The effects of music tempo on cycling performance

R. Appell, K. Carnes, S. Haase, C. Haia, E. Smith, K. Smith, and J. Walsh

Department of Exercise Science, Gonzaga University, Spokane, WA 99258.

Address correspondence to: Department of Exercise Science
Gonzaga University
Spokane, WA 99258-0004
(509) 323-3877
ABSTRACT

Purpose: To determine the influence of music tempo on sub-maximal cycling physiological and performance variables including oxygen consumption (\(\dot{V}O_2\)), ventilation (\(\dot{V}E\)), heart rate (HR), respiratory rate (RR), respiratory exchange ratio (RER), and cycling cadence and efficiency.

Methods: Subjects were 11 active college students, 5 male and 6 female (mean age = 20.4 ± 1.6 yrs). An initial incremental work test on a cycle ergometer was used to determine a work rate (WR) that elicited 50 % of each subjects’ heart rate reserve (HRR). On a subsequent day, subjects performed 20 min of sub-maximal steady-state exercise at this WR. Subjects pedaled at a freely-chosen rate (they were not required to maintain a constant cycling cadence). The test consisted of three, 5 min conditions in which either fast-tempo music (110 min\(^{-1}\)), slow-tempo music (60 min\(^{-1}\)), or no music (control) was played. Music was played in the lab at all times except during the control condition. Gas exchange variables were measured using standard open-circuit techniques. HR was measured using either a Polar HR monitor or a 3-lead ECG. HR and cycling cadence were recorded at regular intervals. Cycling cadence, \(\dot{V}O_2\), and RER were used to calculate cycling efficiency. Results: Mean RR was significantly higher during the slow-tempo music condition (30.78 ± 5.69 min\(^{-1}\)) than during the control (28.81 ± 5.50 min\(^{-1}\), \(P = 0.03\)). Mean RER was significantly higher during the fast-tempo music condition (0.99 ± 0.03) than the control (0.97 ± 0.03, \(P = 0.02\)). Conclusions: Music tempo had no significant affect on physiological and performance variables related to cycle ergometry. Differences observed in RR and RER were not large enough to be of any physiological significance.
INTRODUCTION

The interest in musical rhythm as a stimulus for the promotion of “natural movement” has been a topic of interest for the past century (9). In recent years, the use of music as a motivational device during physical activity has increased dramatically. Consequently, research on the effects of music on physical performance has grown substantially. In 2007, the USA Track and Field banned the use of headphones and portable audio devices during official races for safety reasons, but more importantly to prevent a possible performance advantage. Literature suggests three ways in which music could potentially increase exercise performance, 1) distracts sensations of fatigue, 2) increases level of arousal, and 3) stimulates motor coordination and/or synchronization (8).

Recent research has determined musical tempo synchronized with exercise tempo as a critical factor in maximizing the benefits of music during exercise (2, 4, 6, 7, 10, 12, 13). However, during these studies, participants were aware that music was being used as an active motivational tool and they were encouraged to change their work rate (WR) in accordance to the changes in music tempo. For example, Atkinson et al. (2004) determined that tempo and rhythm were more motivating than harmony and melody for male participants during 10 km cycling tests, and high-tempo (142 min⁻¹) music-induced exercise decreased participants’ 10 km time and increased their rating of perceived exertion (RPE), heart rate (HR), and cycling speed. Szabo and Hoban (2004) also determined that fast-tempo arousing music enhanced the quality of training while slow-tempo music impaired the quality of training. No previous studies, however, have examined the passive effects of music tempo on cycling performance in which individuals are blinded to the use of music as a treatment.
Music has also been shown to elicit changes in breath length (Etzel et al., 2006), respiration depth, and heart rate (HR; Blood & Zatorre, 2001) during rest due to its emotionally evocative quality. However, the effects of music tempo on physiological and performance variables during sub-maximal steady-state exercise have not been examined. Thus, the purpose of this study was to determine the passive influence of music tempo on sub-maximal cycling physiological and performance variables including oxygen consumption ($\dot{V}O_2$), ventilation ($\dot{V}E$), heart rate (HR), respiratory rate (RR), respiratory exchange ratio (RER), and cycling cadence and efficiency. We hypothesized that 1) music tempo will have no effect on HR and RR, 2) fast-tempo music will improve cycling efficiency and increase cycling cadence, and 3) slow-tempo music will have the opposite effect of fast-tempo music.

**METHODS**

*Subjects*

The subjects were 11 Gonzaga University students, 5 male and 6 female, aged 18 to 22 yrs. All subjects classified themselves as active according to the American College of Sports Medicine guidelines (participated in moderate intensity exercise, 3-5 sessions per week, $\geq$ 30 min per session). Prior to testing, the research was approved by the Internal Review Board at Gonzaga University, and all subjects completed a Physical Activity Readiness Questionnaire (PAR-Q) and informed consent to participate in the study. One male subject chose to terminate testing and was therefore excluded from the study.

*Protocol*

Pre-test stature (cm), body mass (kg), and resting heart rate (RHR, min$^{-1}$) were measured using a Detecto scale, stadiometer, and Polar HR monitor, respectively. Each subject performed two separate cycling tests with 2 to 3 weeks between tests. Music was played in the lab at all
times except during the control condition. The first test consisted of an incremental work test on the cycle ergometer. The WR (W) began at 30 W for females and 50 W for males, and was increased every 5 min until the subjects’ HR (min⁻¹) reached 50 % of his or her calculated HR reserve (HRR, min⁻¹; using the Karvonen method). Each subject cycled between 15 and 25 min, maintaining a cycling cadence of 60 min⁻¹. HR was recorded at the end of each 5 min increment. The test was terminated when the subjects reached approximately 45 % or higher of their calculated HRR. A regression analysis was used to determine the WR necessary to elicit a steady-state HR of 50 % of each subject’s HRR.

The second test consisted of 20 min of sub-maximal, steady-state exercise on a cycle ergometer at the WR corresponding to 50 % of the subjects’ HRR. Subjects pedaled at a freely-chosen pedaling rate and they were not required to maintain a constant cycling cadence (min⁻¹). The test was preceded by 5 min of seated rest and a 5 min warm-up phase, which allowed the subject to reach steady-state at his or her appropriate WR. The test consisted of three, 5 min treatment conditions including no music (control), fast music (tempo = 110 min⁻¹), and slow music (tempo = 60 min⁻¹). Music tempo was determined using a metronome. All treatment music consisted of popular rock music and was played at a moderate volume on portable computer speakers approximately 3 m away from the subject. The treatment order was counterbalanced and then randomly assigned to each subject.

Metabolic variables including oxygen consumption (\( VO_2 \), L·min⁻¹), ventilation (\( V_E \), L·min⁻¹), respiratory rate (RR, min⁻¹), and respiratory exchange ratio (RER) were measured at 30 s averages using a SensorMedics Vmax 229L metabolic cart. A 3-lead ECG was used to record HR for the first 5 subjects, however for the remaining 6 subjects, HR was recorded at 30 s intervals using a Polar HR monitor. Additionally, cycling cadence was recorded at 15 s intervals
during the test. Cycling cadence, $\dot{V}_O_2$, and RER were used to calculate cycling efficiency during the treatment and control conditions.

Statistical Analysis

Statistical analysis was performed using SPSS Version 11.0 (SPSS, Inc., Chicago, IL). A multivariate analysis of variance (MANOVA) with repeated measures, followed by a post hoc Tukey HSD analysis, was used to compare differences in physiological and performance variables between the 3 testing conditions. The significance level was set a priori at $P < 0.05$.

RESULTS

Subject characteristics are presented in Table 1. Physiological and performance data for the 3 testing conditions are presented in Table 2. These data indicated that mean RR was significantly higher during slow-tempo music than during the control ($P = 0.03$), while mean RER was significantly higher during the fast-tempo music than during the control ($P = 0.02$).
Table 1. Subject characteristics

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Age (yr)</th>
<th>Weight (kg)</th>
<th>Height (cm)</th>
<th>RHR (min⁻¹)</th>
<th>WR (W)</th>
</tr>
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<tbody>
<tr>
<td>All subjects</td>
<td>11</td>
<td>20.4</td>
<td>72.9</td>
<td>171.5</td>
<td>76.0</td>
<td>127.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.6)</td>
<td>(27.5)</td>
<td>(4.5)</td>
<td>(11.0)</td>
<td>(33.5)</td>
</tr>
<tr>
<td>Females</td>
<td>6</td>
<td>20.2</td>
<td>63.1</td>
<td>168.6</td>
<td>74.8</td>
<td>101.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.5)</td>
<td>(8.3)</td>
<td>(3.8)</td>
<td>(13.6)</td>
<td>(17.1)</td>
</tr>
<tr>
<td>Males</td>
<td>5</td>
<td>20.6</td>
<td>84.5</td>
<td>174.9</td>
<td>77.4</td>
<td>158.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.8)</td>
<td>(38.6)</td>
<td>(2.6)</td>
<td>(8.1)</td>
<td>(14.9)</td>
</tr>
</tbody>
</table>

Values are means with SDs in parentheses.

Table 2. Physiological and performance data for steady-state cycle ergometer exercise in a control and 2 music conditions.

<table>
<thead>
<tr>
<th></th>
<th>$\dot{V}O_2$ (L·min⁻¹)</th>
<th>$\dot{V}E$ (L·min⁻¹)</th>
<th>HR (min⁻¹)</th>
<th>RR (min⁻¹)</th>
<th>RER</th>
<th>Cycling cadence (min⁻¹)</th>
<th>Cycling Efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No music (control)</td>
<td>1.67</td>
<td>38.45</td>
<td>143.54</td>
<td>28.81</td>
<td>0.97</td>
<td>75.52</td>
<td>22.00</td>
</tr>
<tr>
<td></td>
<td>(0.43)</td>
<td>(6.50)</td>
<td>(7.32)</td>
<td>(5.50)</td>
<td>(0.03)</td>
<td>(15.43)</td>
<td>(1.89)</td>
</tr>
<tr>
<td>Slow music (60 min⁻¹)</td>
<td>1.66</td>
<td>39.81</td>
<td>144.70</td>
<td>30.78†</td>
<td>0.98</td>
<td>75.99</td>
<td>22.12</td>
</tr>
<tr>
<td></td>
<td>(0.42)</td>
<td>(7.90)</td>
<td>(5.49)</td>
<td>(5.69)</td>
<td>(0.03)</td>
<td>(14.41)</td>
<td>(1.71)</td>
</tr>
<tr>
<td>Fast music (110 min⁻¹)</td>
<td>1.69</td>
<td>39.96</td>
<td>143.2</td>
<td>30.45†</td>
<td>0.99</td>
<td>77.62</td>
<td>21.88</td>
</tr>
<tr>
<td></td>
<td>(0.44)</td>
<td>(7.77)</td>
<td>(4.07)</td>
<td>(5.58)</td>
<td>(0.03)</td>
<td>(15.54)</td>
<td>(1.78)</td>
</tr>
</tbody>
</table>

Values are means with SDs in parentheses.
† = Variable was significantly different than control ($P < 0.05$)
DISCUSSION

The hypotheses for this study were 1) music tempo has no effect on HR and RR, 2) fast-tempo music improves cycling efficiency and increases cycling cadence, and 3) slow-tempo music has the opposite effect of fast music. However, our results suggest that music tempo does not have an influence on physiological ($\dot{V}O_2$, $V^E$, HR, RR, RER) and performance variables (cycling cadence and efficiency) during sub-maximal steady-state cycling exercise. This finding is congruent with previous research which has shown that music may act as a distracter during exercise, altering the perception to fatigue, or it may motivate an individual to work harder (8).

Our findings, however, are inconsistent with previous studies that have examined the effects of music on physiological variables. For example, music was shown to engender significant changes in breath length (5), respiration depth, and heart rate (3) due to its emotionally evocative quality. Etzel et al. (2006) suggested that changes in respiration may be influenced by the different tempos of different songs. Although our results indicated statistically significant differences in mean RR between slow-tempo ($30.78 \pm 5.69 \text{ min}^{-1}$) and control ($28.81 \pm 5.50 \text{ min}^{-1}$, $P = 0.03$) conditions, and in mean RER between fast-tempo ($0.99 \pm 0.03$) and control ($0.97 \pm 0.03$, $P = 0.02$) conditions, these differences were too small ($3 \text{ min}^{-1}$ and 0.03, respectively) to be of practical and physiological significance. Furthermore, Etzel et al. (2006) examined the immediate physiological response to music at rest. In our study, this response may have been altered or perhaps masked by the much greater physiological changes accompanying exercise.

Our results are also inconsistent with previous studies that have investigated the effects of music tempo on cycling performance. For example, Atkinson et al. (2004) found that cycling speed and mean HR increased while listening to fast-tempo ($142 \text{ min}^{-1}$) “Trance” music during a
sub-maximal exercise bout. Although these findings run counter to our study, they may reflect differences in tempo of music used and the duration of music exposure. In Atkinson et al. (2004), higher tempo (142 min\(^{-1}\)) music was played throughout the entire test and researchers found significant increases in speed during the first 3 km of a 10 km cycling test. However, in our study subjects were exposed to lower-tempo (60 min\(^{-1}\) or 110 min\(^{-1}\) music for 5 min intervals, the work rate was held constant, and no significant differences in HR or cycling cadence were identified. These differences in protocol may have accounted for the smaller variations in cycling cadence identified in our study. Thus, both studies support the conclusion that the performance response to sub-maximal exercise is determined by an individual’s WR, not directly by music tempo.

Based on our results, music has no passive or subconscious influence on cycling cadence or RR. However, an individual may actively and consciously alter cycling cadence and RR in response to musical stimuli during exercise, as seen in Atkinson et al. (2004). This could subsequently alter other variables such as cycling efficiency, and RER. Additionally, in concordance with other research in the area (1, 6, 8, 10), this study supports the notion that any effect experienced by an individual due to music is psychological in nature, rather than music acting to boost the physiological response.

The strengths of this study include its single-blind design, which allowed for conclusions about the passive effects of music tempo during exercise. Also, this study included both control and music treatment conditions during a single session, allowing for a dynamic investigation of the effects of music tempo on the physiological and performance responses to cycle ergometry. Also, the low variability in all measures indicated a considerable consistency and successful
reproduction of testing conditions across subjects. This allowed for a small error and substantial validity in our statistical analysis, despite the small sample size.

A weakness in this study was the manner in which the music was presented to the subjects. Unfortunately, we were unable to apply the music in a more direct fashion due to the single-blind design, which possibly allowed for other stimuli to have a distracting influence. Thus, future studies should investigate freely-chosen music applied directly to the subject’s ears. Moreover, a study combining a dictated cycling cadence with no music followed by a freely-chosen cadence with music would examine a possible relationship between music tempo and cycling cadence.

In conclusion, music tempo has no significant effect on physiological (\(\dot{V}O_2\), \(\dot{V}E\), HR, RR, RER) and performance variables (cycling cadence and efficiency) during sub-maximal steady-state cycling exercise. Furthermore, significant findings in this study were not large enough to be considered physiologically relevant, thus music has no passive effect on sub-maximal cycle ergometry.
REFERENCES


