Effect of Music Genre on Power Output during a Wingate test

A project completed in partial fulfillment of the requirements for the Honors Program

by

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Abstract

There has been substantial evidence on the effects of music during moderate intensity exercise, however less attention has been given to the effects of music on performance during supra-maximal exercise. **PURPOSE:** To compare the effects of musical genre on power output during supra-maximal exercise testing. **METHODS:** Three genres of music (rock, dance and rap) all of similar tempo (120-155 beats per minute) were played during a supra-maximal exercise test (Wingate test). The Wingate test consisted of pedaling on a cycle ergometer as fast as possible for 30 seconds at a resistance determined from body mass. Peak anaerobic power (Pk-AnP), Fatigue Index (FI), and Rate of Perceived Exertion (RPE) were determined during the Wingate test. All genres were compared to a no music (CON) condition. **RESULTS:** A repeated measures analysis of variance (repeated-measures ANOVA) was performed to determine differences between music genres on power output. There was a difference between CON and each genre, but no differences in peak anaerobic power were seen between genres. **CONCLUSION:** Wingate peak anaerobic performance appears to be influenced more by the presence of music rather than the genre.

**KEYWORDS:** peak anaerobic power, music, genre, power output
Introduction

Music has been around for centuries and research has focused on the relationship between music and individuals in multiple settings, whether that is within a work environment (Laird, 1927) or during athletic performance (Jarraya et al, 2012). Brownley et al, (1995) demonstrated how variations in auditory stimulus intensity, tone, and tempo evoke dynamic psychological and physiological responses within individuals. Karageorghis et al, (1999) confirmed that highly motivational music is associated with an optimal psychological state between the athlete and the skills required to perform the exercise test as well as the motivations to perform at their maximum capability. Other benefits have been recognized, ranging from how music can alter attention from focusing on increasing work load, thus delaying the perception of fatigue (Nethery, 2002), to optimizing arousal and psychological states (Hall & Erickson, 1995; Terry & Karageorghis, 2011), to encouraging rhythmic movement (Karageorghis et al, 2009).

Not only does music have an effect on the psychological responses of the individual performing exercise, but there are physiological responses that affect exercise performance while incorporating music (Yamashita et al, 2006). Variations in heart rate are mediated by the autonomic nervous system, comprising of the parasympathetic and sympathetic nervous system. While at rest, the parasympathetic nervous system actively suppresses heart rate until a stimulus, such as exercise, stimulates the sympathetic nervous system to increase heart rate. This increase in sympathetic activation coincides with the removal of the parasympathetic activity. Likewise, the autonomic nervous system sends signal responses from the brain to the body in response to a music stimulus, which will ultimately cause a physiological response. Increasing the intensity of exercise leads to an increase in the activity of the sympathetic nervous system, therefore, causing an increase in heart rate (Yamashita et al, 2006).
Recognizing that music can produce both psychological and physiological benefits while performing exercise, has led to numerous studies focusing on the use of music during a variety of settings and whether music has a positive or negative effect on performance (Laird, 1927; Brownley et al, 1995; Atkinson et al, 2004; Birnbaum et al, 2009; Gfeller, 1988). Most studies have been performed within the moderate intensity domain, such as running on a graded treadmill (Brownley et al, 1995, Birnbaum et al, 2009) or cycling on a cycle ergometer (Atkinson et al, 2004) at various music tempos while measuring heart rate and rate of perceived exertion (RPE). A study conducted by Bernardi (2005) examined the effect of heart rate, blood pressure, and breathing rate prior to and during listening to short pieces of music with various tempos. The results showed that music with high tempo increased heart rate and breathing rate compared to other tempos and concluded that high tempo music affected athletic performance at maximum levels. This is due to the increasing blood flow and cardiac output, thus ultimately causing an increased amount of oxygen to be delivered to skeletal muscles. This supports the positive relationship between music and duration of exercise. Similarly, Karageorghis et al, (2006) acknowledged that selected music has to relate to the type of exercise and exercise intensity in order to produce a substantial effect on performance.

Although substantial data has been obtained during moderate intensity exercise, there is little evidence that compares the effects of music during supra-maximal, anaerobic exercises. Equally, there is little data on the effects of differing music genres within the same tempo on supra-maximal exercise. Therefore, the purpose of this study is to test anaerobic performance during a Wingate test with and without the presence of high tempo music in order to determine if there is a relationship between high intensity anaerobic exercise and music genre. We hypothesize that the presence of music will increase peak anaerobic power and that a particular
genre will increase peak anaerobic power compared to no music.

Methods

Subjects- Thirteen healthy volunteers (6 females, 7 males) participated in this study. All subjects were between the ages of 20-23 years of age and had no reported preference level to the genres included. Volunteers reported to Battelle Hall at Ohio Dominican University in Columbus, Ohio. They were informed of all risks and benefits involved. The exercise protocol was approved by the Ohio Dominican Institutional Review Board.

Instrumentation and Music- An electronically-braked Monark (model 939E) cycle ergometer was used to perform the anaerobic test. A Monark anaerobic test computer software program (Monark 939E Analysis Software) was used to record the Wingate and the subject’s progression based on their body mass, which was converted from kilograms (kg) to force (N) using a standard formula provided by the American College of Sports Medicine: Guidelines for Exercise Testing and Prescription, which is provided below. Music was chosen by examining three genres of music (rock, dance, rap). All songs were of high tempo between 120-155 beats per minute (bpm) and was determined by a website called jog.fm. Each genre had two songs that were played during warm up and the anaerobic test. During the experimental tests, music was played on a standard device (iPhone 5) with the use of headphones to ensure there were no distractions while conducting the exercise test. Dance songs were Scooter- Mesmerized (144bpm) and Scooter- Pulstar (138bpm). Rap songs were Outkast- B.O.B (154bpm) and Eminem- Rap God (148bpm). Rock songs were Disturbed- Guarded (137bpm) and Metallica- To Whom the Bell Tolls (124bpm).
Experimental Protocol- Each subject was shown the cycle ergometer and explained the Wingate exercise protocol, excluding the category of genres being used in the study.

Measurements of height (cm) and body mass (kg) were taken, as weight would be converted to force in Newtons for the purpose of the test. Based on the ACSM Guidelines for Exercise Testing and Prescription, the standard conversion formula was calculated based on body mass (BM) in kilograms $\times 9.80665 = \text{BM(N)} \rightarrow \text{BM(N)} \times 0.086 \text{ (female)}$ and $\text{BM(N)} \times 0.90 \text{ (male)} = \text{Force (N)}$. Prior to beginning the test, each subject had a three minute relaxation period to ensure heart rate was at resting level, followed by measuring heart rate and thus beginning the 6.5 minute exercise period (3 minute warm up, 30 second Wingate, 3 minute cool down). There were four trials in this experiment; control, genre 1 (dance), genre 2 (rock) and genre 3 (rap), each performed on different days. Each trial was at least one week apart to minimize the learning effect. The no music condition protocol comprised of each subject warming up by pedaling between 60-70rpm on the cycle ergometer at a low resistance (0.5-1.0kp), followed by the Wingate test which involved pedaling as fast as possible for 30 seconds at a resistance determined from body mass. Heart rate was measured before the Wingate started, after the Wingate and twice during the cool-down phase. Rate of perceived exertion (RPE) was also measured after the Wingate based on the Borg Scale (6-20). For the three music trials, each subject listened to music for 1 minute before the warm up began and continued to listen until the test was completed (after cool down). Subjects performed the same exercise protocol as described above. Again, heart rate was measured throughout the test. After the data was collected, Fatigue Index was calculated in percentage based on the standard formula provided by the *ACSM Guidelines for Exercise Testing and Prescription* $(\text{Fatigue} = (\text{Pk-AnP}) - (\text{lowest AnP})/\text{Pk-AnP} \times 100)$.
Music Genre and Power Output

Questionnaire- Following the fourth, and final, anaerobic test, each subject was provided with a questionnaire that was comprised of three questions. The questions, provided in Table 3, were used to assess whether the subjects believed there was an effect in their performance with the use of music and if one genre caused a greater effect than the others used.

Statistics- Peak anaerobic power and fatigue index were analyzed using a repeated-measures ANOVA design. Student-Neuman-Keuls post hoc analysis was performed when appropriate to determine significant F-ratios. F-ratios were considered statistically significant when \( p<0.05 \).

Results

Based on the repeated-measures ANOVA, there was a difference in peak anaerobic power when comparing CON and music genres. When determining if there was a difference in peak anaerobic power between the musical genres, there were no significant differences. All tables and figures are illustrated in the Appendix. Table 1 shows the anthropometrics of the 13 subjects. Age was represented in years, height in centimeters and body mass in kilograms. Force was based on ACSM standard equation which was described above (body mass (BM) in kilograms * 9.80665 = BM(N) \rightarrow BM(N) * 0.086 \text{ (female)} \text{ and } BM(N) * 0.90 \text{ (male)} = \text{ Force (N)}).

Table 2 demonstrates the mean values of Pk-AnP in watts, Fatigue Index in percentage and Rate of Perceived Exertion based on the Borg Scale 6-20. There was a significant difference (\( p<0.05 \)) in peak anaerobic power output when comparing the CON to music, as illustrated in Table 2. There were no differences in any other variables measured (FI and RPE) and no
differences when comparing the musical genres for any measured variables (FI, Pk-AnP, and RPE).

Figure 1 displays the mean peak anaerobic power represented in watts from the 4 exercise protocols. As shown, there is a significant difference illustrated between the CON and music, as indicated with the use of asterisks (*). When analyzing the three music protocols, it is apparent that there are no significant differences between the genres (dance, rock, rap), as each are relatively close to one another.

Table 3 illustrates the answers provided by the questionnaire. According to the answers, a majority of the subjects indicated that the presence of music had an effect on their exercise performance, which can be supported by the data showing that music increases peak anaerobic power. Although subjects indicated that a particular genre had a greater effect on their performance, this was not supported by the data, which indicate no difference in peak anaerobic power between genres.

**Discussion**

The present study investigated the effects of different musical genres on peak anaerobic power during the Wingate test. Our results showed there was a difference between no music (CON) and music when comparing peak anaerobic power, but there were no discernible differences between any of genres for any of the variables measured (RPE, FI and Pk-AnP).

The results could be due to the possibility that music genre does not have an effect on exercise ability for this specific intensity due to the short amount of time performing the exercise (i.e., 30 seconds). It appears that simply listening to music with a tempo between 120-155bpm is sufficient to improve peak anaerobic power. Similarly, Jarraya *et al.* (2012) demonstrated that
heart rate, RPE, and fatigue index were not significantly affected between the two conditions (music and no music) while performing a Wingate test, despite a significant increase in power output, all of which is supported by the present study. Pujol (1999) conducted a supra-maximal power output test and concluded that there were no significant differences between music and non-music conditions by any measures. These inconsistent results invite further investigation to better understand the effects music has, or does not have, on supra-maximal exercise.

Upon completion of the testing protocol, each subject was given a questionnaire to complete to provide an understanding of perception on whether musical genre had an effect on his or her ability to perform the supra-maximal exercise. Questions consisted of whether they believe music has an effect on their performance ability as well as if there was a genre that had the greatest effect. Most of the subjects identified a particular genre that they believed had the greatest influence on their ability to perform. In fact, the majority of the subjects stated music, in general, distracted them from the task at hand, giving greater motivation to complete the given exercise protocol. This is supported by Gfeller (1988), who demonstrated that subjects felt that music improved mental attitude toward exercise with 97% of the subjects indicating that music made a difference in their performance. Also, 79% of the subjects indicated that music aided in pacing, strength, and overall endurance, thus supporting the psychological benefits of listening to music while exercising.

This present study also adds to the increasing body of literature discerning the relationship between music and exercise, illustrating that there is a positive effect of motivational music on exercise performance (Karageorghis et al., 1999; Karageorghis et al., 2006). This claim is supported by the present study that shows that there is an increase in peak power output between no music and music, although there were no differences when comparing the musical
genres. Given past research, music is a useful method when used during exercise performance as it provides both psychological and physiological benefits (Yamashita et al, 2006; Gfeller, 1988; Nethery, 2002; Hall & Erickson, 1995; Karageorghis et al, 2009; Terry & Karageorghis. 2011). Psychologically, subjects in this study believed the presence of music influenced their ability to perform, which can be supported by there being a difference between CON and music. Although peak anaerobic power was influenced by the presence of music, this cannot be supported when comparing the musical genres. In conclusion, musical genres have no effect on short term anaerobic performance.

References


Hall, K.G., & Erickson, B. (1995). The effects of preparatory arousal on sixty-meter dash


Table 1. Average anthropometrics of each subject (mean ± SD).

<table>
<thead>
<tr>
<th>Gender (#)</th>
<th>Age (yrs)</th>
<th>Height (cm)</th>
<th>Body Mass (kg)</th>
<th>Force (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male (7)</td>
<td>22.3 ± 0.8</td>
<td>182.9 ± 5.8</td>
<td>83.1 ± 8.4</td>
<td>68.6 ± 2.4</td>
</tr>
<tr>
<td>Female (6)</td>
<td>22.0 ± 1.2</td>
<td>163.8 ± 7.14</td>
<td>60.8 ± 6.12</td>
<td>51.2 ± 5.0</td>
</tr>
</tbody>
</table>

Age represented in year; Height represented in centimeters; body mass in kilograms and force calculated Newtons provided by the standard formula by the *ACSM Exercise Testing and Prescription* (body mass(BM) in kilograms * 9.80665 = BM(N) → BM(N) * 0.086 (female) BM(N) * 0.90 (male) = Force (N)).
Table 2. Performance during Wingate Test illustrating Peak anaerobic power (Pk-AnP), Fatigue Index (FI) and Rate of Perceived Exertion (RPE). All data reported as mean ± SD. * Indicates significantly different from control (p < 0.05).

<table>
<thead>
<tr>
<th></th>
<th>Control</th>
<th>Dance</th>
<th>Rock</th>
<th>Rap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pk-AnP(W)</td>
<td>822.2 ± 236.6</td>
<td>942.6 ± 240.6*</td>
<td>964.4 ± 266.4*</td>
<td>940.4 ± 197.5*</td>
</tr>
<tr>
<td>Fatigue Index (%)</td>
<td>59.2 ± 12.3</td>
<td>60.1 ± 8.7</td>
<td>65.9 ± 6.5</td>
<td>60.5 ± 9.7</td>
</tr>
<tr>
<td>RPE (#)</td>
<td>15.4 ± 2.1</td>
<td>14.1 ± 2.6</td>
<td>13.8 ± 2.8</td>
<td>13.8 ± 2.7</td>
</tr>
</tbody>
</table>

Peak anaerobic power calculated in Watts by Force (N) * (maximal revolution for 5 seconds * 6 meters) / 5 seconds

Fatigue Index calculated in Percentage by (Pk-AnP) – (lowest AnP)/ Pk-AnP * 100

Rate of Perceived Exertion determined using Borg Scale 6-20
Table 3. Questionnaire answers.

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Do you believe listening to music had any effect on your performance during the Wingate test?</strong></td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td><strong>Did a particular genre have a greater effect on your ability to perform the Wingate test?</strong></td>
<td>12</td>
<td>1</td>
</tr>
<tr>
<td><strong>Do you prefer to listen to music when you exercise?</strong></td>
<td>13</td>
<td>0</td>
</tr>
</tbody>
</table>

Tallied answered provided by the subjects after completing the questionnaires.
Figure 1. Mean Peak anaerobic power during 4 exercise protocols

Peak anaerobic power calculated in watts (W) during control (no music) and three genres.

* Indicates significantly different from control.