

Our hypothesis was supported, as 800 m running performance improved during the CR following HCC, indicated by faster time and higher cadence compared with a baseline Run. The total 800 m time decreased by an average of 3.72% from the CR, and cadence increased by an average of 1.41%. These findings suggest that the acute benefit of HCC was expressed primarily through cadence-related changes that supported faster running performance.

**Table 1.** Paired-samples t-test results for the total 800 m performance and average spatiotemporal variables are presented as mean ± SD. Bold indicates statistical significance.

| | Run | CR | 95% CI | p (d) |
|---|---|---|---|---|
| Time (s) | 205.63 ± 40.0 | 197.99 ± 35.0 | [2.17 13.11] | .004 (.522) |
| Velocity (m/s) | 4.06 ± 0.8 | 4.18 ± 0.7 | [-0.22 -0.03] | .005 (.504) |
| Cadence (spm) | 170.77 ± 8.9 | 173.17 ± 9.2 | [-4.04 -0.76] | .003 (.547) |
| Step Length (m) | 1.42 ± 0.3 | 1.45 ± 0.2 | [-0.054 0.003] | .040 (.330) |
| Step Time (s) | 0.353 ± .02 | 0.349 ± .02 | [0.001 0.008] | .005 (.500) |

d = Cohen's d; p = p-value; spm = steps per minute

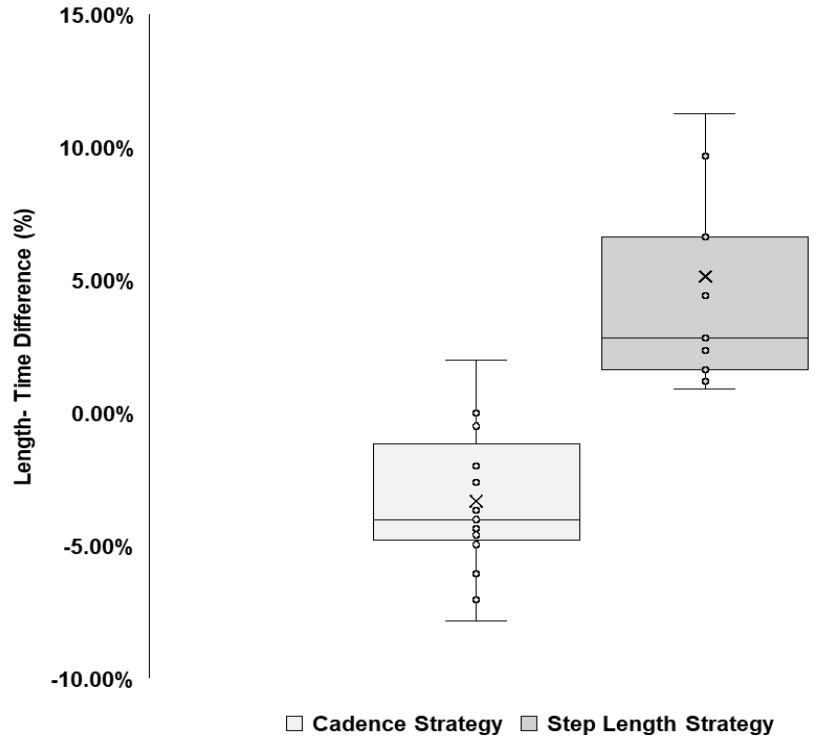


**Figure 2.** Distribution of length-time difference (LTD) values across running strategies. Boxplots represent LTD % for classification into cadence-dominant and step-length-dominant strategy groups. Negative LTD values indicate a cadence-dominant strategy, whereas positive values indicate a step-length-dominant strategy.

**Table 2.** Paired-samples t-test results for the total 800 m performance and average spatiotemporal variables between running strategies are presented as mean ± SD. Bold indicates statistical significance.

| | Run | CR | 95% CI | p (d) |
|---|---|---|---|---|
| **Cadence Strategy** | | | | |
| Time (sec) | 193.96 ± 31.06 | 190.59 ± 32.55 | [-8.26 1.54] | 0.150 (0.106) |
| Velocity (m/s) | 4.24 ± .63 | 4.32 ± .66 | [-0.04 0.20] | 0.190 (0.124) |
| Cadence (spm) | 168.64 ± 7.12 | 173.29 ± 9.47 | [2.39 6.89] | 0.001 (0.561) |
| Step Length (m) | 1.51 ± .21 | 1.49 ± .21 | [-0.04 0.02] | 0.273 (0.095) |
| Step Time (s) | .359 ± .01 | .348 ± .02 | [-0.02 0.00] | 0.004 (0.667) |
| **Step Length Strategy** | | | | |
| Time (sec) | 215.84 ± 44.62 | 204.46 ± 36.79 | [-21.34 -1.42] | 0.023 (0.280) |
| Velocity (m/s) | 3.89 ± .84 | 4.06 ± .76 | [0.01 0.33] | 0.030 (0.212) |
| Cadence (spm) | 172.63 ± 10.00 | 173.06 ± 9.20 | [-1.78 2.66] | 0.668 (0.045) |
| Step Length (m) | 1.35 ± .27 | 1.41 ± .25 | [0.02 0.10] | 0.012 (0.231) |
| Step Time (s) | .349 ± .01 | .349 ± .02 | [-0.01 0.01] | 0.834 (0.056) |

d = Cohen's d; p = p-value; spm = steps per minute

These results are consistent with previous literature demonstrating improvements in running following cycling. Gottschall & Palmer (2002), for example, reported that triathletes in a fast-cycling condition ran 4% faster during a 3200 m run after 30 minutes of HCC (Gottschall & Palmer, 2002). They also found that running cadence increased immediately after cycling by 5% compared to a control group and by 10% compared to a slow-cadence group. In other settings, increases in gait velocity after HCC have been shown. Keating *et al.* (2025) demonstrated that 15 minutes of HCC increased post-cycling gait velocity during a 10-meter walk test (Keating *et al.,* 2025). That improvement in gait velocity was reflected in increased cadence, suggesting temporally shorter stance and swing phases, while no change in step length was observed. In the current study, the effect sizes for 800 m time, velocity, cadence, and step time were small-to-moderate, indicating modest but measurable changes after completing the HCC stimulus before a run. A reduction of 3.72% of 800 m time (~7.6 seconds) may be meaningful for recreational active healthy adults. However, given the modest effect sizes, individual variability, and a fixed order design, these findings provide preliminary evidence of a potential acute stimulus from HCC to alter spatiotemporal parameters rather than a definitive performance recommendation. Together, these findings suggest that HCC may promote cadence-driven adaptations that transfer to both walking and running in healthy adults, and support the idea that cadence is a tunable parameter for running performance.

In addition to overall performance, the present study examined spatiotemporal variables, with step time emerging as a key contributor to the observed changes in running time and cadence. Since cadence is inversely related to step time, even small changes may allow runners to complete a run faster without requiring substantial increases in step length. In contrast, average step length did not significantly change, suggesting that the observed performance was primarily due to running cadence. This is meaningful as it indicates that the acute transfer of HCC may operate by reorganizing stride timing rather than altering longer strides

These findings also have practical importance beyond performance. Previous work has shown that increasing running cadence can reduce braking mechanics, overstriding tendencies, and joint loading during running (Anderson *et al.,* 2022; Chumanov *et al.,* 2012). Although the present study did not assess joint kinetics or injury-related outcomes, the observed increase in cadence and reduction in step time suggest that HCC may influence stride organization in a direction that is mechanically efficient. However, future research may seek to determine whether the cadence-related changes observed after HCC are accompanied by meaningful changes in lower-extremity loading during overground running.

Beyond changes in running performance and spatiotemporal parameters between the Run and CR, the present study also examined individual differences in stride-organization strategies that underline increased running velocity. Baudendistel *et al.* (2021) demonstrated that faster gait speed can be achieved through distinct spatiotemporal strategies, as classified by the length-time difference (Baudendistel *et al.,* 2021). LTD characterizes an individual's speed-strategy phenotype based on how an individual achieves increased velocity; using either a cadence-dominant strategy - when speed is achieved primarily through shorter step time, or a step-length-dominant strategy - when speed is achieved primarily through greater step length, to achieve increased velocity. One notable finding was that both LTD strategies were equally represented in this current sample. This suggests that healthy adults may retain an individualized stride organization while still benefiting from the acute effects of HCC. The cadence-strategy group demonstrated greater increases in cadence from the HCC protocol than the step-length-strategy group, with no change in step-length. However, the step-length strategy group saw an increase in step length following HCC. These findings suggest that HCC did not impose one universal stride pattern on all participants. In the context of the current study, HCC may have improved the runners' ability to run faster, while the expression of that improvement depended on the individual's strategy. As a result, runners may have been better able to organize lower-limb cadence around a quicker rhythm, contributing to the observed increase in cadence during the run.

The individual responses to the HCC protocol were not uniform when examined in the context of LTD, consistent with the broader idea that acute adaptations to cycling may differ across participants. Prior work by Lama *et al.* (2024) showed that some individuals demonstrate meaningful improvements in gait velocity following cycling, whereas others show smaller or negligible changes (Lama *et al.,* 2024). In the present study, some runners demonstrated greater sensitivity to the cadence stimulus of HCC, which may have allowed the cycling bout to act as a rhythmic primer for the subsequent run. One possible explanation is that HCC increased sensorimotor input or influenced central motor processes that contributed to faster step timing, as previously proposed in prior cycling-to-running research (Gottschall & Palmer, 2002). However, because neural activation, muscle activity, and physiological markers were not directly measured, these explanations should be interpreted as hypotheses rather than mechanisms directly supported by the present study. Conversely, runners who demonstrated a small response may have experienced a less effective dose from the same cycling protocol (Herold *et al.,* 2019). Thus, in the context of the present study, some participants may have experienced the 10-minute bout at 100 ± 2 rpm as a sufficient stimulus to facilitate carryover into running cadence and step timing, whereas for others the same protocol may not have provided an adequate individualized dose to elicit the same transfer effect. Individual differences in prior cycling experience or familiarity with maintaining a high cadence on the ergometer may also have contributed to the variability in responsiveness observed in the present study. Collectively, these findings suggest that HCC may be associated with cadence-driven changes in motor control and stride organization. However, the underlying neural or physiological mechanisms remain unknown and may vary between individuals.

From a practical perspective, the present findings suggest that a brief bout of HCC may be considered as a pre-run stimulus for healthy adults. Specifically, 10 minutes of cycling at 100 rpm was associated with faster 800 m performance, increased running velocity, higher cadence, and shorter step time. Therefore, coaches, runners, and practitioners may consider using HCC as part of a warm-up strategy before short or middle-distance running bouts. However, these recommendations should be interpreted cautiously as the present study did not compare with a non-cycling warm-up. In addition, the study did not determine whether the 100 rpm or 10 minutes represents the optimal cadence or duration. Future studies should examine different cadence targets, durations, and recovery periods between cycling and running to determine whether HCC can be a strong recommendation as a standardized pre-race or training strategy.

The results of this study should be considered with notable limitations. First, participants were instructed to perform each 800 m run at a self-selected maximal workout pace; however, effort was not directly controlled using physiological markers such as ventilatory threshold, blood lactate, or heart rate. Therefore, some of the improvement observed during the CR may reflect differences in pacing strategy, motivation, or readiness rather than the isolated effect of HCC. Second, this study used a fixed-order repeated-measures design, with the baseline Run always completed before CR. As a result, potential learning and familiarization effects cannot be ruled out. Although

participants improved time by 3.72% and cadence by 1.41% following HCC, an unknown portion of these improvements may have been influenced by repeated exposure to the 800 m run rather than the cycling protocol itself. Third, the absence of a non-cycling control condition limits the ability to determine whether the observed improvement was specific to HCC. In addition, participants' prior cycling experience was not assessed, which may have contributed to variability in the response to the HCC protocol. Future studies should include a randomized crossover design and quantify participant cycling experience to determine whether cycling familiarity moderates the acute effects of HCC, while reducing the potential influence of repeated exposure to the running task.

Additional limitations relate to measurement precision and generalizability. Lap times were measured manually with a handheld stopwatch, which may have introduced timing errors, particularly for lap-by-lap accuracy. Step length was not directly measured but was indirectly estimated from running velocity and cadence. As a result, conclusions regarding spatial adaptations following HCC should be considered preliminary and less definitive. Finally, the sample consisted primarily of young healthy adult runners and included a greater proportion of males than females, which may limit the generalizability of these findings. Given known sex differences in running biomechanics, sex may have influenced the observed performance and spatiotemporal outcomes. Future studies should include a larger sample size or sex-balanced samples to determine whether the acute effects of HCC differ between males and females.

## 5. Conclusion

This study found that a brief bout of HCC was associated with improved subsequent 800 m running performance in healthy adults and altered spatiotemporal parameters. The overall response was characterized by faster running time, increased running velocity, higher cadence, and shorter step time, with no change in step length or RPE. LTD indicated that runners were not uniform in their adaptation to this benefit, with participants adopting both cadence- and step-length-dominant strategies. These findings suggest that HCC may serve as an acute stimulus that enhances subsequent running performance. The present study provides preliminary support for HCC as a practical intervention in healthy adults. Future studies should examine whether repeated HCC exposure produces chronic adaptations in running performance, whether similar effects occur across different running distances and populations, and whether cadence-dominant and step-length-dominant runners differ in their responsiveness to longer interventions. Future studies should directly assess neural activation, muscle activity, and lower-extremity kinetics to clarify the mechanisms underlying the acute transfer effect from HCC to running.

## References

Anderson, L.M., Martin, J.F., Barton, C.J., Bonanno, D.R. (2022). What is the Effect of Changing Running Step Rate on Injury, Performance and Biomechanics? A Systematic Review and Meta-analysis. *Sports Medicine - Open*, 8(1), 112. [DOI] [PubMed]

Baudendistel, S.T., Schmitt, A.C., Stone, A.E., Raffegeau, T.E., Roper, J.A., Hass, C.J. (2021). Faster or Longer Steps: Maintaining Fast Walking in Older Adults at Risk for Mobility Disability. *Gait & Posture*, 89, 86–91. [DOI] [PubMed]

Bernard, T., Vercruyssen, F., Grego, F., Hausswirth, C., Lepers, R., Vallier, J.-M., Brisswalter, J. (2003). Effect of Cycling Cadence on Subsequent 3 km Running Performance in Well Trained Triathletes. *British Journal of Sports Medicine*, 37(2), 154–159. [DOI] [PubMed]

Bernard, T., Vercruyssen, F., Mazure, C., Gorce, P., Hausswirth, C., Brisswalter, J. (2006). Constant versus Variable-Intensity during Cycling: Effects on Subsequent Running Performance. *European Journal of Applied Physiology*, 99(2), 103–111. [DOI] [PubMed]

Chumanov, E.S., Wille, C.M., Michalski, M.P., Heiderscheit, B.C. (2012). Changes in muscle activation patterns when running step rate is increased. *Gait & Posture*, 36(2), 231–235. [DOI] [PubMed]

Cohen, J. (2013). Statistical Power Analysis for the Behavioral Sciences. *Routledge*. [DOI]

Dingenen, B., Staes, F., Vanelderen, R., Ceyssens, L., Malliaras, P., Barton, C.J., Deschamps, K. (2020). Subclassification of recreational runners with a running-related injury based on running kinematics evaluated with marker-based two-dimensional video analysis. *Physical Therapy in Sport*, 44, 99–106. [DOI] [PubMed]

Etxebarria, N., Anson, J.M., Pyne, D.B., Ferguson, R.A. (2014). High-intensity cycle interval training improves cycling and running performance in triathletes. *European Journal of Sport Science*, 14(6), 521–529. [DOI] [PubMed]

Faul, F., Erdfelder, E., Lang, A.-G., Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods*, 39(2), 175–191. [DOI] [PubMed]

Gottschall, J. S., Palmer, B.M. (2002). The acute effects of prior cycling cadence on running performance and kinematics. *Medicine & Science in Sports & Exercise*, 34(9), 1518–1522. [DOI] [PubMed]

Gottschall, J.S., Palmer, B.M. (2000). Acute Effects of Cycling on Running Step Length and Step Frequency. *The Journal of Strength and Conditioning Research,* 14(1), 97–101. [DOI]

Herold, F., Müller, P., Gronwald, T., Müller, N.G. (2019). Dose–Response Matters! – A Perspective on the Exercise Prescription in Exercise–Cognition Research. *Frontiers in Psychology*, 10, 2338. [DOI] [PubMed]

Holmes, J.C., Pruitt, A.L., Whalen, N.J. (1994). Lower extremity overuse in bicycling. *Clinics in Sports Medicine*, 13(1), 187–205. [PubMed]

Keating, C.J., Hester, R.J., Thorsen, T.A. (2025). High cadence cycling not high work rate, increases gait velocity post-exercise. *Sports Biomechanics*, 24(6), 1645–1659. [DOI] [PubMed]

Lama, N., Keating, C.J., Donahue, P.T., Oliveira, N., Thorsen, T.A. (2024). Minimum Normalized Cycling Cadence to Increase Post-Cycling Gait Velocity. *Journal of Functional Morphology and Kinesiology*, 9(4), 235. [DOI]

Middleton, A., Fritz, S.L., Lusardi, M. (2015). Walking Speed: The Functional Vital Sign. *Journal of Aging and Physical Activity*, 23(2), 314–322. [DOI] [PubMed]

Price, F.G., Smith, J.W., Turner, A.J., Krings, B.M., Waldman, H.S., Chander, H., Knight, A.C., McAllister, M.J. (2020). High-Intensity Interval Training in Middle-Distance NCAA Division I 800/1500m Collegiate Athletes. *International Journal of Kinesiology and Sports Science*, 8(3), 28. [DOI]

Suriano, R., Bishop, D. (2010). Combined cycle and run performance is maximised when the cycle is completed at the highest sustainable intensity. *European Journal of Applied Physiology*, 110(4), 753–760. [DOI] [PubMed]

Thorsen, T., Strohacker, K., Weinhandl, J.T., Zhang, S. (2020). Increased Q-Factor increases frontal-plane knee joint loading in stationary cycling. *Journal of Sport and Health Science*, 9(3), 258–264. [DOI] [PubMed]

Thorsen, T.A., Hester, R.J., Keating, C.J. (2024). Changes in Lower-Extremity Gait Biomechanics Following High-Cadence Cycling. *Sports*, 12(6), 159. [DOI] [PubMed]

VanSwearingen, J.M., Perera, S., Brach, J.S., Wert, D., Studenski, S.A. (2011). Impact of Exercise to Improve Gait Efficiency on Activity and Participation in Older Adults with Mobility Limitations: A Randomized Controlled Trial. *Physical Therapy*, 91(12), 1740–1751. [DOI]

Warburton, D.E.R., Jamnik, V.K., Bredin, S.S.D., Gledhill, N. (2011). The Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) and Electronic Physical Activity Readiness Medical Examination (ePARmed-X+). *The Health & Fitness Journal of Canada*, 4(2), 3-17. [DOI]

## Author's contribution

Matthew Ott: Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft. Jason Simpson: Writing - review & editing. Nuno Oliveria: Methodology, Writing - review & editing. Paul Donahue: Methodology, Writing - review & editing. Tanner A. Thorsen: Conceptualization, Writing - review & editing, Supervision. All authors have read and agreed to the published version of the manuscript.

## Ethics Approval Statement

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of The University of Southern Mississippi (#25-0505).

## Funding

This study received no external funding.

## Does this article pass screening for similarity?

Yes