

UNIVERSITY OF WISCONSIN-LA CROSSE

Graduate Studies

THE EFFECTS OF SPONTANEOUS MUSIC TEMPO ON RUNNING
PERFORMANCE

A Manuscript Style Thesis Submitted in Partial Fulfillment of the Requirements for the
Degree of Clinical Exercise Physiology

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College of Science and Health
Clinical Exercise Physiology

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THE EFFECTS OF SPONTANEOUS MUSIC TEMPO ON
RUNNING PERFORMANCE

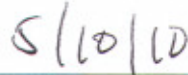
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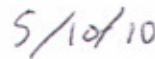
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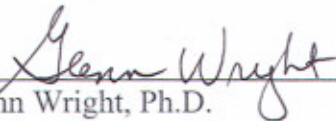
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ABSTRACT

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Exercise intensity has been shown to increase with the use of music. **Objective:** To determine if spontaneous music tempo affected running performance (eg. velocity, heart rate, ratings perceived exertion-RPE, and VO_2). **Methods:** Fifteen apparently healthy college aged subjects ran two, 31 minute experimental runs on an indoor 200 meter track. The subjects listened to a 31 minute playlist created by the investigator for one of the runs, and 31 minutes of no tempo music for the other run. The playlist consisted of two songs having no-tempo (0 bpm), two songs with slow tempo (<100 bpm), two songs with moderate tempo (100-129 bpm), and two songs with fast tempo (>130 bpm). The order of the runs was randomized. Oxygen consumption (VO_2) was integrated every 30 seconds. Velocity was calculated by manually timing 100 meter split times. HR and RPE were recorded at the end of each of the songs. **Results:** There was a significant increase in running velocity when faster tempo songs were being played. There was no significant difference found in HR, VO_2 , or RPE in relationship to the tempo being played. However, practical significance was noted as there was not an increase in RPE with the increase in velocity. **Conclusions:** Music can be used while running to increase the intensity or velocity of the run. However, the effects of music on running performance are not as distinct as cycling due to mechanical constraints of running. Due to the mechanical constraints of running, it is thought that music increases running intensity through general arousal to the beat or tempo.

ACKNOWLEDGEMENTS

I would like to first thank the University of Wisconsin-La Crosse RSEL grant for the help funding my research. Next, I would like to thank my advisor Carl Foster for all of his help during this study. I would also like to thank Chris Dodge for teaching me how to use the portable gas analyzer and for helping me whenever a problem arose with it. I would like to thank my committee members for supporting me. I would like to thank my family, especially my fiancé Alex for all of his support and for being so understanding after my long (what seemed like endless) days collecting data. Finally, I would like to thank all of my very dedicated subjects for all of their hard work. Without them, this study would not have been possible.

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INTRODUCTION

The use of music during exercise has become increasingly popular due to advancing technology which has made music much more convenient and accessible (7). Music has been shown to have several different physiological effects on an individual while exercising (5,6). These different effects include changes in: rating of perceived exertion (RPE), heart rate, and total work output (2,5,9,10,11).

RPE is a subjective tool used to measure and evaluate work output. However, the effect of music on a subject's RPE during exercise remains inconclusive. Zilonka et al found that RPE remained unchanged between trials of music use and non-music use, although the subjects reported that walking was more enjoyable when they were listening to music (12). Lim et al (6) found RPE was lower at matched workloads when subjects listened to music, as did Prieboy (7). Johnson found that RPE was highest in subjects while cycling when they were listening to fast music tempos, and lowest when the subjects were not listening to music, but given that power output follows music tempo, a higher RPE was to be expected (4).

Heart rate is another method used to evaluate exercise intensity. Several studies have evaluated whether music has an effect on heart rate, but again the data remain inconclusive (1,8,9,12). Schwartzmiller found faster music tempos elicited significantly higher heart rates, but as a consequence of higher power output (9). Copeland and Franks found a lower heart rate at matched workloads while exercising when listening to soft,

slow music (1). Other studies have found that music did not have an effect on heart rate with increased music tempo (8,12).

Music has been shown to increase power output for individuals while they exercise, making it very advantageous for individuals who may be training for an event (2,3,4,9). This can also benefit individuals who are trying to improve or maintain their general health. Work output for running is determined by the speed, percent grade and total distance an individual runs.

Many previous studies were done using the cycle, where work output can be measured in watts and revolutions per minute (RPM). Schwartzmiller found a significant difference in watts and RPM when subjects listened to medium or fast tempo music as opposed to slow or no tempo music (9). Johnson also found that power output was linked to musical tempo, apparently independently of musical genre (4).

Running differs from cycling in several important ways, the most important being that there is a fixed minimal absolute intensity of running at about 8 METs (~ 5 mph). Additionally, it may be more difficult to increase running velocity in small increments than to increase cycle power output in small increments. Accordingly, music may have a smaller influence on exercise intensity during running compared to cycling. The purpose of this study is to investigate how music tempo influences running velocity, RPE, heart rate and VO_2 during non-competitive running in apparently healthy college age individuals. There are four components to the hypothesis. First, it is hypothesized the participants will have faster running pace when music tempo is the fastest and the slowest running pace when there is no music tempo. Second, it is hypothesized the participants will have higher oxygen consumption (VO_2) when music tempo is fastest,

and a lower VO_2 when there is no tempo in the music. Next it is hypothesized that participants will have a higher heart rate when the music tempo is the fastest, and well as the lowest heart rates when there is no tempo. Finally, it is hypothesized the participants RPE will not change in relationship to a change in tempo of music.

METHODS

Fifteen apparently healthy, college age (age= 21.9 ± 1.9) males ($n= 7$) and females ($n= 8$) participated in this study (Table 1). All subjects were regular runners and could complete a 31 minute run without problem. Approval from the University of Wisconsin-La Crosse Institutional Review Board for the Protection of Human Subjects was obtained prior to beginning. All participants also provided written informed consent before participating in this study (Appendix A).

Table 1. Descriptive statistics of the subjects

Subjects	Age (years)	Height (in)	Weight (kg)	VO_2max ($\text{ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$)	HR_{max} (BPM)
Male: 7	21.9 ± 1.6	70.1 ± 2.5	76.6 ± 10.7	56.8 ± 6.8	193.0 ± 6.3
Female: 8	21.9 ± 2.2	65.4 ± 2.4	62.6 ± 5.7	45.8 ± 2.2	190.6 ± 8.0

Procedures

Subjects completed an incremental running maximal exercise test on the treadmill to measure maximal oxygen consumption. The protocol involved a three minute warm up walking at three miles per hour, followed by one minute stages. The test progressed from three miles per hour to four miles per hour and then half mile per hour increments after the second stage. The test continued until maximal effort was established.

Subjects also participated in a practice run for habituation to training while wearing a Haeger Oxycon Mobile Unit (portable metabolic gas analyzer) (CareFusion, San Diego) as well to become familiar with the music playlist. The practice run as along with the two experimental runs took place on an indoor 200-meter track. Subsequently, the subjects performed two randomly ordered trials (music and no music). Table 2 illustrates the music play list created by the investigator.

There were 8 tracks on the music play list; 2 tracks had no tempo (thunderstorms/0 bpm), 2 tracks had a slow tempo (<100 bpm), 2 tracks had a medium tempo (100-129 bpm), and 2 tracks had a fast tempo (>130 bpm) (12). The first half of the playlist increased in tempo in a sequential order (no tempo, slow tempo, medium tempo, fast tempo). After the first five tracks, the final no tempo track was placed, and the remaining three tracks were placed in random order. The playlist was created this way to eliminate any warm-up like effects the runners may have experienced. The playlist for the no tempo run was 31 minutes of thunderstorms. This trial served as a control run.

Table 2. Music playlist

Song #	Song Title	Tempo (BMP)	Length of Track (seconds)
1	<i>Thunderstorms</i>	0	240
2	<i>Sunday Morning</i>	89	251
3	<i>Don't Stop Believing</i>	120	250
4	<i>Are You Gonna Be My Girl</i>	209	216
5	<i>Thunderstorms</i>	0	240
6	<i>I'm A Believer</i>	161	192
7	<i>Get Out</i>	88	241
8	<i>Eye of the Tiger</i>	109	244

Upon completion of the pre-tests, subjects completed two 31 minute runs. Participants were instructed to complete a five minute warm-up prior to beginning the experimental runs. After their warm up, subjects put on a polar heart rate monitor and an iPod nano that were supplied by the investigator. The subjects set their own volume on the iPod nano. Finally, each subject was connected to the Haeger Oxycon Mobile Unit (portable metabolic gas analyzer) (CareFusion, San Diego). When they were ready to begin, the subjects were told to press start on the heart rate watch, wait for one minute, and then press play on the iPod nano. Once play was pressed on the iPod nano, they were to begin running, and run as if they were going on a normal training run.

Gas analysis was integrated every 30 seconds throughout the run. Heart rate was recorded at the end of each music track using radio telemetry (Polar Heart Rate Monitor). RPE was also recorded at the end of each music track using the Borg (0-10) scale. Speed was determined by manually timing each half lap (100 meters) using a stop watch.

Statistical Analysis

Data analysis was completed using repeated measures analysis of variance (ANOVA) to investigate how varying music tempos affect running performance as defined by the independent variables: velocity, heart rate VO_2 and RPE. A Bonferroni corrected 1-tailed t-test was utilized to further analyze the results. The average values for velocity and VO_2 over the course of the song were used for evaluation.

RESULTS

Figures 1,2,3 and 4 illustrate a representative subject's data for velocity, heart rate, RPE, and VO_2 throughout the two experimental runs. Figure 1 and Figure 2 show

the oscillation of the data throughout the two playlists. Since the oscillations did not vary greatly, the averages were able to be used for data analysis.

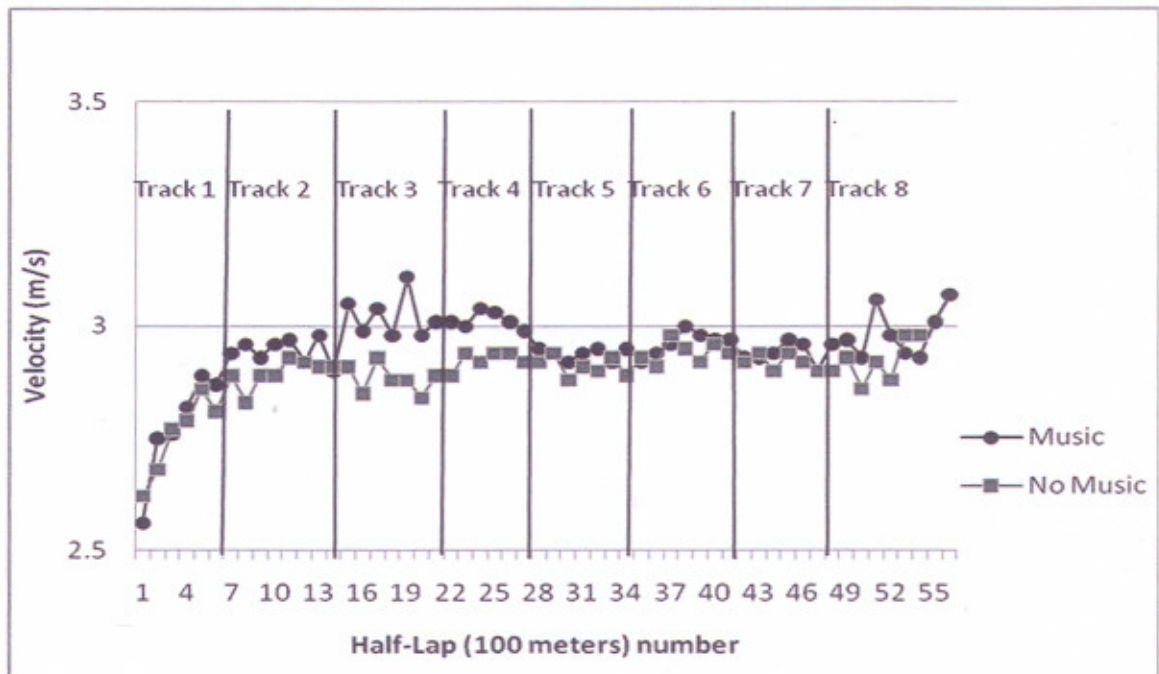


Figure 1. Representative subject's velocity during runs

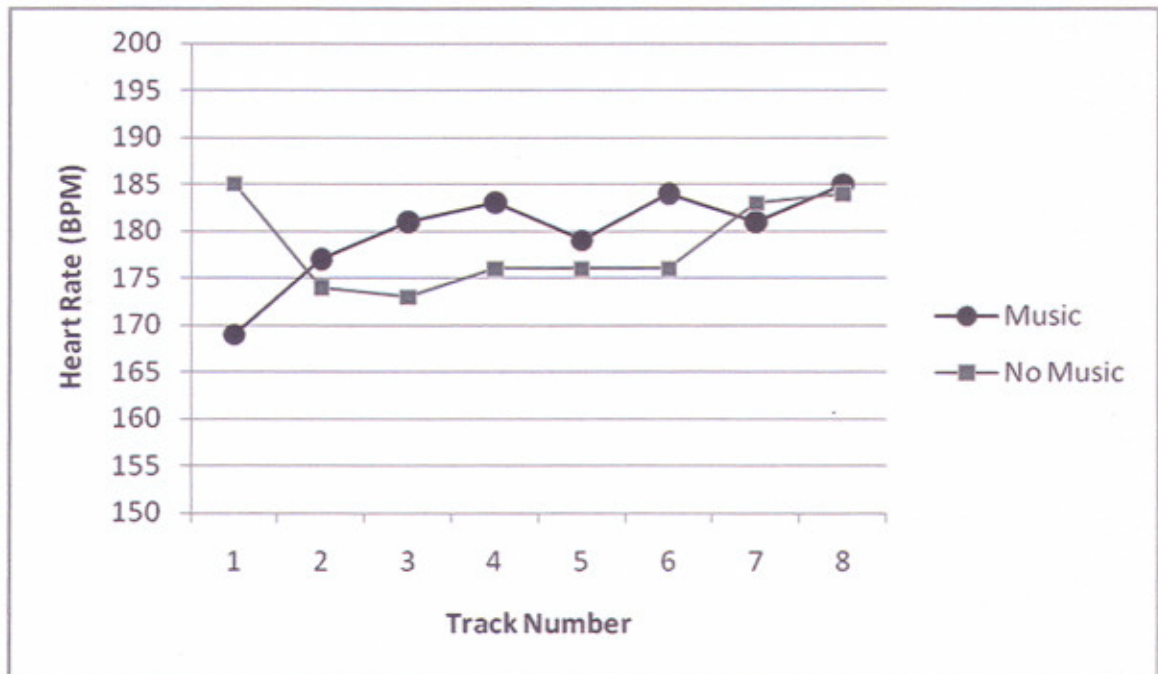


Figure 2. Representative subject's heart rate during runs

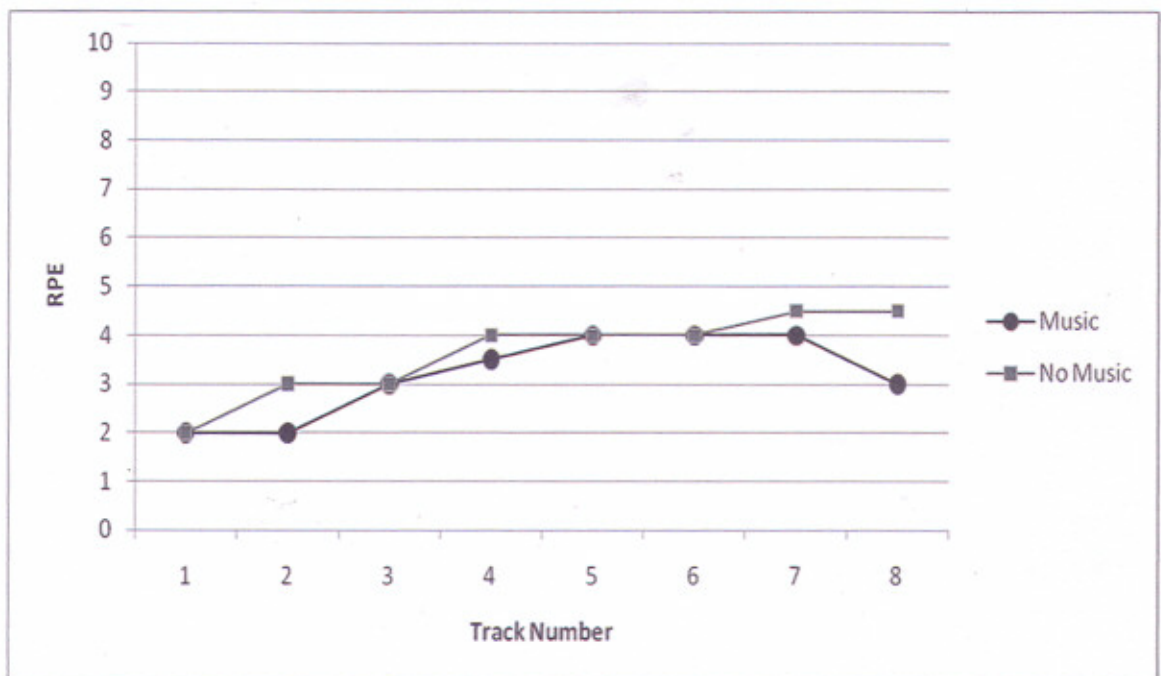


Figure 3. Representative subject's RPE during runs

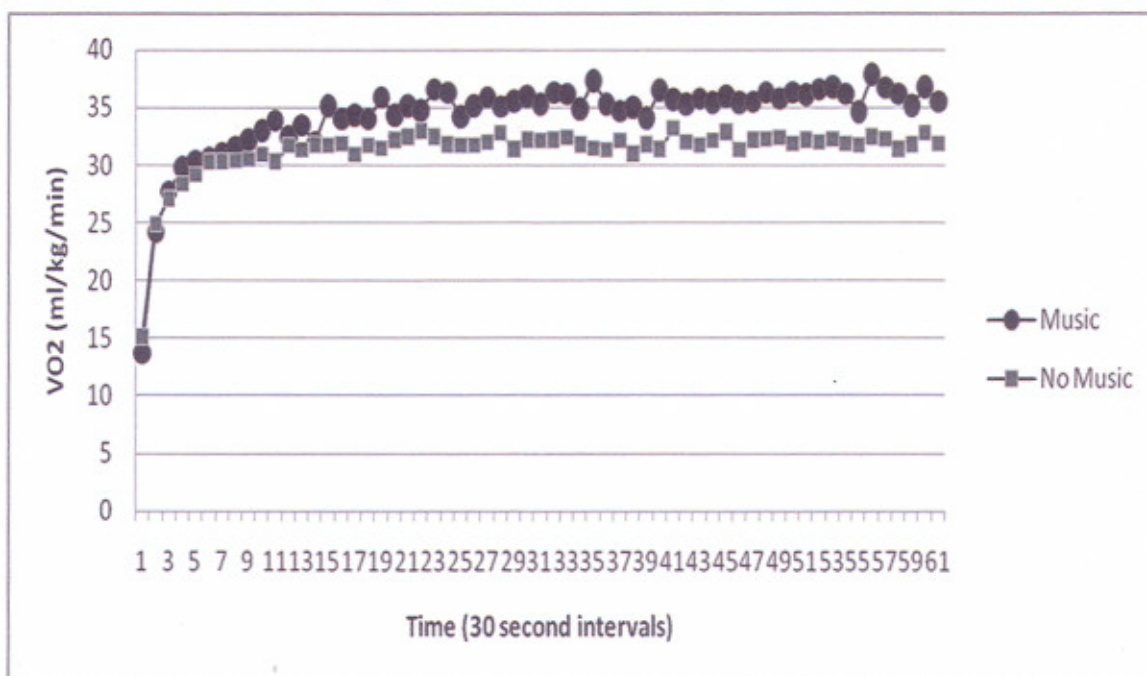


Figure 4. Representative subject's VO₂ during runs

The mean and standard deviations for velocity, heart rate, RPE, and VO₂ over the different tracks and two experimental playlists are illustrated in Table 3.

Repeated measures ANOVA revealed a statistically significant difference ($p < 0.01$) between running velocity and song tempo. A Bonferroni corrected one-tailed, paired t-test was run to examine if running velocities were significantly faster when listening to the faster tempos, compared to listening to no tempo. The t-test found that during song 4 (tempo=209 bpm) ($t=0.01$) and song 8 (tempo=109 bpm) ($t=0.00$) the subjects ran significantly faster when the music was playing (Table 4 and Figure 5).

There was a statistically significant difference ($p < .01$) found between tracks, but not between music and no music playlists for heart rate, and RPE. (Figure 6 and Figure 7). RPE and heart rate increased across the duration of the exercise bout despite no differences in running velocity or VO₂. No significance was found in VO₂ (Figure 8).

Table 3. Mean results for velocity, heart rate, RPE and VO₂ among all participants (n=15) during experimental runs (music and no-music)

Track	Velocity (m/s)		Heart Rate (bpm)		RPE		VO ₂ (ml*kg ⁻¹ *min ⁻¹)	
	Music	No-Music	Music	No-Music	Music	No-Music	Music	No-Music
1	3.06 ± 0.46	3.07 ± 0.51	160.80 ± 13.62	161.73 ± 16.42	3.13 ± 1.96	2.87 ± 1.46	33.72 ± 4.67	33.69 ± 4.41
2	3.10 ± 0.46	3.05 ± 0.54	168.53 ± 13.65	167.13 ± 15.69	3.53 ± 1.73	3.50 ± 1.30	35.64 ± 5.37	34.86 ± 4.73
3	3.14 ± 0.52	3.03 ± 0.55	171.33 ± 12.61	169.33 ± 15.53	4.00 ± 1.36	3.97 ± 1.26	36.14 ± 5.45	35.40 ± 5.01
4	3.15 ± 0.52*	3.02 ± 0.55 *	173.40 ± 13.48	171.13 ± 14.77	4.43 ± 1.32	4.40 ± 1.30	36.22 ± 5.45	35.54 ± 5.04
5	3.05 ± 0.55	3.01 ± 0.56	172.40 ± 11.59	172.20 ± 15.41	4.80 ± 1.32	4.67 ± 1.59	35.75 ± 5.48	35.45 ± 4.87
6	3.07 ± 0.52	2.99 ± 0.54	175.33 ± 11.93	172.40 ± 15.68	4.87 ± 1.30	5.10 ± 1.42	35.67 ± 5.35	35.25 ± 4.92
7	3.03 ± 0.59	3.02 ± 0.56	175.53 ± 12.45	174.40 ± 15.14	5.13 ± 1.36	5.43 ± 1.70	35.67 ± 5.22	35.23 ± 4.61
8	3.11 ± 0.53*	2.97 ± 0.59 *	179.33 ± 11.36	176.47 ± 13.85	5.20 ± 1.86	5.57 ± 1.74	35.83 ± 5.55	35.48 ± 4.69

Table 4. Mean velocity among all participants (n=15)
p was adjusted for multiple comparisons (= p<0.01)

Track	Velocity (m/s)		Significance
	Music	No-Music	
1	3.06 ± 0.46	3.07 ± 0.51	0.90
2	3.10 ± 0.46	3.05 ± 0.54	0.39
3	3.14 ± 0.52	3.03 ± 0.55	0.34
4	3.15 ± 0.52	3.02 ± 0.55	0.01*
5	3.05 ± 0.55	3.01 ± 0.56	0.19
6	3.07 ± 0.52	2.99 ± 0.54	0.03
7	3.03 ± 0.59	3.02 ± 0.56	0.83
8	3.11 ± 0.53	2.97 ± 0.59	0.00*

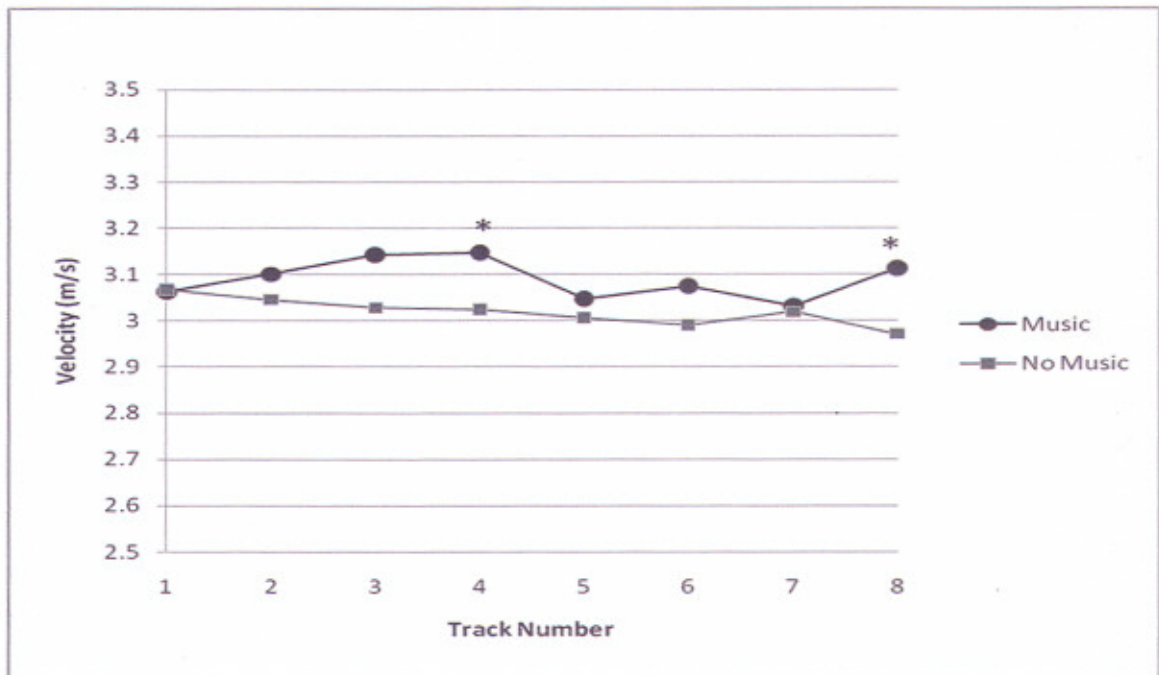


Figure 5. Velocity during experimental runs

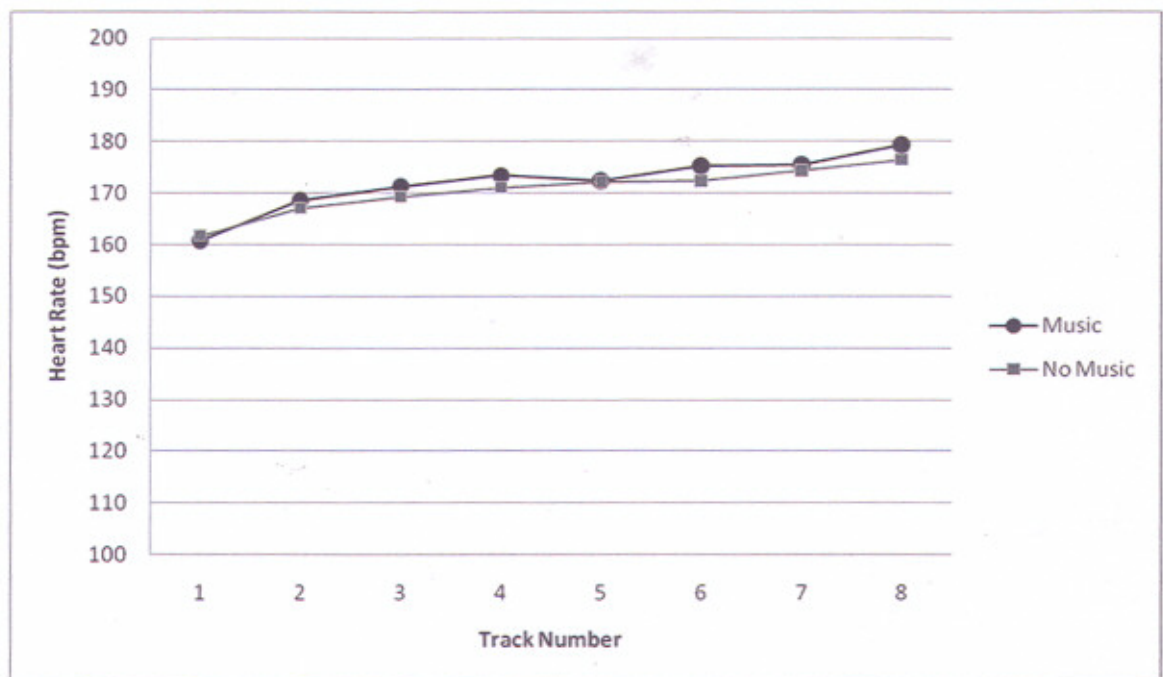


Figure 6. Heart Rate during experimental runs

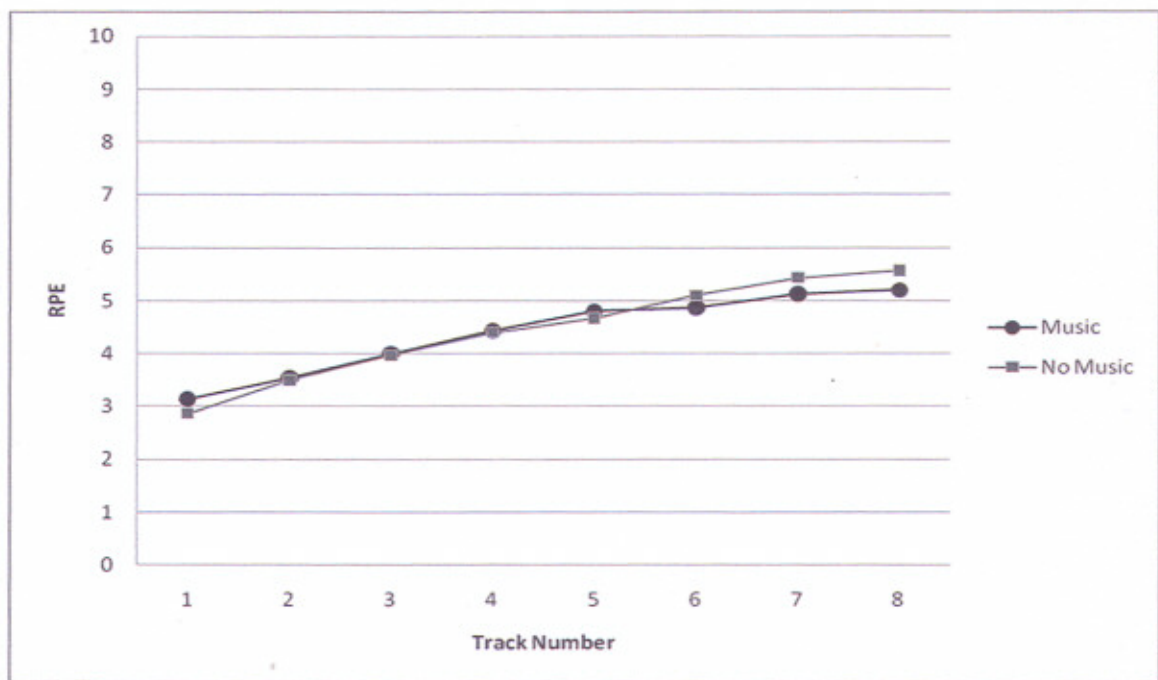


Figure 7. RPE during experimental runs

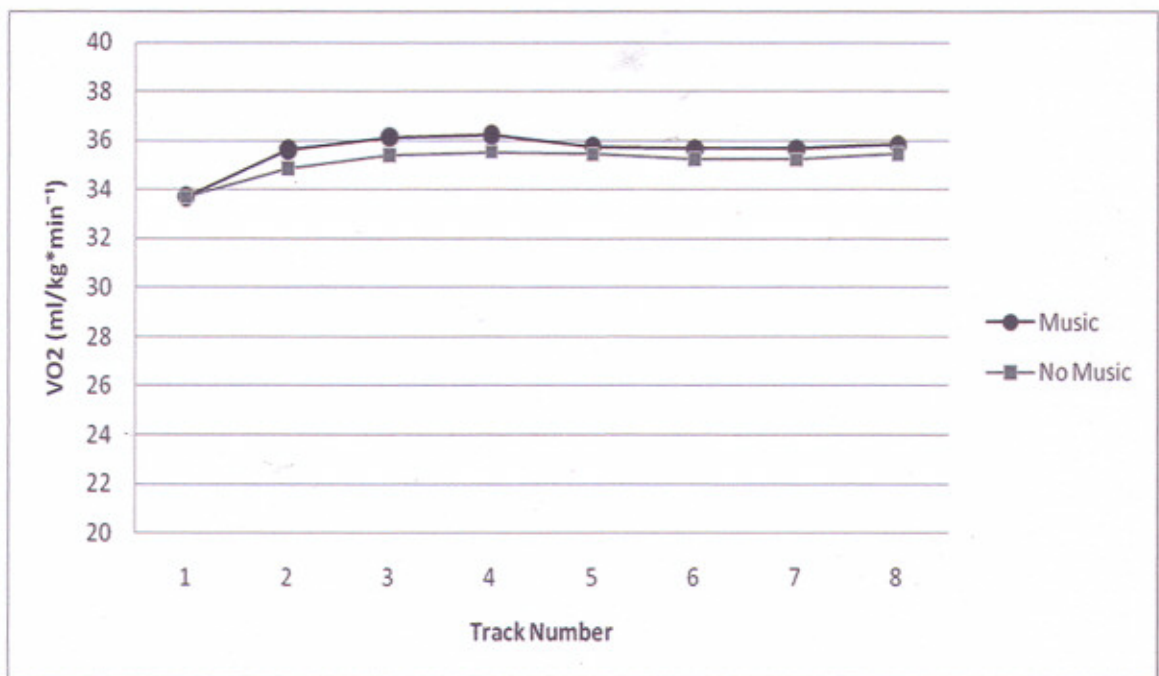


Figure 8. VO_2 during experimental runs

DISCUSSION

The purpose of this study was to determine if there was a relationship between running performance and music tempo. Running performance was evaluated using velocity, heart rate, RPE, and VO_2 . This study found a significant difference between velocity and music track tempo; when the tempo was faster, running velocity was faster. There was also a significant difference found between heart rate and RPE and track number, but no significant difference was found between the music and no music condition. No significant differences were found in VO_2 .

The results of this study support the first hypothesis, in that the participants had faster running times when the music tempo was fastest and slowest running times when there was no tempo. This study also supports the fourth hypothesis in which RPE of the participants did not change with the change in tempo of music. RPE appeared to increase across the duration of the exercise bout without regard to music tempo, running velocity or VO_2 . However, the results do not support the second and third hypotheses that heart rate and VO_2 are highest during fast tempo music and heart rate and VO_2 are lowest with no tempo.

The results suggest that the subjects may have used the music as a way to pace themselves throughout the 31 minute recreational run. Running velocity was significantly faster during the run where the subjects listened to the playlist with varying tempos when compared to the playlist with no tempo. Specifically, the subjects ran significantly faster ($p < .012$) during song 4 and song 8 where the tempos were 209 bpm, and 109 bpm respectively. The increase in velocity during these songs may be due to arousal as the effect of beat dominance. The finding that music increases exercise intensity is consistent

with previous research (2,4,10). Johnson found that music tempo positively influenced chosen exercise intensity in subjects riding a cycle. He concluded that the music influenced the subjects through general arousal as opposed to synchronization (4).

The subjects' RPE significantly increased over the course of both playlists. However, there was no relationship found between RPE and music tempo. Lim et al found similar results, in which RPE increased over time, but was not statistically significant between different conditions (music during 0-5 km, music during 5-10 km, and control-no music) (6). The results also correspond with Zilonka's results in which no differences were found in RPE during trials with music and without music (12).

Like RPE, heart rate increased significantly over the playlist, however there was no difference found between the two playlists. The results for heart rate were supported by other previous studies (8,12).

There are several different factors that could have influenced the results of this study. The data was collected on the indoor track at UW-La Crosse. The track is shared by many different athletic and recreational groups. This made it very difficult to elicit exactly similar environmental conditions between the two runs as well as from subject to subject. Variations in who the track was being shared with may have influenced the subject's running performance.

Running velocity was calculated based on the subjects 100 meter splits times. The splits were measured using a stop watch. There may have been some error in this method as it may not be the most accurate way to measure velocity.

Finally, the investigator created the music playlist, and while trying to compile a playlist of songs that many people were familiar with and enjoyed listening to, it may not

have appealed to everyone. However, Johnson has reported that there was little relationship between musical genre (eg. musical taste) and exercise responses (4). Accordingly, we think it unlikely that differences in musical taste are likely to be critical.

Future research that can be done on this topic include using step plates to measure the runners velocity to get a more accurate idea of the runners work output. There can also be research done in which there are multiple trials where the subject listens to playlists consisting of one tempo per trial (no tempo, slow tempo, medium tempo, and fast tempo). This may give us a better understanding if and how music tempo really affects running performance.

In summary, the use of music increases running velocity. More specifically, faster tempos elicit faster running velocities. Other measures used to evaluate running intensity (RPE, HR, and VO₂) were unaffected by the music. Music can be used to increase running velocity through arousal of the beat of the music.

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APPENDIX A
INFORMED CONSENT

Protocol Title: Effects of Music Tempo on Running Performance

Principle Investigator: Jerica Kreitinger
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Emergency Contact: Dr. Carl Foster
133 Mitchell Hall
608-785-8687

Purpose and Procedure

- The purpose of this study is to determine if and how music tempo affects different physiological responses during running, including: speed, distance, kcal burned, heart rate, and RPE.
- My participation will involve four trial runs. The first trial will be a maximal effort run on the treadmill, running at increasing speeds until maximal effort has been achieved. I will wear a portable metabolic gas analyzer. This trial will be 10-20 minutes in duration. The other three trial runs will be on the indoor track in Mitchell hall. These runs will be 31 minutes in duration. For two of the runs I will be listening to music, and the other run I will not be listening to music.
- During the 31 minute runs on the indoor track, I will be hooked up to a portable metabolic analyzer, which will help determine my metabolic intensity during the run. I will also be using an MP3 player and ear buds while running.
- I will bring my own set of ear buds for listening to the MP3 player.
- The total time requirement is four hours over a two to three week period.
- Testing will take place in room 225 Mitchell Hall, UW-L.

Potential Risks

- I may experience fatigue and/or muscle soreness upon completion of each trial.
- Individuals trained in CPR, Advanced Cardiac Life Support and First Aid will be in the laboratory, and the test will be terminated if complications occur.
- The risk of serious or life-threatening complications, for healthy individuals, like myself, is near zero.

Rights & Confidentiality

- My participation is voluntary.
- I can withdraw from the study at any time for any reason without penalty.
- The results of this study may be published in scientific literature or presented at professional meetings using grouped data only.
- All information will kept confidential through the use of number codes. My data will not be linked with personally identifiable information.

Possible benefits

- I and other athletes may benefit by understanding how music tempo may have beneficial effects of running performance, including influencing total work output, heart rate, and RPE.

Questions regarding study procedures may be directed to Jerica Kreitinger (608-347-1054), the principal investigator, or the study advisor Dr. Carl Foster, Department of Exercise and Sport Science, UW-L (608-785-8687). Questions regarding the protection of human subjects may be addressed to the UW-La Crosse Institutional Review Board for the Protection of Human Subjects, (608-785-8124 or irb@uwlax.edu).

Participant _____

Date _____

Researcher _____

Date _____

APPENDIX B

RATINGS OF PERCEIVED EXERTION SCALE

Ratings of Perceived Exertion Scale

- 0 Rest
- 1 Really Easy
- 2 Easy
- 3 Moderate
- 4 Sort of Hard
- 5 Hard
- 6
- 7 Really Hard
- 8
- 9 Really, Really, Hard
- 10 Maximal: Just like my hardest race

APPENDIX C
REVIEW OF LITERATURE

REVIEW OF LITERATURE

Music has been shown to increase exercise intensity through dissociation, arousal, and synchronization (1,6,8,12,16). Dissociation allows the individual to focus on an external stimulus which helps prolong the exercise bout or increase exercise intensity. People can use music to arouse them through stimulation or relaxation before or during an exercise bout. Finally, individuals can synchronize their movements to the beat or tempo of the music through synchronization. Intensity of exercise can be quantified in several ways, the most common being with heart rate, RPE, and power output. These methods have been studied in the past on how music may affect them.

Music and Heart Rate

Measuring heart rate is one way to quantify exercise intensity. ACSM recommends 30 minutes of moderate intensity (50-70% HR max) five days a week, or 20 minutes of vigorous intensity (70-85% HR max) 3 days a week. Schwartzmiller studied the effects of music tempo on spontaneous cycling performance (13). Each subject had a preprogrammed play list of varying tempos. The subjects cycled for 60 minutes while listening to the play list. Schwartzmiller found heart rate was significantly higher when the tempo of the music was faster. Copeland and Franks looked at the effects of types of intensities of background music on treadmill endurance (3). They found individuals elicited lower heart rates during soft and slow music conditions.

Johnson et al studied the effect of musical genre on spontaneous exercise performance (6). They also found significant increases in heart rate when music was

present compared to no music while cycling. However, they did not find a difference between the different genres of music (polka, rock, country, no music, and preferred music).

In 2007, Gordon looked at what the effects of music tempo were on middle-age subjects participating in chair aerobics. Gordon quantified exercise intensity using percent heart rate max. She found that when the subjects were listening to the faster tempo music, their heart rate was much higher compared to the lower music tempo, concluding that a faster music tempo elicits a higher heart rate.

In 1999, Zilonka et al studied the effects of music programming on walking velocity (17). They found the music did not elicit higher heart rates than the non-music trials. Preiboy's data supported Zilonka's findings in 2009 (11). It was found that there were no significant differences in heart rate among different auditory trials. The results from Prieboy and Zilonka support what Boucher and Trenske found in 1990 (1,11,17). There was no difference found in heart rate while the participants were listening to music or when they were deprived of sensory stimulators (subjects wore opaque glasses and ear plugs).

Although there have been several studies completed that examine the effect that music may have on heart rate, the results remain inconclusive (1,3,5,6,11,13,17). The results do not agree with each other, which is why more research must be done on this topic, paying extra close attention to external factors that may affect the results.

Music and RPE

Ratings of perceived exertion (RPE) is another way to quantify exercise intensity. It is an overall feeling of how hard one may perceive he or she is working. The most common tool used for RPE is the Borg Scale (6-20 or 0-10).

Prieboy conducted research on how different auditory inputs affected perceived exertion while cycling (11). There were four types of listening material used for this study: no music, sedative music (yoga music), self-selected motivating music, and verbal conversation (Comedy tape). Prieboy's research revealed there was a significant difference in RPE among the different auditory inputs. There was a significant lower rating of RPE when the subjects were listening to the self-selected music. However, the significantly lower rating of RPE did not show up until 20 minutes into the exercise, and continued for the remaining 20 minutes.

Boutcher and Trenske's results supported what Prieboy found regarding RPE and music (1). They found that when individuals listened to music while cycling they reported a lower RPE during light and moderate workloads.

Johnson et al found results that contradict what Prieboy and Boutcher found (1,6, 11). They found that there was a significant difference between RPE and music tempos, however RPE was lowest when there was no music. RPE was also lower when the subjects listened to the slower music compared to the medium and fast tempo music. There were no significant differences between genres in this study.

In contrast to the previous studies, in 2009, Lim et al studied the effects of differentiated music on cycling time trials (10). The subjects complete three trials under different music conditions (no music, music played initially then removed between 5-10

km, and music played between 5-10 km only). The final results indicated that there were no significant differences in RPE between the different music groups, however when the subjects listened to music they maintained higher mean speeds without the corresponding increase in RPE.

Karageorghis researched the psychophysical and ergogenic effects of synchronous music during treadmill walking (7). The study consisted of three trials, each with different music (motivational synchronous music, outdeterous music, and a no music control). The participants walked to exhaustion starting at 75% HR max. During the trials, RPE, in-task affect, and exercise-induced feelings states were recorded every 2 minutes. The results show there was no significant differences in RPE among the different music groups.

Zilonka also found no significant changes in RPE between the music trial and no music trial, however, the participants did note that listening to the music while exercising made it a more enjoyable walking experience (17).

The results to the previous studies are very inconclusive regarding RPE and music use during exercise (1,6,7,10,11,17). Again, this is why it is extremely important to continue studying this concept, in order to come up with results that are more similar.

Music and Power Output

Power output is calculated by how fast one is traveling, and the resistance one may experience (ex. grade on a treadmill, resistance on a cycle ergometer). Power output can be converted into METs, whereupon we can calculate exercise intensity.

According to Terry and Karageoghis, there are three factors that can have an effect on power out put and the use of music (16). Music can have a dissociation effect, arousal effect, and a synchronization effect.

Dissociation is the ability to focus on an external stimulus, allowing one to complete a task for a longer period of time. This is due to a decreased feeling of fatigue or pain due to the dissociation. Music can be the external stimulus that allows one to dissociate while exercising, in turn increasing total work out put.

Music can cause arousal in people as they exercise. It can have a calming effect which can be useful before competing in an event, or during a competition. It can also have a stimulating effect, which can again be useful before or during an event.

Finally, music can be used as a synchronization tool. One can synchronize his or her physical movements to the beat or tempo of the music he or she is listening to, allowing him or her to increase or decrease speed and intensity. A classic example of the use of synchronization is by the Ethiopian distance runner Haile Gabreslasse. He synchronized his steps to the song Scatman, which allowed him to set a new world record in the 2000 meter run.

In 2005, Elliott et al completed a study on the effect of motivational music on sub-maximal exercise (4). They found both motivational music and oudeterous music had a significant effect on the total distance traveled during a 20 minute cycle trial, however there were no differences between the two music groups. Schwartzmiller also found significant increases in power output with increasing tempos (13).

In 2005, Simpson and Karageorghis examined the effects of synchronous music on 400-meter sprint performance (14). The subjects completed three 400-meter time

trials each trial with a different auditory stimulus (motivational music, oudeterous music and a no-music control). Simpson and Karageorghis found that the motivational and oudeterous music elicited faster running times when compared to the control group, and that there were no significant differences between the two music running times.

Szabo et al looked at the effects of slow and fast rhythm classical music on progressive cycling to voluntary physical exhaustion (15). The subjects participated in five different trials, each consisting of different music rhythms. The trials consisted of a control trial, slow music trial, fast music trial, slow to fast music trial, and fast to slow music trial. The tempo was changed in the last two trials once the participants reached 70% of their maximal HR reserve. Szabo et al found there was a significant increase in workload in the trial that used slow to fast music. They also noted that the participants preferred the fast music and slow to fast music sessions over the other sessions.

In 2009 Karageorghis et al examined the psychophysical and ergogenic effects of synchronous music during treadmill walking (7). The participants participated in two experimental conditions (synchronous motivational music and synchronous oudeterous music), and one no music control condition. The participants walked on a treadmill until voluntary exhaustion. The results indicated that there was a significant increase in time to exhaustion in the trials that used music.

Lim et al also found a significant increase in distance in the trails that listened to music compared to the control trial without music (10). Johnson also found similar results to his study (6). Lower tempos elicited lower total work output, and faster tempos elicited higher work output. Johnson did also note there was no significant difference between music genres.

Music has a pretty substantial effect on total work output. Most of the studies completed found that the use of music during exercise actually increases total work output (4,5,6,7,8,10,13,14,15). This is due to a number of reasons, synchronization, arousal and dissociation (16).

Summary

Music use during exercise has become increasingly popular, however it remains unclear what the effects of using music during exercise may be. Some studies have found that the use of music during exercise increases heart rate and RPE, however, other studies have found no changes in heart rate or RPE, or reverse changes. Many studies agree upon the fact that music ultimately increases total work output. This can be due to the psychological effects music plays on the mind and body. More research needs to be done on this topic, especially on the effects of music during exercise on heart rate and RPE. Also, a lot of the research that was completed was done using the cycle ergometer, so more research needs to be done on different modes of exercise.

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