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Effects of Motivational Music on a 1.5 Mile Running Time Trial

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Effects of Motivational Music on a 1.5 Mile Running Time Trial

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Table of Contents

Contents Page

Table

Figures

Abstract

Music has a positive effect on performance measures during exercise and sport at submaximal intensities. **Purpose:** To measure the effects of self-selected motivational music on a 1.5 mile maximal intensity running time trial. **Methodology:** Subjects were trained male and female runners (N = 14), age 19-34 ($M = 24.86$). Each subject self-selected and rated a motivational song to be used as treatment in the running trial. The study was conducted as a repeated-measures crossover design in which the subjects were randomly assigned and ran two trials with and without motivational music. The variables of performance time, average heart rate, and rating of perceived exertion (RPE) were measured. The results from the data were analyzed using dependent *t* tests. The alpha level was set at $p < 0.05$. **Results:** On average, the subjects ran the trial 11 seconds faster with music, but the motivational music condition did not significantly improve performance time, $t(13) = 1.754$, $p = 0.0515$, $r = 0.43$. Subjects experienced a higher average heart rate of 5.2 beats per minute faster with the music condition, although the increase was not statistically significant, $t(12) = -1.637$, $p = 0.064$, $r = 0.42$. The music condition significantly lowered subjects' RPE by 0.5 points on a scale of 0-10, $t(13) = 2.446$, $p = 0.029$, $r = 0.56$. **Conclusion:** The results of this study may help with the application of music in enduring high intensity exercise, which is essential as the research on the relationship between high intensity exercise and improved health markers continues to emerge.

CHAPTER ONE: Introduction

Motivational music is a performance-enhancing tool that is often used by athletes during pre-competition and training. Individual music preferences and individual responses to music involve distinctly subjective factors and inherent properties of the music itself. The multiplicity of these factors causes great variety in how athletes perform with music, making it challenging to study (Bishop, 2010).

Laukka and Quick (2011) surveyed 252 athletes and found that when using music during sports, 32% of participants preferred intense and rebellious music, 28% preferred energetic and rhythmic music, 25% preferred up-tempo and conventional music, 1% preferred reflective and complex music and 14% preferred other music. With so many widely distributed musical preferences, a maximal athletic performance for any individual would be more likely to occur with a self-selected song that is distinct to that individual's arousal response to variables such as tempo, lyrics, melody and personal associations (Karageorghis, Terry, & Lane, 1999). In other words, a particular song which greatly motivates one athlete may have little effect on another athlete. If an athlete has an optimal emotional and physical performance with a self-selected motivational song, will performance, physiological, and psychological measures improve? The purpose of this study is to examine how a self-selected motivational music condition affects performance time, average heart rate, and perceived exertion of trained runners in an outdoor time trial.

Music provides a distraction from the exercise task. It is a concept known in psychology as dissociation, in which the music helps narrow the attention and works as a diversion away from the effort and discomfort that a person exerts during submaximal exercise, (Koç & Curtseit, 2009). Music and its effect on exercise have been studied during submaximal, maximal and supramaximal intensities. Hagen et al. (2013) studied the effect of music on a cycling time-trial performance. In the decision to study a time-trial protocol, the researchers made the argument that a closed-loop session would more closely model the conditions that athletes face in competition. Rarely ever do athletes compete to exhaustion in a given sport, and the protocol of exercising to exhaustion has been researched in prior studies relating to motivational music (Crust & Clough, 2006; Ghaderi, Rahimi, & Ali Azarbayjani, 2009; Nakamura, Pereira, Papini, Nakamura, & Kokobun, 2010; Szabo, Small, & Leigh, 1999). In keeping with the concept of modeling a competition environment, this study will use an outdoor setting, a maximal intensity protocol (1.5 mile run), and trained runners on a paved trail. Simpson and Karageorghis (2006) referred to this competition-simulated research environment as an "ecologically valid setting" when they studied the effects of synchronous music on 400-m sprint performance.

Synchronous music is commonly used for fitness classes to keep participants in rhythm with a designated pace and workload. The tempo of a song is expressed in beats·min^{-1} or BPM (Karageorghis, Jones, & Low, 2006a). Bishop (2010) wrote that the effects of tempo can also positively increase an individual's affective state which can improve performance. But tempo can also be a detriment to pacing for runners if music is poorly selected because humans have a tendency to match stride or movement with a given tempo or BPM (Karageorghis & Terry, 1997). If a runner is using music during a training session or competition and the BPM of a song is too fast or slow (not matched to desired pace), the tempo of the music could alter the runner's stride and pace. Bishop

(2010) presented a case study in which a runner used his split times from a marathon and manipulated a playlist of songs in an attempt to control and affect his pacing in a subsequent marathon. The runner chose low-arousal tracks for the first 30 minutes of the race to moderate typically fast starts. Bishop compared pace times between the first marathon (M1) in which the playlist was not in any particular order and the second marathon (M2) in which the playlist was created to control pace. A significant difference in the rate of reduction of pace was found between M1 and M2 ($t(2) = 5.74$, $p < 0.05$). Most notably, the runner completed the 10K of M2 00:01:12 slower than M1, which is the section of the race in which the runner was attempting to see a markedly slower pace through the use of music.

Rating of perceived exertion (RPE) is a psychophysiological measurement. It is an individual's subjective rating of the amount of energy being exerted to complete a task/exercise (Katch, McArdle, & Katch, 2011). It is theorized that music can help reduce an individual's RPE. In other words, while performing at a constant workload, the exercise is perceived to be easier for an individual when listening to music. In one study, the researchers found a significant increase in RPE values ($p < .05$) throughout the course of the trials for runners who were listening to motivational music and RPE values remained steady for participants who were not listening to music (Elliott, Carr, & Orme, 2005). This is a contradictory finding to the theory, because the participants who were listening to music felt that the run became increasingly harder as time passed, although the workload of the run did not increase in the protocol that was used. Birnbaum, Boone and Huschle (2009) also found no change in RPE when testing treadmill running (mean scores ±standard deviation: fast music = 13 ± 1, slow music = 13 ± 1, control group = 13

± 2). In another study in which runners were tested while listening to motivational music, relaxing music, and no music, RPE values were significantly lower ($p = 0.007$) for the two music groups when compared to the no music group (Ghaderi et al., 2009). There was no significant difference found for RPE between the motivational music and relaxing music. This finding suggests the need to study how a variety of music types affect RPE.

Heart rate has also been examined in the context of motivational music. Experiencing an increase in heart rate during exercise while listening to music is not considered a positive effect. On the contrary, as individuals exercise consistently, they should see a decrease in average heart rate as the body adapts and becomes more efficient at circulating blood and oxygen during exercise. Birnbaum et al. (2009) found heart rate to be relatively unchanged between the music and no music groups (mean BPM: fast music = 167 ± 16 BPM, slow music = 165 ± 16 BPM, control group = 163 ±19 BPM, p = 0.158). However, the researchers found the average VO_{2max} (the measure of the maximal oxygen uptake during exercise) increased significantly for runners listening to fast music compared to no music (VO_2: fast music = 2.52 ± 0.69 L·min, slow music = 2.39 ± 0.71 L·min, control group = 2.34 ± 0.61 L·min, $p = 0.003$). This finding is remarkable. If the heart rate stayed the same, but the amount of oxygen uptake increased, the researchers theorized that music improved the contractility of the heart and, therefore, the amount of blood ejected by the heart per beat (increased stroke volume and cardiac output). To discover that motivational music could make a person's heart beat more efficiently is an important finding in the body of research on this topic.

Research Questions

Research Question 1: Will subjects' finish time be significantly lower when running a 1.5 mile outdoor time trial with self-selected motivational music (MU) when compared to running without music (NM)?

Research Question 2: Will subjects' average heart rate be significantly higher when running a 1.5 mile outdoor time trial with self-selected motivational music (MU) when compared to running without music (NM)?

Research question 3: Will subjects' rating of perceived exertion (RPE) be significantly different when running a 1.5 mile outdoor time trial with self-selected motivational music (MU) when compared to running without music (NM)?

Hypotheses

Hypotheses 1 – Finish time

$H_0: \mu_{MU} = \mu_{NM}$

$H_1: \mu_{MU} < \mu_{NM}$

Hypotheses 2 – Average heart rate

$H_0: \mu_{MU} = \mu_{NM}$

$H_1: \mu_{MU} > \mu_{NM}$

Hypotheses 3 – RPE

$H_0: \mu_{MU} = \mu_{NM}$

$H_1: \mu_{MU} \neq \mu_{NM}$

Delimitations

1. Subjects were trained male and female runners.
2. The age of subjects was limited to 18-35 years.
3. For the purposes of this research, “trained runners” was defined as training at least six miles per week for the past 6 months.
4. Subjects ran a 1.5 mile maximal effort run on a paved trail.
5. The trials were conducted in an outdoor environment.
6. Subjects used an mp3 player provided by the primary investigator.
7. Volume of the song was controlled to a moderate level by the primary investigator.
8. Subjects were asked to restrict heavy exercise, alcohol consumption, or caffeine consumption 24 hours in advance of the trials.

Limitations

1. Subject diet (including caffeine and alcohol consumption) was not controlled during data collection, other than the request to restrict alcohol and caffeine consumption 24 hours in advance of the trials.
2. Subjects’ quantity of physical activity was not controlled during data collection, other than the request to restrict heavy exercise 24 hours in advance of the trials.
3. Music tempo was not controlled by the primary investigator because the song was self-selected by the subject.

Assumptions

1. Subjects were motivated by the self-selected music.
2. Subjects ran the protocol at maximal intensity.

3. The instruments used to measure the course and variables were accurate, valid, and reliable.
4. Subjects followed the study instructions and refrained from alcohol, caffeine, or heavy lifting 24 hours prior to testing.
5. Subjects were in the same physical condition during both trials.
6. The maximum heart rate formula used to estimate subjects' estimated maximum heart rate was accurate, valid, and reliable.
7. The weather variations of the outdoor environment did not affect the subjects' performance.
8. Subjects played the song continuously during the entire time trial.

Summary

Using music as a motivational factor has the potential to enhance sport performance. The following research examined the motivational music treatment in a maximal intensity running time trial. It was hypothesized that the performance time would improve with motivational music, because research has shown that music has inherent qualities which can stimulate individuals when appropriately chosen. It was also hypothesized that the average heart rate of the runners would increase with music and the subjective effort ratings would not be affected by music. Music may have the ability to influence the sympathetic nervous system, which may cause an increase or decrease in heart rate, depending on the qualities of the music. Subjective effort has been shown to be reduced when listening to music during submaximal exercise. However, this study measured the effects of music during a maximal intensity run, and it was hypothesized that because of the maximal intensity protocol, subjective effort ratings would not change with the music condition. The findings from the research may be used by competitive athletes in training and pre-competition, by individuals who use high intensity training as part of their fitness program, and by individuals who use high intensity training to increase overall health.

Operational Definitions

1. Rating of perceived exertion - an individual's subjective rating of the amount of energy being exerted to complete a task/exercise
2. Tempo – pertaining to music, tempo of a song is expressed in beats·min-1 or BPM
3. Motivational music – for the purposes of this study, motivational music will be defined by the following statement: "a song that would help motivate me during exercise."
4. Pace – a runner's time defined in minutes·mile
5. Closed-loop design - when the course distance is set and the subject performs in the closed-loop course at a maximum effort, similar to real-world competition settings
6. Open-loop design - when the subject completes the exercise to exhaustion, or for a set amount of time, and the course is open to being traveled the farthest distance possible
7. Time trial – a test of the subject's speed over a set distance
8. Synchronous music – when the subject moves with the beat of the music
9. Submaximal intensity – below the subject's maximal capacity
10. Maximal intensity – at the subject's maximal capacity
11. Ecologically valid setting – a setting that is designed to model a real world setting
12. Chronotropic control – the control of the timing of heart rate
13. Sympathetic nervous system – part of the autonomic nervous system which influences heart rate

14. Stroke volume – the volume of blood pumped from the left ventricle in one beat
15. Cardiac output – the volume of blood pumped from the left ventricle in one minute
16. Dissociation – focus is away from internal cues
17. Association – focus is on internal cues
18. Biomarker profiles – the levels of measurements which may represent a disease state in an individual
19. Insulin sensitivity – how sensitive the body is to the effects of insulin
20. Motivational quotient – the raw measurement of a song’s ability to motivate

CHAPTER TWO: Review of Literature

Motivational music and its effect on exercise and sports performance have been measured in numerous studies. How does music motivate and effect positive changes in people when exercising and what are the mechanisms for these responses? Tenebaum et al. (2004) studied high intensity exercise and how it is affected by associative and dissociative coping strategies. The researchers examined music as an external stimulus which serves to distract and help dissociate from the perceived exertion, pain, and fatigue of exercise which are internal cues. This dissociation is also explained as attentional focus shift. Tenebaum et al. hypothesized that once exercise reaches a level of high intensity, a person is no longer able to keep the focus of attention on the external stimuli and the internal cues of discomfort are realized.

Music can also alter mood states. Bishop, Karageorghis, and Loizou (2007) presented a grounded theory from data collected on young tennis players and their use of music to manipulate emotional states. The researchers arrived at five general dimensions of intended emotional outcomes when listening to music: appropriate mental focus, confidence, positive emotional state, psyched up, and relaxed. These are the higher themes in which athletes may use music to alter mood state before, during, and after competition and training.

Yamasaki et al. (2012) reviewed literature on the effects of music on many metabolic responses in various clinical and exercise settings. The authors researched literature regarding music therapy modalities and found that, most likely due to a response mechanism involving increased endocrine system activity, music plays a large role in processes such as cardio autonomic activity, stimulating gastric motility, and exercise recovery.

The purpose of this literature review is to examine the current research on the effects that music has on exercise. The review will include a validated method for rating motivational music, how individual music preference is studied and quantified, and how music affects the performance variables that will be measured in the present study: performance time, heart rate, RPE and ½ distance split time.

Quantifying Motivational Music

How does a coach or athlete determine if a song has the ability to motivate? Researchers have worked to develop a way to consistently rate a selected musical piece as motivational. Karageorghis, Terry, & Lane (1999) used research to first develop a validated instrument, the Brunel Music Rating Inventory (BMRI) and then the BMRI-2 (Karageorghis et al., 2006b). The BMRI and BMRI-2 are commonly used in the field to rate the motivational quotient of a selected piece or playlist. Karageorghis et. al (1999) used information from existing theory to develop a conceptual framework, which identifies the prominent variables which influence the human response to music. Within the framework, there are the qualities which are inherent to the musical piece such as tempo, melody, and lyrics and these are categorized as internal influence. There are also external factors, which include how an individual interprets music and are influenced by personal association and cultural impact.

In the Karageorghis et. al (1999) study in which the BMRI was developed, the researchers first used two samples of 334 aerobics instructors and 314 exercise participants to respond to a questionnaire and this data was used for exploratory factor analysis. The initial analysis was performed for 15 items and was a five-stage process in which the questionnaires were analyzed and compared between the two sample groups. The 15 items were reduced to 13 when “instrumentation” and “singalongability” were removed after factor analysis revealed the items were cross-loading above 0.40, a limit the researchers had set prior to testing. The researchers concluded there were four factors which were consistent with the initial theoretical framework. Those four factors were association, musicality, cultural impact, and rhythm response (factor estimates for all groups, N = 648, association = 11.8 $\pm$ 5.95, cultural impact = 19.8 $\pm$ 7.18, musicality = 11.6 $\pm$ 4.57, and rhythm response = 34.1 $\pm$ 5.67). From those initial four factors, 13 questions were developed and a Likert-style 10-point scale was used to rate the 13 questions from “not at all motivating” to “extremely motivating.”

Karageorghis et al. (2006b) redesigned and validated the BMRI-2. The authors contended that the BMRI was not applicable to non-experts. The authors validated the initial survey with aerobics instructors but not exercise participants, and the authors felt they were making an inference by using the instructor validations on how an exercise participant would use a selection. The authors wished to design a survey that could easily be used by athletes for selecting music. The authors also set out to resolve limitations from the first design in the areas where they found inconsistencies and instabilities in the initial factor analyses.

To design the BMRI-2, Karageorghis et al. (2006b) first completed a qualitative appraisal (personal interview) of the BMRI using exercise participants. The participants (four females, four males, mean age = 31.9 ± 8.9 years) were then allowed to: 1. self-select 3 songs and use the BMRI to rate their songs, 2. rate the relevance of the questions from the BMRI, and 3. give thoughts and responses regarding the BMRI. The content analysis of the interviews revealed themes which were deemed irrelevant by the subjects and themes that were not easy to understand by the subjects, such as the concept of "harmony."

From the results of the qualitative data, Karageorghis et al. (2006b) devised a pool of 24 items and used a 7-point Likert scale to rate the items from 1 "strongly disagree" to 7 "strongly agree." The authors used 78 fitness instructors (mean age = 24.9 ± 5.9 years) to review the 24 item pool of questions. Any item that scored an average above four on the 7-point scale was included in the redesigned survey, of which six total questions scored over four and were included in the redesigned survey. The BMRI-2 was then validated by administering the survey to two independent groups of students (first group n = 151, mean age = 19.4 ± 2.8 years, second group n = 99, mean age = 19.9 ± 1.4 years) for a multisample confirmatory factor analysis. The single-factor model demonstrated acceptable fit (CFI: 0.86-1.00; SRMR: 0.04-0.07). The authors noted that the BMRI-2 was half the length of the original survey and they concluded with instructions for administering the redesigned survey.

Individual Preference

According to Karageorghis et al. (1999), rhythm and response, which are two of the four qualities that draw humans to particular musical selections, are factors that involve internal responses. The second two qualities, cultural impact and association, are influenced from external factors. Each person has a distinct history and set of experiences that influences the factors that determine musical preference.

The many individual preferences of music type create widely distributed definitions of what makes a selected musical piece deemed motivational. Laukka and Quick (2013) studied the ways athletes use music for emotion and motivation with a questionnaire. The authors received 252 survey responses (135 women and 117 men, mean age = 23 years). The subjects were Swedish athletes who participated in a wide variety of sports at the national or international level. The 24-item questionnaire included forced-choice quantitative ratings and open-ended questions. The questions asked about every day listening habits of the athletes, semantic estimates of uses of music in sport, and episodic estimates about a recent emotional episode in relation to music/sports. The subjects were asked to rate the importance of music in everyday life. On a 6-point scale with six being the highest rating, the mean response was 4.42 ± 1.32. The subjects were asked to rate the importance of music during practicing sports and the mean response was 3.70 ± 1.51.

The authors ran a *t*-test to compare the difference in gender response to the music during practice and found that females rated music during practice significantly more important ($p = 0.008$) than males. Athletes were asked to identify reasons why they use music in sports from a fixed list of 15 motives. The top five responses were as follows: to increase pre-event activation/to pump up (mean rating = 4.68 ± 1.52), to increase positive affect (mean rating = 4.22 ± 1.59), to get help with my motivation (mean rating = 3.70 ± 1.69), to perform better (3.68 ± 1.75), and to experience 'flow'/being in the zone (mean rating = 3.60 ± 1.76). The following motives were ranked 12th, 13th, and 14th, respectively: to decrease my perceived exertion (mean rating = 2.70 ± 1.70), to divert my attention from fatigue and pain (mean rating = 2.36 ± 1.55) and to be able to synchronize my movements with the music (mean rating = 1.93 ± 1.36). However, when asked how the athletes felt music and emotional regulation affected their performance, the second most frequent was response was to increase endurance/fatigue management (19%). The authors concluded that athletes typically use music for pre-event preparation, warm-up, and training to increase happiness (positive affect mood state) and alertness. The authors also theorized that music is not used as often during competition because there is usually not an opportunity to listen to music while competing.

Crust and Clough (2006) separated out the emotional and rhythmic components of music to study how these characteristics affect motivation when isolated. The authors measured participant response to music conditions while performing an isometric weight-holding task. The subjects were 58 physically active participants (male = 41, female = 17, mean age = 22.3 ± 6.4 years). The task was performed under the following conditions: no music, rhythm only, and motivational music. The authors sought to separate and test the concepts of melody, harmony, and lyrics, which are viewed as emotional components of music, from the rhythm and tempo qualities of music. By isolating the rhythm portion of a song, the researchers tested the theory that endurance performance would be greater when performed to the full song with emotional components, as opposed to the rhythm-only portion. The participants held a 1.1 kg sand-filled dumbbell in an overhand grip to exhaustion under the three conditions. The researchers used a repeated-measures design in which the participants underwent all three trials in a randomized order.

The results of the repeated-measures analysis of variance (ANOVA) showed that participants held the weight significantly longer ($p < 0.01$) when listening to music (mean = 211.7 ± 53.7 seconds) than rhythm (mean = 197.5 ± 52.6 seconds) and they held the weight significantly longer ($p < 0.05$) when listening to rhythm than no music ($M = 190.08 \pm 52.4$ seconds). The researchers concluded that the participants were able to complete the endurance task for 11% longer when exposed to the motivational music condition.

In the same study, Crust and Clough (2006) also investigated individual personality types and how personalities influence a person's response to music. Participant personalities were evaluated and classified using the Sixteen Personality Factor Questionnaire (16PF). The researchers theorized that participants who were rated as extraverts would be more sensitive to the stimuli of the music, and therefore could endure the task longer. Multiple regression analyses revealed that there was a significant response to music for the primary personality trait of liveliness ($r = 0.29$, $p < 0.05$) and a significant response to music for the primary personality trait of sensitivity ($r = 0.35$, $p = 0.01$). The Crust and Clough (2006) study was important because it attempted to study and quantify how personality is a separate factor in response to the stimuli of motivational music. The theory that different personality types are motivated and affected by music differently makes a strong case for allowing individuals to self-select motivational music in order to test a subject who is maximally stimulated by a selected piece.

Lane, David, and Devonport (2011) examined the effect of music on emotion regulation and its effect on perceived running performance. The researchers tested two music conditions: self-selected music vs. *Audiofuel* (music designed specifically for the synchronous movement of running). The participants consisted of 65 volunteer runners (Age: $M = 41.48 \pm 9.39$ years, Male: n = 19, Female: n = 41). The study was set up in three stages. In the first stage, each participant answered a survey regarding a recent running event and the extent to which emotional state was affected by music used during the run. Participants also chose and rated their running music playlists using the BMRI-2, which is used to rate the motivational quotient of music. In the second stage, participants set a running goal and attempted to reach this goal prior to stage three so that a baseline measurement could be established pre-intervention. The participants were then randomly assigned to the self-selected music group or the *Audiofuel* music group. For stage three, the participants attempted their running goal again, while listening to the music selection of the group to which they were assigned.

The researchers used a repeated-measures MANOVA with a within-group factor (using the surveyed emotions of three distinct phases of the run) and a between-group factor (using the two different types of music) and compared the two runs (pre-intervention and post-intervention emotional state surveys). Results revealed that there was no significant difference in emotional states between the two music groups (Wilks's lambda $_{2,62}$ = 0.070, p = 0.50, Partial Eta^2 = 0.02). The participants indicated pleasant emotional states were increased with music intervention, and that emotional states did relate to performance.

The study measured and compared perceived performance and emotional states of two different runs, and also compared these measurements between two control groups. This study contained several limiting factors. First, the researchers could not control for the administration of the testing and the running conditions. Runners were allowed to choose their own course and time of run. Weather could have had an effect on one of the two run attempts. Self-managed testing could have produced inconsistency. Course familiarity would have also been established on the first run, making it easier to pace on the second attempt. The runners were allowed to establish individual goals and then the tests were contained for each individual runner against the individual goal, which allows for variation in the type of running goal and this was a positive trait of the study. The authors believed that the knowledge of the course could directly contribute to goal-setting and music selection for the varying emotional states during a varying course.

Music and Performance

Researchers have looked at overall performance measures and how performance is affected by motivational music through various protocols and types of exercise such as anaerobic power, metabolic anaylsis, aerobic endurance, task endurance, and time to exhaustion. Elliott, Carr, and Orme (2005), Brooks and Brooks (2010), and Koç, Curtseit, and Curtseit (2009) all measured the effect that motivational music on the Wingate cycle ergometer. In the Elliott et al. (2005) study, the researchers measured the effects of motivational music on sub-maximal exercise. The participants were 10 males (mean age 21.2 years) and eight females (mean age = 20.7 years). The researchers chose a 20 minute cycling trial protocol that allowed the participants to work within an intensity of 60-70% HR_{max}. The participants performed the trials on a Monark 818E Ergomedic cycle ergometer. Participants had to complete three trials. In one trial the participants listened to a motivational song. In a second trial, the participants listened to a song that was determined to be oudeterous (neutral). In a third trial, the participants completed the cycling trial with no music. The music was rated before the cycling trials by a group of 35 undergraduate students using the BMRI. During the trials, data was collected on distance cycled in kilometers, RPE using the Borg (1982) 0-10 scale, and in-task affect using The Feeling Scale (Hardy & Rejeski, 1989). Participants traveled significantly farther ($p < 0.05$) with motivational music ($M = 9.94 \pm 1.89$ km), and they also traveled significantly farther ($p < 0.05$) with oudeterous music ($M = 9.85 \pm 1.67$ km), when compared to the no music condition ($M = 8.93\pm 1.76$). RPE increased throughout the trial for the motivational and oudeterous music, unaffected for the no music trial. Participants also reported significantly higher levels of in-task positive affect ($p < 0.04$) for the motivational music trials compared to the no music trials. The researchers found increased performance for both music groups (whether motivational or oudeterous) when compared to the no music trial. This study reveals that any music makes a difference, regardless of type.

Brooks and Brooks (2010) measured the effect that motivational music had on anaerobic power output. The method of measurement was the Wingate cycle ergometer test. The subjects were volunteers ranging in age from 18-38, and a total of 71 males and females were used. The subjects were tested in two trials, and within the trials each participant performed the Wingate test once with motivational music playing and once with no music. The musical piece was chosen using the BMRI to determine motivational potential. The order of testing (with music or without music) was randomized. The subjects then tested one week later in a second trial. The researchers measured and compared peak power, average power, and power drop of the participants and used a repeated -measures ANOVA. The researchers found a significant difference in the peak power ($p<.001$) and overall peak power ($p<.001$) between the music and no-music tests. The subjects produced an average of 120 watts (W) higher peak power and 155 W higher average power in the music tests than the no-music tests. The participants also averaged longer to fatigue in the music tests with an average power drop of 255 W, while the average power drop was 285 W in the no-music tests. The authors concluded that using motivational music during anaerobic performance causes a significantly higher power output and delays fatigue.

Koç et al. (2009) studied 20 college age students (14 males, 6 females, mean age = 19.97 ± 1.34 years) performing a Wingate cycle ergometer protocol under slow, fast, and no music conditions. The subjects were allowed to pick song selections from a pre-determined list which was chosen by the authors from contemporary chart music. Maximum power output (PP), mean power output (AC), minimum power output (MP) and fatigue index (FI) were compared between all the test conditions. FI provided percentage decline in power output and was calculated as follows: FI % = ((PP - MP) ÷ (PP))/100. The authors performed a repeated measures ANOVA. PP, AC, and MP were all increased while listening to slow music and fast music compared to listening to no music ($p < 0.0005$). The fatigue index, tested under the slow (54.30 ± 13.12) and fast (52.10 ± 14.04) conditions, was significantly lower than the no music condition (62.34 ± 18.57; $p < 0.005$; $p < 0.05$, respectively). These findings indicated that performance increased regardless of the type of music tempo or individual preference of selected pieces. The authors did not define tempo in beats·min^{-1} for the musical selections.

Barwood, Weston, Thelwell, and Page (2009) studied motivational music in combination with video and high-intensity exercise performance. The body of research on high-intensity exercise is important to the outline of the present study because the effect of motivational music on a maximal performance is being measured. Barwood et al. (2009) hypothesized that using both a video and music intervention would help the participant to experience greater dissociative attentional strategy from the exercise task. This dissociation from task would help the runners to fun for a longer period of time at maximal effort. The researchers used six male participants (mean age = 20 ± 1 years) to run in three maximal effort runs on a treadmill. The three conditions were control (CON), motivational (M), or non-motivational (NM). B_{lac} was collected from each subject and distance travelled in 15 minutes was used to measure performance. The researchers used a multivariate analysis of variance (MANOVA) with repeated measures and used post hoc pairwise comparisons with Bonferroni adjustments.

During the M condition, the subjects listened to motivational songs that were chosen by the researchers, and the subjects watched clips of influential sporting feats that were likely to have been covered in the media. During the NM condition, the subjects listened to 30 minutes of public speaking from a political trial. During the CON condition, all conduct was the same except the subjects did not listen to any music or watch any video.

The MANOVA results indicated a significant difference between the CON, NM, and M conditions (F = 3.68, $p = 0.023$, $\beta = 0.77$). Post hoc analysis showed that subjects ran significantly further in the M condition compared to the NM condition ($p = 0.049$) and compared to the CON condition ($p = 0.019$). The mean distance traveled was 415 m (13%) and 251 m (8%) further in the M condition than the NM and CON respectively. Analysis also indicated significant differences in B_{lac} accumulation between trials ($F_{2,10} = 5.33$, $p = 0.026$, $\beta = 0.70$). Post hoc tests revealed that B_{lac} accumulated to a significantly greater extent in the M compared to the NM condition ($p = 0.05$).

It is difficult to understand how the video condition in combination with motivational music may have helped the runners dissociate from the task of running at a maximal effort, as opposed to running the same study with a video or music condition only. However, it is important that the researchers found a significant effect on time to exhaustion with a high-intensity protocol. Brownley, McMurray, and Hackney (1995) suggested that music is not as effective on high-intensity tasks or on trained subjects when focus is on the internal cues of high intensity running and is unresponsive to external stimuli.

Music and Exercise Heart Rate

Birnbaum et al. (2009) theorized that the stimulating effects of tempo could influence the heart rate during exercise. They measured the effects of fast and slow music tempos on cardiovascular responses during exercise. The researchers from this study aimed to measure the following physiological effects: steady-state oxygen consumption (VO_2), expired carbon dioxide (VCO_2), frequency of breaths (F_b), minute ventilation (V_E), heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), systemic vascular resistance (SVR), estimated cardiac output (Q), stroke volume (SV), arteriovenous oxygen difference ($a\text{-}vO_{2diff}$), myocardial oxygen consumption (MVO_2), respiratory exchange ratio (RER), and RPE.

The study subjects consisted of 11 college-aged students; six males (age 23±2 years) and five females (age 23± 1 years). The researchers used three conditions: a fast tempo condition in which the participants ran to four fast-paced popular songs, a slow tempo condition in which the participants ran to four slow-paced popular songs, and a third condition (the control) in which participants ran to no music at all. During all three conditions, the participants ran on a treadmill for 15 minutes at 0% grade at 5.5 mph. The researchers randomized the order of the conditions. The researchers used an ANOVA with repeated measures to test for differences in the cardiovascular responses across the three conditions. When significance was found, the researchers used a post hoc Scheffe test ($p < 0.05$) to determine which conditions caused a significant difference.

The fast tempo condition caused a significant increase in VO_2 ($p = 0.003$), Q ($p = 0.003$), SV ($p = 0.010$), and SVR ($p = 0.047$). The increase in VO_2 was related to the increase in Q, which was caused by the increase in SV. Although significance was found in three of the measures (VO_2, Q, and SV), they are all directly related physiologically. The authors note that the faster music could have caused an increase in contractility of the heart, a stimulation of increased catecholamine release, or an increased venous return, which led to increased SV and directly influenced the increase in VO_2 and Q.

The hemodynamics of the participants showed no changes. This is of particular interest since the factors such as HR and SBP were unchanged, but VO_2, Q, and SV increased with fast tempo music. Also noteworthy was the fact that a-vO_{2diff} remained unchanged through the three conditions, and although more oxygen was not extracted while participants were listening to fast music, the amount of oxygen that was delivered to the working muscles would have been higher during fast tempo music exercise due to higher Q and SV.

The lungs worked harder while the participants listened to fast-paced music. F_b ($p = 0.026$) and V_E ($p = 0.015$) were significantly increased when participants ran to fast tempo music compared to slow tempo music or no music. The authors posited that some lung efficiency was lost when listening to fast tempo music because the increase in V_E

was caused by an increase in F_b, although it was only 2 additional breaths per minute. RER was unchanged. The Birnbaum et al. (2009) research was important because it was a comprehensive study of 14 physiological and psychological responses during a music condition.

Nakamura, Pereira, Papini, Nakamura and Kokobun (2010) examined HR and RPE of subjects completing a cycle ergometer protocol at a high intensity with preferred music, nonpreferred music, and no music. The subjects were 15 males (mean age = 22.8 ± 3.1 years) who were categorized as recreational cyclists. The subjects chose the 10 preferred and 10 nonpreferred musical selections.The subjects performed five total test sessions over 15 days, and the last three were used for the experimental trials. The protocol was to cycle to exhaustion at a prescribed critical power intensity and the end time was recorded to mark performance.

Nakamura et al. performed a two-way repeated measures ANOVA of the exercise distance over the three conditions. A factorial ANOVA was applied to compare mean HR and RPE among conditions and times (HR and RPE were recorded every minute). A one-way ANOVA showed a statistically significant main effect of condition ($F_{2,42} = 2.00$, $p = 0.03$) and post hoc comparison showed that exercise distance (performance time) in the preferred music condition (m = 9.8 ± 4.6 km) was significantly greater than the nonpreferred condition (m = 7.1 ± 3.5 km) and the no music condition (m = 7.7 ± 3.4 km). There was no interaction between condition for HR or RPE. There was a main time effect for HR ($p = 0.0001$) and RPE responses ($p = 0.01$). Post hoc analysis revealed that the RPE in the nonpreferred condition was significantly higher ($p = 0.007$) than in the preferred music and no music conditions ($p = 0.026$).

The authors discussed the important finding that the RPE was significantly lower in the preferred music condition although the HR did not change among conditions. Preferred and nonpreferred music was never defined in the article. The authors may have defined these terms for the purpose of helping the subjects make musical selections but the definitions were not included and the reader must draw conclusions on how the subjects were instructed to make musical selections. The mean track length and beats·min^{-1} were compared for all preferred and nonpreferred tracks and it was noteworthy that the beats·min^{-1} were 117 ± 29 beats·min^{-1} for preferred music and 95 ± 28 beats·min^{-1} for the nonpreferred music which suggests that the tempo of the music, at the very least, made a difference in music selection as preferred or nonpreferred.

Miller, Swank, Robertson, and Wheeler (2010) studied RPE and enjoyment of the exercise task using a music condition (M) and a dialog condition (D) during submaximal treadmill running. The subjects were 10 males and 10 females (mean age = 23.4 ± 2.4 years). The subjects were allowed to choose the music for the M condition and the dialog for the D condition, which consisted of audiobooks, symposia, and educational compilations. The music had to have a vocal element and a tempo between 80-100 beats·min^{-1}. The participants underwent randomized trials of 20 minutes of treadmill running at 75-85% of age predicted heart rate max for the M and D conditions.

The researchers measured oxygen uptake (VO2), pulmonary ventilation (VE), tidal volume, (VT), frequency of breaths (f) and mean HR and compared the responses between two conditions: music (M) and dialog (D). The researchers found a significant ($p < 0.05$) difference for all of the variables except V_T. The VO_2, V_E, f, and HR were all higher for the M condition than the D condition, which is interesting because in the same study the RPE was lower for the M condition, which contradicts the finding that metabolic response was greater for the M condition.

Music and the Effect on Perceived Exertion

Another aspect of using motivational music with exercise is that music may help an athlete reduce the amount of perceived exertion, which is the subjective rating of how hard a person felt they worked to complete a given task. Borg (1982) redefined the rating of perceived RPE to a scale that ranges from 0-10, which is the scale that will be used in the present study.

Deutsch and Hetland (2012) examined performance, perceived effort, and perceived enjoyment of 9-11 year olds who participated in a fitness test. The subjects participated in the PACER test which is a multi-stage, progressive fitness test. Subjects consisted of 69 4^{th} and 5^{th} graders (male = 37, female= 32). The tests were conducted using three different conditions: a high-tempo music condition, a mild-tempo music condition, and a no music condition. The subjects were also given a survey following the test to capture data pertaining to perceived enjoyment and effort. The researchers found that students scored higher on the PACER test when one of the two music conditions was present, but the finding was not statistically significant. The researchers found a strong relationship between the survey results for enjoyment and perceived effort and the PACER results (males $p < 0.01$, females $p < 0.01$), indicating that the music condition increased enjoyment and decreased perceived effort. Scheffe post-hoc comparisons revealed that there were significant differences between each version of the music and the non-music condition (no music vs. mild-tempo $p = 0.031$; no music vs. high-tempo $p = 0.025$), but researchers did not find a significant difference between mild-tempo music and high-tempo music. The researchers found that boys performed the PACER test better to mild-tempo music (mean scores, no music = 27.84 ± 17.90, high-tempo music = 29.19 ± 19.34, and mild-tempo music = 30.68 ± 18.11). Girls performed the PACER test better to high-tempo music (mean scores, no music = 20.56 ± 10.87, high-tempo music = 22.34 ± 11.34, and mild-tempo music = 20.75 ± 11.17).

The survey that Deutsch and Hetland (2012) created for the study was a simple, 4-question survey using a Likert 4-point rating scale to come up with a total score. This was a simplistic way to measure enjoyment and effort which was efficient for the purposes of this study, but the results of this survey regarding RPE are not comparable to a standard 0-10 point or 6-20 point RPE scale that is typically used in studies in which perceived work is being measured. Because the researchers were testing younger subjects, it might have been more age-appropriate to use a 4-point rating scale.

In the Miller et al. (2010) study, the authors also hypothesized that RPE and enjoyment would be inversely related to each other. RPE was measured with the OMNI Perceived Exertion Scale and a subjective rating of exercise enjoyment was assessed with a 10-point Likert Scale following each trial. The two dependent variables of RPE and enjoyment were statistically analyzed between the two conditions with paired samples t-tests.

The statistical analysis revealed that RPE ratings were significantly higher (p = 0.01) for the D condition (m = 4.30 ± 0.83) than the M condition (m = 3.65 ± 0.87). Mean scores of enjoyment were significantly higher (p = 0.001) for the M condition (m = 8.95 ± 0.95) than the D condition (m = 5.60 ± 1.64). The data was consistent with the authors' hypotheses and shows that at submaximal exercise intensity, music can decrease RPE and increase enjoyment of the exercise task.

Nakamura et al. (2010) measured RPE during a high intensity cycling protocol under three music conditions of preferred, nonpreferred and no music. The researchers found that although heart rate remain unchanged among the conditions, RPE in the nonpreferred condition was significantly higher ($p = 0.007$) than in the preferred music and no music conditions ($p = 0.026$). If no change in HR over the three conditions indicated that metabolic demand was the same, a possible theory is that RPE would also remain unchanged. This study supports the theory that distraction from external stimulus can be possible through the use of music even with high intensity exercise.

Another theory in the literature is that music will only help lower RPE for untrained subjects, and that it will have minimal effect on trained subjects. Brownley et al. (1995) studied eight untrained and eight trained subjects in graded treadmill exercise under three conditions: no music, sedative music, or fast music. The sedative music was commercially-marketed stress management selections and the fast music was a sampling of music that ranged in beats$\cdot$min^{-1} from 154-162. The researchers hypothesized that the trained subjects would be unresponsive to music and would see no change in RPE, and that the music effects would be observed during the low and moderate exercise only and would not affect the subjects’ perception during high intensity activity. The protocols were three discontinuous walk/run treadmill sessions consisting of 10-minute stages of low (HR = 120 ± 10 BPM), moderate (HR = 140 ± 10 BPM), and high intensity exercise (HR = 160 ± 10 BPM). A fourth voluntary session was completed to exhaustion following the high intensity test. The subjects listened to each type of music condition for each low, moderate, and high intensity session. RPE was assessed with the Borg scale (6-20) and was collected at the end of each intensity stage. Another subjective scale was used for Feeling, with a score of very bad (-5) to very good (+5) (Hardy & Rejeski, 1989).

Statistical analyses were performed on the three conditions and intensities for RPE and Feeling with a repeated measures ANOVA and Tukey post hoc comparisons. A trend for a music × group × intensity interaction was found. Post-hoc analyses revealed that untrained subjects reported more positive effect during low intensity exercise compared to train subjects and untrained individuals reported more positive affect during fast music and trained individuals reported lowest affect during fast music. During the fourth phase to exhaustion, Feeling was significantly different between the groups ($F_{1,36} = 7.35$, $p < 0.01$). The trained subjects reported an overall negative feeling and the untrained subjects reported an overall positive feeling, with the largest group difference occurring under the fast music condition but the *P* value was not reported for the post-hoc analysis of the fast music condition in the exhaustive stage.

The Brownley et al. (1995) study reveals data that contradicts theory of music and RPE. First, the trained group reported overall higher RPE than the untrained group. The trained group RPE increased with the introduction of music conditions and was lowest during the no music condition (a reverse, non-significant trend). Also, the untrained group had the lowest mean RPE score with the fast music condition. Although these findings were not statistically significant, the trends counter the authors' hypotheses. The authors suggested that the findings reveal that "influence of music on RPE may not be generalizable to all exercise activities," (Brownley et al., 1995). The authors also theorized that the athlete who has more experience and trained aerobic capacity (indicators of training maturation), the less likely they are to experience a disruption of internal focus from an external stimuli, such as music, and they recommended further investigation of these concepts.

Mohammadzadeh, Tartibiyan, and Ahmadi (2008) also compared the effect of music on trained and untrained runners. The subjects were 18 males and six females (trained number = 12, mean age = 23.31 ± 2.06 years and untrained number = 12, mean age = 22.96 ± 2.31 years). The subjects completed a Bruce treadmill protocol to exhaustion with and without pre-selected music. The music was chosen by the authors and was described as stimulative music with a fast rhythm. The subjects reported the level of exertion using the Borg 0-10 scale at specific intervals throughout the test.

Mohammadzadeh et al. (2008) performed a 2 × 2 (Music Condition × Fitness Category) ANOVA. The authors found a significant main effect of music on RPE (F = 24.59, $p < 0.05$). RPE was lower in the music condition than the no music condition (trained w/music = 3.64 ± 1.43 vs. trained without music = 3.98 ± 1.51 and untrained w/music = 3.82 ± 0.97 vs. untrained without music = 4.79 ± 1.02) These findings are an important contribution to the body of research that is helping fitness professionals understand how to encourage untrained subjects to have more pleasant exercise experiences to encourage compliance with exercise programs. One major limitation of this study is that the music was pre-selected by the authors and no validation was done on the music to determine its motivational score.

Tenebaum et al. (2004) investigated the effect of music type on running and effort sensations. The subjects were 15 male participants (mean age = 23.24 ± 3.46 years) who regularly ran less than 3 times per week. The authors hypothesized the music would not divert the attention of the runners from the pain, fatigue, and discomfort experienced during the high intensity protocol and they would not see a difference in mean RPE among music and no music conditions. The treadmill protocol was graded to take each subject to 90% of VO_{2max} within 5 minutes and then the subjects ran to exhaustion. Song selections were done in a pilot study and were organized by theme: rock, inspirational, and dance. There was also a fourth no music condition. RPE was recorded every minute during each trial. The subjects were also given a survey pertaining to perception, motivation, and attention. Two of the questions dealing with demand and exertion during the exercise task were asked continually throughout the run and were assessed on a Likert 5-point scale. The remaining eight questions were asked after the completion of the run. These questions were related to features of the music and the effect of music type on perceptions of the run.

Tenebaum et al. (2004) used the means and standard deviations for "time to RPE strong" and "time in exertion" for each of the four running conditions. The researchers used a repeated measures ANOVA and post-hoc comparisons to identify the effect of music type on performance. The researchers found no significant difference in RPE or time to exhaustion between the three running trials ($p > 0.05$). The analysis of the demand survey revealed a significant effect for music type (Wilks' Lambda = 0.73, $F_{2,23} = 4.13$, $p < 0.03$). Inspirational music resulted in a significantly higher mean than the dance or rock conditions. The subjects indicated that the music had a greater effect during the initial phase of the run (m = 3.54 ± 1.12) compared to the end of the run (m = 2.52 ± 0.74) but overall the demands of the run were found to be non-significant based on music condition. These findings support the theories that type of music matters to subjective ratings of exertion and feeling during exercise and that music does not affect focus of attention during high intensity work.

Music Tempo and the Effect on Exercise

Runners attempt to manipulate their stride rate and intensity to follow a pace during the run in order to conserve metabolic cost for the duration of the event. Hausswirth, Le Meur, Bieuzen, Brisswalter, and Bernard (2010) looked at different pacing strategies during the running leg of the Olympic distance triathlon. The authors of this study were analyzing pacing changes as minor as 5% above or below a normal 10-km pace, and those minor differences in pace significantly affected the overall time of the entire run ($p < 0.05$). The pacing variable is a natural fit with music tempo. Using the beat or tempo of a musical piece to synchronize movements (Simpson & Karageorghis, 2006) has been studied with relation to how synchrony affects endurance, metabolic responses and rating of perceived exertion. The present study will analyze potential differences in pacing during the running protocol with a motivational music intervention.

Simpson and Karageorghis (2006) studied synchronous music and its effect on the 400-m sprint to examine anaerobic endurance. Before the experimental trial began, the researchers used 20 male undergrads to rate 32 songs for motivational rating with the BMRI-2. From these ratings, the researchers were able to identify two songs for each experimental condition. There was a motivational music condition, in which the highest rated BMRI-2 track was used (*Chase the Sun*, by Planet Funk) an oudeterous music condition, in which the lowest rated BMRI-2 track was used (*Starlight* by Supermen Lovers), and a control condition in which participants listened to white noise. The difference in ratings for the high and low rated songs was confirmed with a *t* test (t_{19} = 22.10, $p < 0.001$).

The experimental trial participants were 36 males (mean age = 20.4 ± 1.4 years) who all participated in a sport, independent of each other. Participants ran on a 400-m track and were timed with a stopwatch and performance times were compared among three conditions. They were also recorded with a digital video camera to analyze lower-limb movement to measure stride. Before the first experimental trial, the subjects ran the course and data was collected for the researchers to place them into six stride rate groups. The selected songs were then digitally altered to match the tempo closely to the projected stride rates for each group with the foot striking the ground at each beat. All subjects ran under each condition with a week rest between each trial. The researchers used a single-factor repeated measures ANOVA and Bonferroni adjusted pairwise comparisons were used to identify the differences.

The researchers found a large difference between all conditions ($F_{2, 68} = 10.54$, $p < 0.01$, $n^2 = 0.24$). Follow-up pairwise comparisons indicated that there was difference between the motivational music and the control condition (95% CI = -1.14 to -0.21. $p < 0.01$), the oudeterous music and the control condition, (95% CI = -0.50 to -0.12, $p < 0.01$), and no difference between the motivational music condition and the oudeterous music condition (95% CI = 0.12 to 0.50, $p > 0.05$). These findings indicated that, regardless of the motivational rating of the music, the music condition helped increase sprint time performance. The synchrony of the music and how it may have helped the runners was not affected by the motivational rating of the song. These findings further support the theory that the rhythm component is the strongest predictor of the motivational quotient of a motivational music piece (Karageorghis et al., 1999). One major limitation to this study was that the researchers were unable to quantify if perfect synchronization was matched to the musical piece.

Bacon, Myers, and Karageorghis (2012) studied VO_2, HR, and RPE of subjects performing cycle ergometry to three different tempi conditions: slow tempo asynchronous (ST-Async), synchronous (Sync), and fast tempo asynchronous (FT-Async). The subjects were 10 untrained males (mean age 21.7 years ± 0.8). The subjects cycled for 12 minutes at 70% maximal HR for each trial. The subjects completed the trials in synchrony with the music and out-of-synchrony with the music and researchers tried to determine the effect of these conditions on physiological measures. The musical selections for the experimental trials were assigned in random order using a double-blind procedure, and were identical musical tracks at 123, 130, and 137 $beats \cdot min^{-1}$. All three trials were ridden at a pedal cadence of 65 $revolutions \cdot min^{-1}$ and the Sync trial pedal cadence was synchronized to the music at 130 $beats \cdot min^{-1}$. The researchers performed repeated measures ANOVAs with Bonferroni adjusted pairwise comparisons on mean VO_2, HR, and RPE scores.

The researchers found a significant difference in mean VO_2 between the music conditions ($F_{2,18} = 6.4$; $p = 0.008$), and post hoc analysis showed that the Sync mean VO_2 was lower than the ST-Async, but no other significant differences existed among other comparisons. The authors were unable to discern if the reduced VO_2 was a result of the synchrony to music, rhythmic response to the different tempi, or a combination of both. The researchers posited that the higher VO_2 may have existed for the group trying to synchronize when a slower tempo is playing as they experienced a greater metabolic demand to make frequent, subtle adjustments to the pedal crank as they attempted to stay synchronized. The finding suggests there could be some effect of music tempo on metabolic demand.

Karageorghis et al. (2006a) also studied the relationship between exercise heart rate, music tempo preference and gender. The researchers used 29 subjects (14 women, mean age = 20.4 ± 1.3 years, and 15 men, mean age ± 1.1 years). The subjects were tested with pre-selected music conditions of three different tempi (80, 120, and 140 bpm). The subjects completed a treadmill walking protocol at 40%, 60%, and 75% intensity under the three music conditions while wearing heart rate monitors. The subjects were also asked to rate their preference for the music selection based on their current work level at the conclusion of each treadmill test. The subjects rated the music selections with a Likert 10-point scale. The authors hypothesized that there would be a positive linear relationship between exercise intensity and music tempo preference.

The researchers applied a mixed-model 3×3×2 (Exercise Intensity × Music Tempo × Gender) ANOVA. The authors found the interactions for Exercise Intensity × Music Tempo × Gender and two way interactions of Exercise Intensity × Gender and Music Tempo × Gender were all nonsignificant ($p > 0.05$). There was a significant effect for Exercise Intensity × Music Tempo ($p < 0.05$). Follow-up analysis revealed that preference for medium tempo music over fast tempo music differently significantly at 75% intensity ($F_{1,27} = 12.60$, $p < 0.01$). The most interesting finding that the authors made was that regardless of the heart rate intensities at which the subjects worked, the subjects preferred fast tempo music to slow tempo music ($p < 0.001$) and medium tempo music to slow tempo music ($p < 0.001$). This finding supports the theory that exercisers prefer fast tempo music for work at any given intensity. The subjects in this study were not able to synchronize walking to tempo because the researchers used the gradient to increase intensity, rather than increase the speed of the treadmill.

Deutsh and Hetland (2012) did not define the music tempo in their study to quantify the labels of mild- and high-tempo music. In order to further test the concepts of tempo, authors may include beats·min^{-1} (BPM) data in studies regarding tempo as standard practice. In the present study, BPM of each song will be included in the data to understand how the tempo of the song relates to the pace of the run and the potential variations in heart rate.

CHAPTER THREE: Methodology

Subjects

The subjects were 14 (Male = 6, Female = 8) trained runners age 19-34 (*M* = 24.86 ± 5.12 years). For the purpose of this study, the definition of trained runner was training at least 6 miles per week for the past 6 months. The subjects' mean resting heart rate was 70.64 ± 10.04 beats per minute. The subjects' mean calculated maximum heart rate was 188.43 ± 3.58. Anthropometric data are shown in Table 1.

Table 1

Descriptive statistics of anthropometric data

	N	Min	Max	M	SD
Age	14	19	34	24.86	5.12
Resting HR	14	54	95	70.64	10.04
Max HR	14	182	192	188.43	3.58

Note. N=number, M=mean, SD=standard deviation

Recruitment

Subjects were recruited through several methods. Approved flyers were distributed around the campus of a local university, in-class announcements were made to nine kinesiology and physical education classes, an announcement was made to the university's ROTC unit, a local running store displayed approved flyers in the store, and several subjects contacted the primary investigator after hearing about the study from friends or family (word of mouth). Institutional Review Board approval was granted before the commencement of the study.

Music Selection

The subjects were asked to self-select one motivational song. The instructions for selecting a song were sent to the participants prior to the study by electronic communication. The subjects were asked to “choose a song that would help motivate you during exercise.” The subjects were also asked to rate the motivational quotient for the song by using the Brunel Music Rating Inventory-2 (BMRI-2). The BMRI-2 is a six-question survey used to score a song for its motivational qualities (Karageorghis, Priest, Terry, Chatzisarantis, & Lane, 2006b). The survey is shown in Appendix A. The raw BMRI-2 score for each subject’s song was collected using an online survey tool by hyperlink in an email to each subject. BPM for each song were calculated by the primary investigator by counting the downbeat of the song for a minute and verifying with the online databases http://www.songbpm.com and http://www.jog.fm.

The mean beats per minute of the songs chosen for the music condition (MU) was 122.36 ± 25.17 beats per minute. Thirteen subjects completed the online survey for the motivational song, the Brunel Music Rating Inventory-2 (BMRI-2). The mean score of the BMRI-2 for the songs chosen for the MU condition was 39.23 ± 3.14 points out of a possible maximum score of 42. Descriptive statistics of the survey and music data are shown in Table 2.

Each song was purchased and downloaded from iTunes® for consistency of sound quality. All songs were pre-loaded on two music players. One iPod® was used during all the running trials while one was available as a backup. The song selections and artists for individual subjects are shown in Appendix B.

Table 2

Descriptive statistics of music data

	N	Min	Max	M	SD
BMRI2 Q1	13	5	7	6.54	.77
BMRI2 Q2	13	6	7	6.62	.50
BMRI2 Q3	13	5	7	6.31	.63
BMRI2 Q4	13	5	7	6.62	.76
BMRI2 Q5	13	4	7	6.23	.92
BMRI2 Q6	13	6	7	6.92	.27
BMRI2 Total	13	32	42	39.23	3.14
Song BPM	14	81	155	122.36	25.17

Note. N=number, M=mean, SD=standard deviation

Apparatus and Instrumentation

The experimental trials were conducted on a paved multi-use trail of a public park, and written permission was obtained before the commencement of the study. The course was measured with a Garmin™ Geko™ 201Handheld GPS. Weather data was retrieved from The Weather Channel® app for iPhone®, Version 5.5.2. A Trek® 2200 bike was mounted to a 1Up USA® cycling trainer for the prescribed warm-up. Subjects used their own personal headphones. The primary investigator provided the iPod® for music delivery. The iPod® was placed on the subjects with a standard armband designed to hold mp3 players during exercise. The heart rate data was collected with one of two heart rate monitor watches: The Garmin™ Forerunner® 405 Wireless GPS-Enabled Sport Watch with USB ANT Stick and Heart Rate Monitor and the Polar® RC3 GPS™ Heart Rate Monitor. A standard stopwatch was used to record the official time of each trial.

Testing Procedure and Data Collection

Prior to the experimental trials being conducted, the title and artist of the motivational song were collected from each subject. The motivational quotient of song was collected using the BMRI-2 through a hyperlink to an online survey tool at http://www.surveymonkey.com. The start time of the trial, a map to the course, and the study instructions were also communicated to the subjects prior to the experimental trials. The study instructions included the request to refrain from caffeine, a heavy workout, or alcohol 24 hours prior to the test.

The experimental trials were conducted as a randomized, repeated-measures design. The trials were held at least seven days apart to allow runners sufficient time to recover from fatigue following a maximal test, but no more than 14 days apart to avoid any training or de-training adaptations which could have affected the performance during the second trial. Order of testing with and without the music treatment was randomized by alternating the order of treatment for each subject. The order of testing is shown in Appendix C. At the time of check-in, informed consent, age and resting pulse were collected. The Informed Consent document is shown in Appendix D. Subjects were assigned a de-identified number for identification by the primary investigator prior to the trials. Individual data collection is shown in Appendix E.

For the prescribed warm-up, the age of the subject was used to calculate estimated heart rate max with the following equation: 205.8-0.685(age) (Robergs and Landwehr, 2002). The heart rate max was multiplied by 60% intensity to determine the beats per minute target for the warm-up. The subject pedaled on the trainer while watching the heart rate monitor for the target heart rate of 60% of maximum. Once the target heart rate was reached, the stopwatch was started and each subject completed the warm-up at the target heart rate for 10 minutes. The subjects were instructed to increase or decrease pedaling speed to keep the heart rate at the target for the entirety of the 10 minute warm-up. Upon completion of the prescribed warm-up, each subject was allowed the option to complete three minutes of self-lead stretching. Subjects were instructed to use an identical stretching routine (or opt out) for both experimental trials.

Following the completion of warm-up and stretching, the HRM was set to begin recording data. If the runner was testing with the music condition, the iPod was set up on the runner with an armband and the headphones were put in place. Volume was controlled to a moderate level by the primary investigator to ensure that extreme volume was not a variable to affect performance. The selected song was put in repeat mode so that the song would loop continuously until the completion of the trial.

Each runner completed the trial separate from the other subjects to control for a competition effect, in which subjects could be influenced by the pace of another runner during testing. The course was explained to every subject with the following prompt: "This course is an out-and-back 2x course, so you will run out, back, out, back." Each leg of the course was .375 miles. The subjects were instructed to run the 1.5 mile distance "as hard as you can" because it was a maximal intensity protocol. Subjects were then instructed that official time would begin on the primary investigator's verbal command to go. The subject's song was confirmed and started, the heart rate monitor was started, and then the stopwatch was started as the primary investigator gave the verbal command.

The course was marked with double cones, one on each side of the trail, at the start/finish point and the turnaround point. After the run began, the split times were recorded at the start/finish markers (the second turnaround), and the subject continued and ran the second split (out and back again). After the completion of the run, the HRM was stopped for the trial, and the subjects walked with the primary investigator for a five minute cool-down. A single heart rate measurement was taken at the first minute of recovery and again at three and five minutes of recovery. During the cool-down, the subject's RPE was collected using the Borg scale (Borg, 1982), which rates exertion on a scale of 0-10. Every subject was asked to rate the perception of exertion during the run with the following prompt: "Please tell me how hard you feel you worked during the run. On a scale of 0-10, with 0 being equivalent to sitting on the couch at home watching television, and 10 being the equivalent to the hardest workout of your life, how would you rate this run?" RPE was collected after every trial. The raw values for data collection are shown in Appendix F. The order of the procedures for data collection is shown in Figure 1.

Statistical Analysis

Statistical analysis was conducted with IBM® SPSS® Version 21. Three dependent variables were measured against the music condition. Dependent *t* tests were conducted for performance time, average heart rate, and RPE. The alpha level for statistical significance was set at $p < 0.05$.

Power Analysis

To determine the sample size and statistical power, data from a similar study was used. Hagen et al. (2013) studied the effect of music on a 10- km cycling time trial. The researchers measured performance time, mean power output, heart rate max, peak lactate, and peak RPE. The variables of time, heart rate max and RPE were used to calculate

Cohen's d. To calculate the Cohen's d, the control group mean measurement was subtracted from the treatment group mean measurement for each tested variable. The resulting number was divided by the standard deviation of the mean measurement of the control group:

$$\text{Cohen's d} = \frac{\text{M1-M2}}{\text{SD of control group}}$$

Performance time mean with music was 17.75 ± 2.10 minutes and 17.81 ± 2.06 minutes for the no music condition. The heart rate max mean with music was 184 ± 9 bpm and 183 ± 8 bpm for the no music condition. The RPE mean with music was 8.4 ± 1.5 and 8.5 ± 1.6 for the no music condition. The calculated Cohen's d for performance time was 0.03. The calculated Cohen's d for heart rate max was 0.125. The calculated Cohen's d for peak RPE was 0.06. The Cohen's d statistics were used with the statistical power of .80 to determine sample size. The recommended sample size for each variable was 100+ participants. The sample size for this study was limited to 15 participants due to time constraints of the primary investigator.

ORDER OF PROCEDURE FOR DATA COLLECTION	
1. IRB approval obtained	
2. Subjects recruited	
3. Artist/title of motivational song collected from subjects	
4. Music survey data collected from subjects	
5. Study instructions communicated to subjects	
6. Course measured and marked by primary investigator	
7. Subjects were alternated into music (MU) or non-music (NM) upon arrival to Trial 1 by the Primary Investigator (PI).	
MU TRIALS	**NM TRIALS**
8a. Informed consent collected	8b. Informed consent collected
9a. Heart rate monitor (HRM) placed on subject	9b. Heart rate monitor (HRM) placed on subject
10a. Resting heart rate collected	10b. Resting heart rate collected
11a. Prescribed warmup conducted	11b. Prescribed warmup conducted
12a. 3-5 minutes of optional stretching	12b. 3-5 minutes of optional stretching
13a. iPod® placed on subject	13b. Course and trial instructions explained to subject
14a.Song confirmed by subject and volume controlled to a moderate level by PI	14b. Subject moved to start point
15a. Course and trial instructions explained to subject	15b. HRM recording started
16a. Subject moved to start point	16b. Stopwatch (official time) started as PI gave verbal command to go
17a. HRM recording started	17b. Subject completed 1.5 mile trial at maximal intensity
18a. Music started	18b. Upon completion of trial, stopwatch stopped, HRM stopped
19a. Stopwatch (official time) started as PI gave verbal command to go	19b. Subject and PI walked for 5 minute cooldown
20a. Subject completed 1.5 mile trial at maximal intensity	20b. Heart rate data collected at 1, 3, and 5 minutes during recovery
21a. Upon completion of trial, stopwatch stopped, HRM stopped	
22a. Subject and PI walked for 5 minute cooldown	
23a. Heart rate data collected at 1, 3, and 5 minutes during recovery	

Figure 1. The order of procedure for data collection

CHAPTER FOUR: Results

Finish Time

Research Question 1: Will subjects' finish time be significantly lowered when running a 1.5 mile outdoor time trial with self-selected motivational music (MU) when compared to running with no music (NM)?

Hypotheses 1 – Finish time

H_0: $\mu_{MU} = \mu_{NM}$

H_1: $\mu_{MU} < \mu_{NM}$

On average, subjects did not run significantly faster with motivational music (*M* = 11:57 ± 1:43 minutes) than without motivational music (*M* = 12:08 ± 1:46 minutes), $t(13) = 1.754$, $p = 0.0515$, $r = 0.43$. The results of the finish time variable are shown in Table 3 and Figure 2.

Table 3

Results from the dependent *t* test for finish time.

	Statistics			
	N	M	SD	SE
NM finish time	14	12:08	1:46	0:28
MU finish time	14	11:57	1:43	0:27

	Correlations		**Paired test**					
	Corr.	Sig.	M	SD	SE	*t*	*df*	Sig. (1-Tailed)
NM-MU paired	.975	.000	0:11	0:23	0:06	1.754	13	.0515

Note. N=number, M=mean, SD=standard deviation, SE=standard error mean

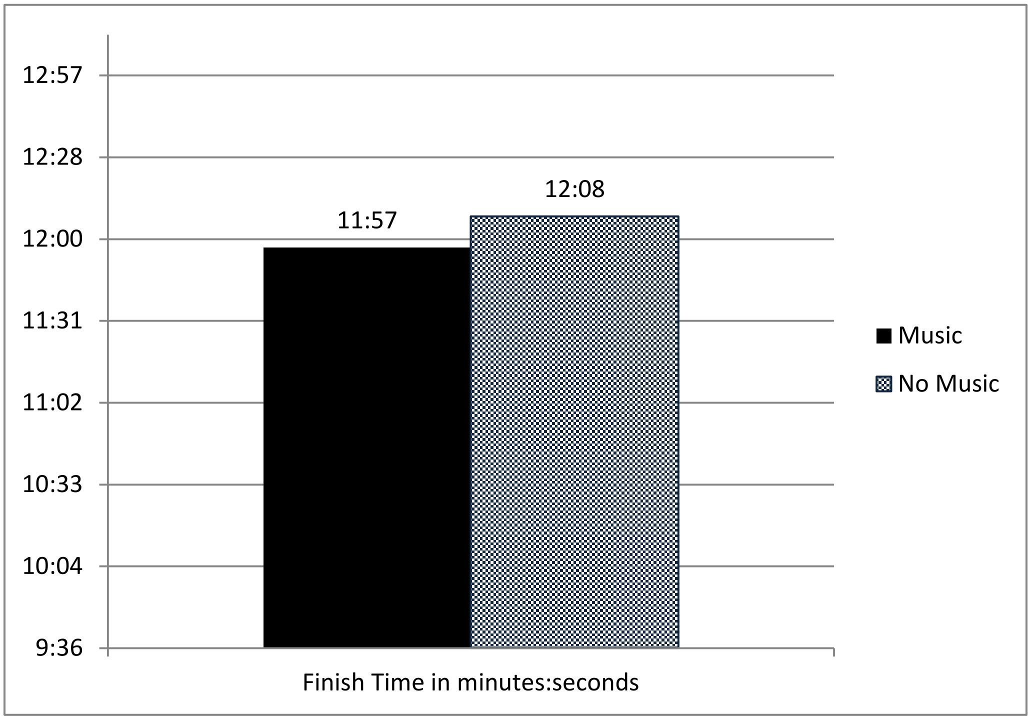

Figure 2. The difference in mean finish time with music (11:57 minutes) and no music (12:08 minutes).

Average Heart Rate

Research Question 2: Will subjects' average heart rate be significantly higher when running a 1.5 mile outdoor time trial with self-selected motivational music (MU) when compared to running without music (NM)?

Hypotheses 2 – Average heart rate

$\mathbf{H_0: \mu_{MU} = \mu_{NM}}$

$\mathbf{H_1: \mu_{MU} > \mu_{NM}}$

On average, subjects did not have a significantly higher average heart rate with motivational music (*M* = 175.62 ± 7.38 beats per minute) than without motivational music (*M* = 170.38 ± 15.8), $t(12) = -1.637$, $p = 0.128$, $r = 0.42$. The results of the average heart rate are shown in Table 4 and Figure 3.

Table 4

Results from the dependent *t* test for average heart rate.

	Statistics									
	N	M	SD	SE						
NM AVG HR	13	170.38	15.8	4.38						
MU AVG HR	13	175.62	7.38	2.04						
	Correlations				**Paired test**					
	Corr.	Sig.			M	SD	SE	*t*	*df*	Sig. (1-Tailed)
NM-MU paired	.736	.004			-5.23	11.51	3.19	-1.637	12	.064

Note. N=number, M=mean, SD=standard deviation, SE=standard error mean

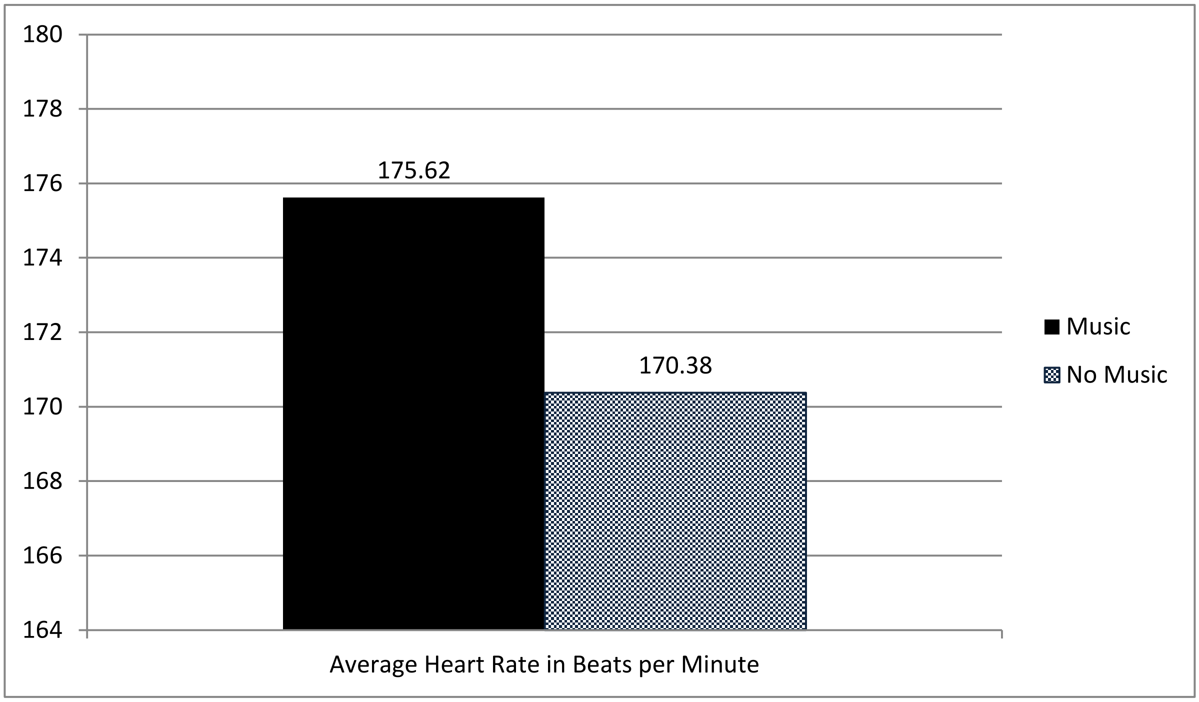

Figure 3. The difference in the average heart rate with music (175.62 bpm) and no music (170.38 bpm).

Rating of Perceived Exertion

Research question 3: Will subjects' rating of perceived exertion (RPE) be significantly different when running a 1.5 mile outdoor time trial with self-selected motivational music (MU) when compared to running with no music (NM)?

Hypotheses 3 – RPE

$$\mathbf{H_0: \mu_{MU} = \mu_{NM}}$$

$$\mathbf{H_1: \mu_{MU} \neq \mu_{NM}}$$

On average, subjects had a significantly lower RPE with motivational music ($M = 6.9 \pm 1.22$) than without motivational music ($M = 7.4 \pm 1.02$), $t(13) = 2.446$, $p = 0.029$, $r = .56$. The results of the RPE are shown in Table 5 and Figure 4.

Table 5

Results from the dependent *t* test for RPE.

	Statistics			
	N	M	SD	SE
NM RPE	14	7.4	1.02	.27
MU RPE	14	6.9	1.22	.32

	Correlations		**Paired test**					
	Corr.	Sig.	M	SD	SE	*t*	*df*	Sig. (2-Tailed)
NM-MU paired	.748	.002	.53	.81	.21	2.446	13	.029*

Note. N=number, M=mean, SD=standard deviation, SE=standard error mean $^*p<0.05$

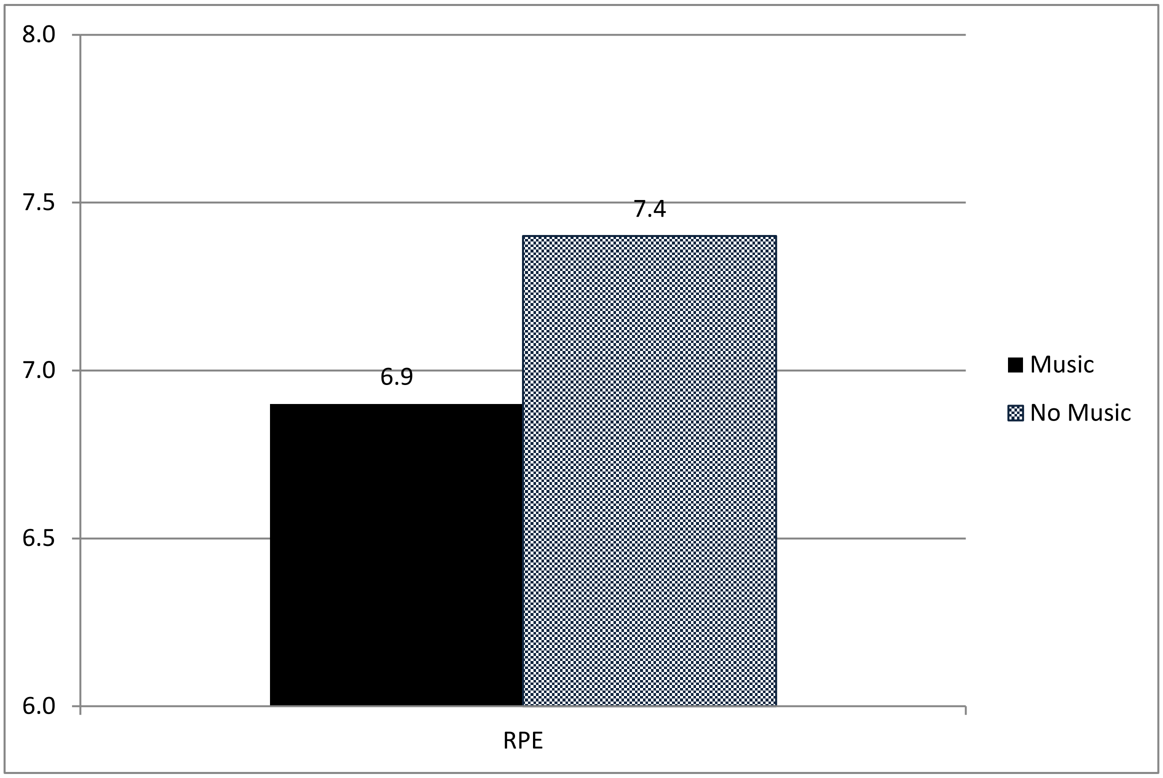

Figure 4. The difference in RPE with music (6.9) and no music (7.4).

CHAPTER FIVE: Discussion

Finish Time

The current study aimed to determine if listening to motivational music during a 1.5 mile time trial would yield a faster finish time. Results indicate that the music condition did not significantly decrease the finish time. The mean difference shows that the subjects ran the time trial an average of 11 seconds faster with the music condition. Although the results were not significant, the faster time with music is supported by previous findings from other studies regarding music and maximizing performance. Lane and Devonport (2011) studied 65 runners who self-selected a goal time to beat to ensure maximal performance. The researchers found significant improvements in finish time with a music condition compared to a no-music condition. The Lane and Devonport protocol is similar to the present study in that the subjects self-selected pace in a closed-loop course.

Hagen et al. (2013) elaborated on the concepts of the open-loop and closed-loop styles of study design. The open-loop design is when the subject completes the exercise to exhaustion, or for a set amount of time, and the course is open to being traveled the farthest distance possible. The closed-loop design is when the course distance is set and the subjects perform in the closed-loop course at a maximum effort, similar to real-world competition settings. The Hagen et al. study protocol and rationale for the design were influential in the present study. However, Hagen et al. found no significant differences in performance time when using self-selected motivational music on well-trained cyclists in a 20 km time trial.

Ghaderi, Rahimi, and Azarbayjani (2009), Barwood et al. (2009), and Nakamura et al. (2010) all found significant differences in performance with a music condition.

These studies were all categorized as open-loop protocols. Nakamura et al. tested a cycling task to exhaustion with preferred music and Ghaderi et al. tested a treadmill running task to exhaustion with motivational music. Barwood et al. (2009) used a 15 minute maximal treadmill protocol with a music and video condition (to simulate the fitness center experience) and found improved distance traveled with the music and video condition. Although the open-loop is not applicable to the ecologically valid setting (Simpson and Karageorghis, 2006) of the present study, these aforementioned findings show that music can improve performance in maximal intensity exercise.

A follow-up analysis was conducted with the results from the dependent *t* test for finish time. The effect size was calculated using the following equation (Field, 2009):

$$r = \sqrt{\frac{t^2}{t^2 + df}}$$

The effect size for the variable of finish time was *r*= 0.43, indicating a moderate to large effect on the variance (Field, 2009). This effect size is consistent with the hypothesis and the support from literature. The follow-up analysis indicates that with a larger sample size, significant results may be found. Future research should focus on recruiting a sample of at least 25 runners.

Music Analysis

The design of the present study allowed for subjects to self-select the motivational song for the music treatment. It was important, within the context of the present study, to allow the subjects the autonomy to choose a song which would motivate each individual to a maximal performance. Accounting for individual preference has been found to be essential to affecting the greatest response in the individual because of the various underlying components to music preference (Karageorghis, Terry, and Lane, 1999).

Subjects rated the motivational quotient of the chosen song with the BMRI-2. The mean score was 39.23 out of 42 possible points, with each question being worth a maximum of 7 points. The scores from the present study show that the self-selected music condition produced highly motivational song choices. Lane and Devonport (2011) revealed a positive association between improved performance time and higher scores on the BMRI-2 when they tested 65 runners who used self-selected and auto-selected motivational music. The study showed that runners had an increase in pleasant emotions during a music intervention and believed that emotional state influences performance.

In the present study, the question with the highest mean score (6.92) was Question 6: “The beat of this music would motivate me during exercise.” The question with the lowest mean score (6.23) was Question 5: “The sound of the instruments used (i.e. guitar, synthesizer, saxophone, etc.) would motivate me during exercise. These findings are in congruence with the concept that tempo is the most important factor in choosing a motivational song, which was supported by Karageorghis, Terry, and Lane (1999) in the initial development of the original Brunel Music Rating Inventory. Even if rhythm is the only component of the musical piece, it can make an impact. Crust and Clough (2006) found that subjects who listened to rhythm-only tracks with no melody or other instrumentation endured an isometric weight-holding task for significantly longer than with no auditory stimulus.

In the present study, the average tempo for the chosen songs was 122.36 bpm, which narrowly meets the classification of fast music (120 bpm) as established by

Karageorghis, Terry and Lane (1999) in the initial development and validation of the Brunel Music Rating Inventory. Karageorghis, Priest, Williams, Hirani, Lannon and Bates (2010) chose and quantified music for a circuit-training study at 120 bpm, which is important because the protocol was not performed at a high intensity. Karageorghis, Mouzourides, Priest, Sasso, Morrish, and Walley (2009) also used music set to 125 bpm for treadmill walking, which is considered a moderate intensity activity (American College of Sports Medicine, 2014). These studies indicate that the average tempo for songs in the present study is low when considering the protocol design of a maximal intensity running time trial. According to jog.fm, a website used to design music playlists for pace training, the average tempo of the present study is equivalent to a 13:00 minute/mile (http://www.jog.fm). Indeed, five runners from the present study chose songs with a tempo at or below 100 beats per minute, which is considerably slow as a running tempo. In future research, it would be of interest to set or manipulate tempo parameters for song selection to ensure that the music tempo may positively impact performance.

Average heart rate

Another objective of the present study was to measure the effect of motivational music on average heart rate during the running time trial. Analysis of the descriptive data revealed two outliers (Subjects 14 and 15). A follow-up review of the heart rate data in one-second intervals showed that the HR monitor recorded heart rate data correctly for Subject 14 and the HR data were left in the sample. Analysis also showed that the HR monitor did not record heart rate data correctly for Subject 15, and the HR data were eliminated from the sample. Final statistical tests were calculated for 13 subjects.

Results indicate that the music condition did not significantly increase average heart rate. The mean difference shows that the subjects experienced an average heart rate of 5.2 beats per minute faster with the music condition. Although the results were not significant, the higher average heart rate indicates that music may have played a role in stimulating the physiological response of subjects. The average maximum heart rate (188 bpm) was divided by the average heart rates of the NM and MU conditions and converted to a percentage of max. An increase of 5.2 beats per minute means that, on average, subjects ran at 90.6% of their maximum heart rate without music, and at 93.4% of their maximum heart rate with music. Effect size was calculated in follow-up analysis and revealed a moderate to large effect ($r = 0.42$) on the variance (Field, 2009).

Ellis and Thayer (2010) explain that the chronotropic control of the heart lies in the sympathetic nervous system, which may be the same pathway of excitatory response to music. Previous studies allude to this stimulating effect. Barwood et al. (2009) found mean heart rates tended to be higher for subjects under a music condition during a maximal treadmill protocol. Similar to findings in the present study, Nakamura et al. (2010) and Brownley et al. (1995) found higher average heart rates under the music condition which were not statistically significant. Birnbaum et al. (2009) tested different tempos and the effects on cardiovascular function and concluded that fast tempo music increased stroke volume and cardiac output, but they did not find a significant increase in heart rate. This finding indicates that motivational music may help the heart function more efficiently during exercise.

Rating of Perceived Exertion

The variable of subjects' perceived exertion was also analyzed. Results indicate that the music condition significantly decreased the subjects' perceived exertion during the run. The mean difference indicates that the subjects had an RPE of 0.5 lower (on a scale of 0-10) with the music condition. There is a great deal of support in the literature (Tenenbaum et al., 2004; Dyer and McKune, 2013; Barwood et al., 2013) that indicates that music does not affect perceived exertion when exercise is performed at a high intensity by trained subjects, such as the present study. The theory is that the focus for trained individuals turns away from external cues such as music (dissociation) and toward internal cues (association) as the exercise intensity and the physiological demand on the body increases (Tenenbaum et al., 2004). In other words, trained individuals are not as sensitive to external stimuli when performing.

It is also noteworthy that RPE was lowered with the music condition in the present study but the average heart rate was higher, although not statistically significant. Miller et al. (2010) also found an increased heart rate and lowered RPE with a music condition, and the authors concluded that this finding is contradictory in nature. If an individual's cardiovascular system is working harder, it is expected that the perceived exertion would also be higher (Miller et al., 2010).

The findings on RPE from the current study are in contrast to the current research and are encouraging to the potential application of music in enduring high intensity exercise. As the body of research on high intensity exercise continues to emerge, researchers such as Gibala, Little, MacDonald, and Hawley (2012) have reported that high intensity may be the key to the improvement of biomarker profiles such as insulin sensitivity and resting blood pressure. It is encouraging to find that music may help with the adherence to an exercise protocol which may have the potential to reduce disease states and improve health.

Conclusion

The current study did not show significantly lower finish time, but the effect size indicates that a larger sample may reveal that the motivational music condition can help to improve performance. Average heart rate was higher for the music condition, which may be due to music's influence on the sympathetic nervous system. However, the finding was not statistically significant. Perceived exertion of the runners was significantly lowered with the motivational music condition. The findings from this study on perceived exertion indicate that there may be a need to further study motivational music and its application to untrained subjects in maximal intensity exercise, as research continues to reveal the benefits of high intensity exercise for improved health.

Recommendations for Future Study

1. Test more subjects with the same protocol. The findings from the current study support a sample size of at least 25 runners to strengthen the results.
2. Conduct the same protocol in a single gender study to test the variance in a larger, more homogenous sample.
3. Measure the effects of motivational music on untrained subjects during maximal intensity exercise.
4. Further delineate the training levels of the runners in the initial study design. In the present study, trained runner was defined as training at least 6 miles per week for the last 6 months. However, there was no cap on the training parameters and the study consisted of a range of recreational to sub-elite runners.
5. Use running clubs to recruit subjects and schedule the study around the running club calendar. An ideal outdoor environment study would be one in which the study is scheduled on a running club's calendar of events for the members, and the trials are scheduled in succession to each other over a single day. The second trials would then be conducted in the same order one week later. Using running clubs would potentially make it easier to recruit for this design, and having all of the runs occur over two days, one week apart, could potentially limit weather variability.
6. Further explore the relationship between tempo and running pace by building the study design around tempo-lead song choices. Subjects can choose from a list of songs at a desired tempo. The songs should be chosen by the investigators for

matched tempo to a desired pace, such as a best recent 5k competition pace for a 5k trial.

7. Take the advice of your Thesis Chairperson early and often. ☺

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TABLES

Table 1

Descriptive statistics of anthropometric data

	N	Min	Max	M	SD
Age	14	19	34	24.86	5.12
Resting HR	14	54	95	70.64	10.04
Max HR	14	182	192	188.43	3.58

Note. N=number, M=mean, SD=standard deviation

Table 2

Descriptive statistics of music data

	N	Min	Max	M	SD
BMRI2 Q1	13	5	7	6.54	.77
BMRI2 Q2	13	6	7	6.62	.50
BMRI2 Q3	13	5	7	6.31	.63
BMRI2 Q4	13	5	7	6.62	.76
BMRI2 Q5	13	4	7	6.23	.92
BMRI2 Q6	13	6	7	6.92	.27
BMRI2 Total	13	32	42	39.23	3.14
Song BPM	14	81	155	122.36	25.17

Note. N=number, M=mean, SD=standard deviation

Table 3

Results from the dependent *t* test for finish time.

	Statistics										
	N	M	SD	SE							
NM finish time	14	12:08	1:46	0:28							
MU finish time	14	11:57	1:43	0:27							
	Correlations				**Paired test**						
	Corr.	Sig.			M	SD	SE	*t*	*df*	Sig. (1-Tailed)	
NM-MU paired	.975	.000			0:11	0:23	0:06	1.754	13	.0515	

Note. N=number, M=mean, SD=standard deviation, SE=standard error mean

Table 4

Results from the dependent *t* test for average heart rate.

	Statistics									
	N	M	SD	SE						
NM AVG HR	13	170.38	15.8	4.38						
MU AVG HR	13	175.62	7.38	2.04						
	Correlations				**Paired test**					
	Corr.	Sig.			M	SD	SE	*t*	*df*	Sig. (1-Tailed)
NM-MU paired	.736	.004			-5.23	11.51	3.19	-1.637	12	.064

Note. N=number, M=mean, SD=standard deviation, SE=standard error mean

Table 5

Results from the dependent *t* test for RPE.

	Statistics					
	N	M	SD	SE		
NM RPE	14	7.4	1.02	.27		
MU RPE	14	6.9	1.22	.32		

	Correlations		Paired test					
	Corr.	Sig.	M	SD	SE	*t*	*df*	Sig. (2-Tailed)
NM-MU paired	.748	.002	.53	.81	.21	2.446	13	.029*

Note. N=number, M=mean, SD=standard deviation, SE=standard error mean *p<0.05

FIGURES

ORDER OF PROCEDURE FOR DATA COLLECTION	
1. IRB approval obtained	
2. Subjects recruited	
3. Artist/title of motivational song collected from subjects	
4. Music survey data collected from subjects	
5. Study instructions communicated to subjects	
6. Course measured and marked by primary investigator	
7. Subjects were alternated into music (MU) or non-music (NM) upon arrival to Trial 1 by the Primary Investigator (PI).	
MU TRIALS	**NM TRIALS**
8a. Informed consent collected	8b. Informed consent collected
9a. Heart rate monitor (HRM) placed on subject	9b. Heart rate monitor (HRM) placed on subject
10a. Resting heart rate collected	10b. Resting heart rate collected
11a. Prescribed warmup conducted	11b. Prescribed warmup conducted
12a. 3-5 minutes of optional stretching	12b. 3-5 minutes of optional stretching
13a. iPod® placed on subject	13b. Course and trial instructions explained to subject
14a.Song confirmed by subject and volume controlled to a moderate level by PI	14b. Subject moved to start point
15a. Course and trial instructions explained to subject	15b. HRM recording started
16a. Subject moved to start point	16b. Stopwatch (official time) started as PI gave verbal command to go
17a. HRM recording started	17b. Subject completed 1.5 mile trial at maximal intensity
18a. Music started	18b. Upon completion of trial, stopwatch stopped, HRM stopped
19a. Stopwatch (official time) started as PI gave verbal command to go	19b. Subject and PI walked for 5 minute cooldown
20a. Subject completed 1.5 mile trial at maximal intensity	20b. Heart rate data collected at 1, 3, and 5 minutes during recovery
21a. Upon completion of trial, stopwatch stopped, HRM stopped	
22a. Subject and PI walked for 5 minute cooldown	
23a. Heart rate data collected at 1, 3, and 5 minutes during recovery	

Figure 1. The order of procedure for data collection

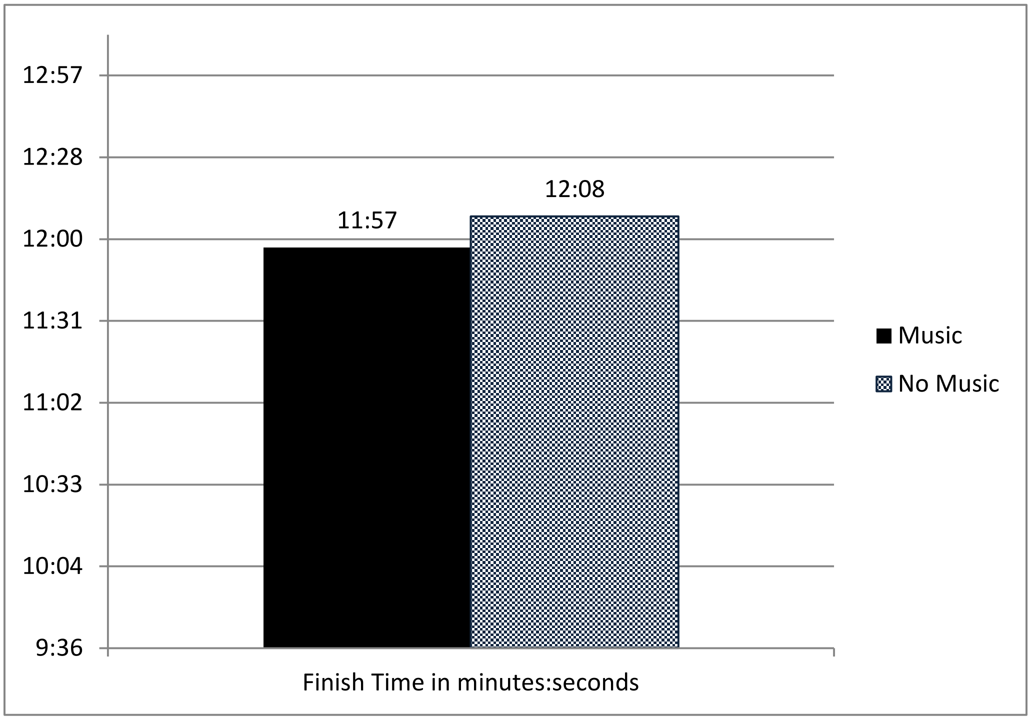

Figure 2. The difference in mean finish time with music (11:57 minutes) and no music (12:08 minutes).

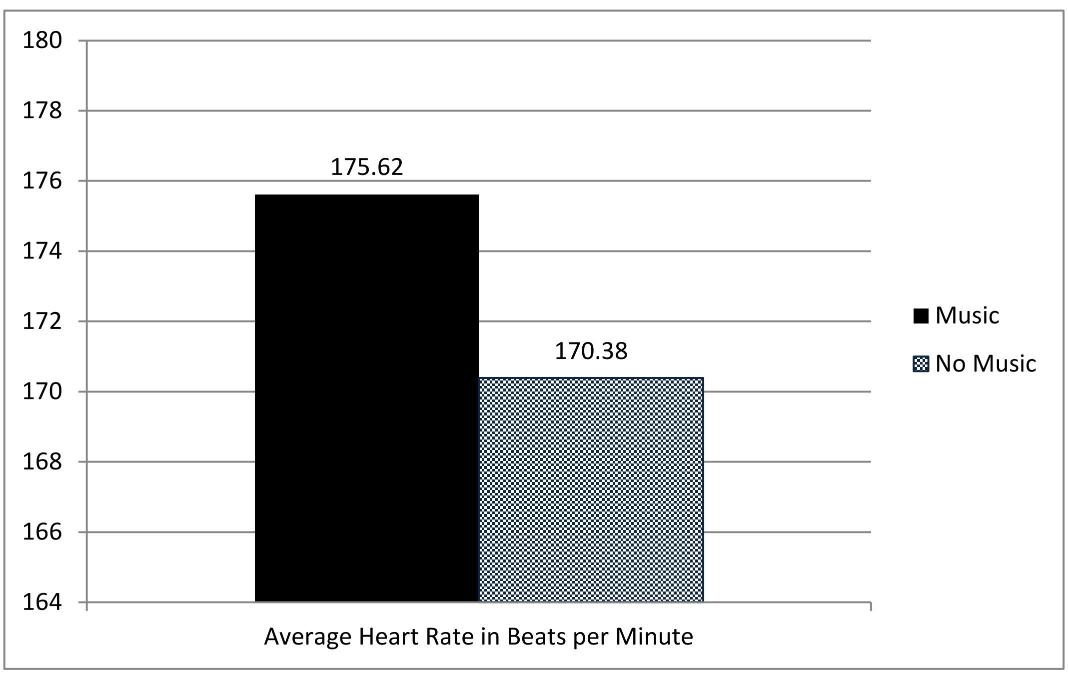

Figure 3. The difference in the average heart rate with music (175.62 bpm) and no music (170.38 bpm).

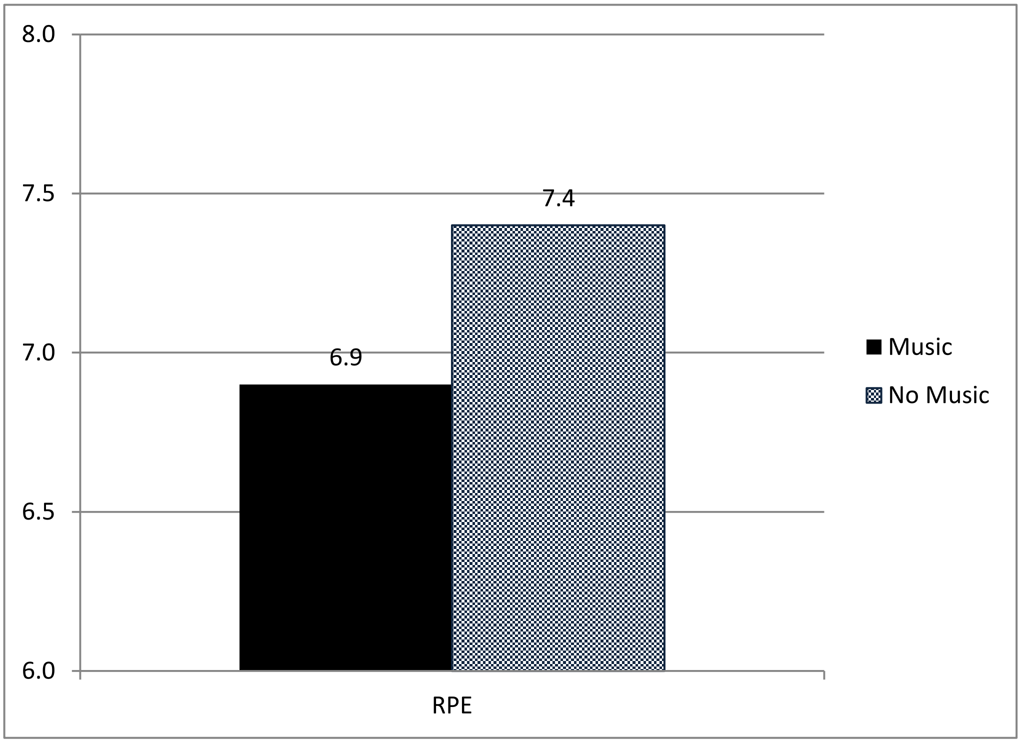

Figure 4. The difference in RPE with music (6.9) and no music (7.4).

APPENDIX A

Brunel Music Rating Inventory-2

BMRI 2

The purpose of this questionnaire is to assess the extent to which the piece of music you are about to hear would motivate you during exercise. For our purposes, the word "motivate" means music that would make you want to exercise harder and/or longer. As you listen to the piece of music indicate the extent of your agreement with the statements listed below by selecting one of the numbers. We would like you to provide an honest response to each statement. Give the response that best represents your opinion and avoid dwelling for too long on any single statement.

1. The rhythm of this music would motivate me during exercise

1 - Strongly disagree	2	3	4 - In-between	5	6	7 - Strongly agree
○	○	○	○	○	○	○

2. The style of this music (i.e. rock, dance, jazz, hip-hop, etc.) would motivate me during exercise

1 - Strongly disagree	2	3	4 - In-between	5	6	7 - Strongly agree
○	○	○	○	○	○	○

3. The melody (tune) of this music would motivate me during exercise

1 - Strongly disagree	2	3	4 - In-between	5	6	7 - Strongly agree
○	○	○	○	○	○	○

4. The tempo (speed) of this music would motivate me during exercise

1 - Strongly disagree	2	3	4 - In-between	5	6	7 - Strongly agree
○	○	○	○	○	○	○

5. The sound of the instruments used (i.e. guitar, synthesizer, saxophone, etc.) would motivate me during exercise

1 - Strongly disagree	2	3	4 - In-between	5	6	7 - Strongly agree
○	○	○	○	○	○	○

6. The beat of this music would motivate me during exercise

1 - Strongly disagree	2	3	4 - In-between	5	6	7 - Strongly agree
○	○	○	○	○	○	○

Done

APPENDIX B

Self-selected motivational songs

Subject	Song Title	Artist Name
1	My Songs Know What You Did in the Dark	Fallout Boy
2	Diamonds from Sierra Leone	Kanye West & JAY Z
3	Oklahoma Girl	Eli Young Band
4	Make War (feat. Flame)	Tedashii
5	Funky Tonight	John Butler Trio
8	Dark Horse (feat. Juicy J)	Katy Perry
10	Babel	Mumford & Sons
11	Demons	Imagine Dragons
12	La La La (feat. Sam Smith)	Naughty Boy
13	Move in the Right Direction	Gossip
14	300 Violin Orchestra	Jorge Quintero
15	Feel This Moment (feat. Christina Aguilera)	Pitbull
16	Sail	AWOLNATION
17	Good Day (feat. Tyga, Meek Mill & Lil Wayne)	Young Money

APPENDIX C

Order of Testing with Treatment

Subject	1st Trial MU	1st Trial NM
1		X
2		X
3	X	
4	X	
5	X	
8		X
10		X
11	X	
12	X	
13	X	
14		X
15	X	
16	X	
17		X

APPENDIX D

UNIVERSITY OF CENTRAL OKLAHOMA

INFORMED CONSENT FORM

Research Project Title: **Effects of Motivational Music on a 1.5 Mile Running Time Trial**

Researchers: **Jamie Aweau and Dr. Brady Redus**

A. Purpose of this research: The purpose of the study is to measure the effect of motivational music on performance, heart rate, pace, and perceived exertion of trained runners in a 1.5 mile maximal effort time trial. The information will be used toward completion of a thesis project by the primary investigator, Jamie Aweau. Additional use of the data includes, but is not limited to, professional publications.

B. Procedures/treatments involved: Participants who volunteer for this study will choose a motivational song, complete a survey about this song, and then complete two experimental trials which will be conducted 7-14 days apart. Both trials must be completed by the participant. During the trial, the participant will warm-up, complete the 1.5 mile run, and cool-down. Participants will listen to a self-selected motivational song with headphones/iPod while running a 1.5 mile maximal effort time trial. Participants will also wear a heart rate monitor.

C. Expected length of participation: Participants will take time to choose a motivational song and answer a six-question web-based survey about the selected song. Each experimental trial will last about 30 minutes each to include check-in, warm-up, run, cool-down, and post-run survey.

D. Potential benefits: There is very little direct benefit to the participant. Performance data that is collected may be used after the completion of the study as training feedback and would be a direct benefit to you. The data that is collected will contribute to the body of research on motivational music and high-intensity exercise.

E. Potential risks or discomforts: There will be inherent risks associated with maximal effort exertion. Only trained runners will be recruited for this study. Trained runners are defined for the purpose of this study as runners who have been training at least six miles per week for at least the past six months. University of Central Oklahoma and Mitch Park will be not responsible for any bodily injury that is sustained during participation in this study and participants shall assume responsibility for their own medical assistance, if needed.

F. Medical/mental health contact information:

Mercy Health Clinic

100 N. University Drive

Edmond, OK 73034

(405) 974-2317

G. Contact information for researchers: Jamie Aweau: (215) 206-7529; Aweau@live.com and Dr. Brady Redus, (405) 974-5232; bredus@uco.edu

H. Contact information for UCO IRB: Dr. Richard Sneed: (405) 974-5497; irb@uco.edu

I. Explanation of confidentiality and privacy: All data collected will be labeled with a unique number instead of by name. Data will be locked and secured in the primary investigators' offices. All informed consent forms will be kept for three years following the study.

J. Assurance of voluntary participation: Your participation is entirely voluntary and you are free to withdraw at any time without penalty. Your data will be reported as group means or as a unique number and will contain no way to personally identify an individual participant and is, thus, anonymous. You have the right to refuse to answer any question.

AFFIRMATION BY RESEARCH SUBJECT

I hereby voluntarily agree to participate in the above listed research project and further understand the above listed explanations and descriptions of the research project. I also understand that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time without penalty. I acknowledge that I am between the ages of 18-35 years old. I acknowledge that I am a "trained runner" as defined by the primary investigator as completing training of at least six miles of running per week for at least the past six months. I have read and fully understand this Informed Consent Form. I sign it freely and voluntarily. I acknowledge that a copy of this Informed Consent Form has been given to me to keep.

Research Subject's Name:________________________________

Signature: ____ Date ____________

APPENDIX E

Individual Data

Subject #______ Age______ Sex_______

Resting HR_______ bpm Max HR_______ bpm 60% of MHR________ bpm

Song Title____

Artist____

BMRI-2:

Q1_____ Q2_____ Q3_____ Q4_____ Q5_____ Q6_____

BMRI-2 score_______________ BPM_______________

Notes

APPENDIX F

Time Trial Data Collection

	No Music (NM)					Music (MU)				
Subject	Final Time	HR Avg	RPE	Wind	Air temp	Final Time	HR Avg	RPE	Wind	Air temp
1	9:31	184	7.5	15	61	9:30	186	6.5	11	41
2	10:56	179	6	18	56	10:41	177	6	12	32
3	12:39	181	7	6	40	12:41	182	8	5	65
4	11:32	167	8	5	34	11:10	166	8	11	20
5	12:56	171	5	5	34	12:42	173	4	15	34
8	14:34	174	8	9	39	13:58	178	7	13	52
10	11:45	153	7	16	38	11:34	174	7	4	33
11	12:36	172	8	19	71	11:56	170	5.5	1	38
12	12:24	183	7	11	41	12:14	186	7	18	56
13	14:55	171	8	17	58	15:33	175	7	19	75
14	12:51	127	8.5	10	18	12:21	165	8	4	31
15	9:51	129	9	8	39	9:38	169	9	6	37
16	14:04	167	7.5	1	32	13:29	167	7	3	29
17	9:20	186	8	5	50	9:53	184	7	23	36

APPENDIX G

Thesis Summary Document

Research has shown that motivational music has a positive effect on sport performance at submaximal intensities. The purpose of this study was to investigate whether motivational music would affect performance time, heart rate, and rating of perceived exertion (RPE) of trained runners during a 1.5 mile running time trial performed at maximal intensity.

The protocol design of the present study was intentionally and purposefully designed to examine the effects of motivational music on the simulated competition environment. The 1.5 mile time trial was completed in the outdoor environment on a paved trail of a public park, a setting which is commonly used in competitive races. This setting was defined by Simpson and Karageorghis (2006) as an “ecologically valid setting” when they studied the effects of music on sprint performance in the competition-simulated environment. Hagen et al. (2013) conducted a study investigating the effects of motivational music on a cycling time trial. In the Hagen et al. study, the authors clarified the concept of the “closed-loop” protocol in which the subjects performed at a set distance. The closed-loop protocol effectively simulates the competition environment in which athletes are accustomed to racing a set distance. Many of the prior studies of the effects of music on sport performance were designed as an “open-loop” in which the subject completed the protocol to exhaustion and the distance or time to exhaustion was measured (Crust & Clough, 2006; Ghaderi, Rahimi, & Ali Azarbayjani, 2009; Nakamura, Pereira, Papini, Nakamura, & Kokobun, 2010; Szabo, Small, & Leigh, 1999). Although it is helpful to know if music can assist in delaying exhaustion, this finding does not relate to competition. Most sports follow a protocol in which the end of competition is set at a particular distance, score, or time on the clock, such as the closed-loop of a road race.

The subjects were allowed to self-select the individual song which would potentially evoke the greatest individual motivation for the trial. Prior research has tested the effects of a particular song or group of songs (Elliott, Carr & Orme, 2005; Brooks & Brooks, 2010; Koç, Curtseit & Curtseit, 2009) which were chosen by the researchers. However, because individual music preference is so varied and distinct (Karageorghis, Terry, & Lane, 1999), it was important to allow for individual selection to produce a maximal performance. Using a self-selected motivational song, would music affect performance time, heart rate, and the RPE of trained runners during a 1.5 mile time trial?

The independent variable of motivational music was used in a randomized, crossover design in which the differences in the dependent variables of performance time, average heart rate, and RPE during a 1.5 mile time trial were measured with dependent *t* tests. Subjects were trained male and female runners (N = 14), age 19-34 ($M = 24.86$). On average, the subjects ran the trial 11 seconds faster with music, but the motivational music condition did not significantly improve performance time, $t(13) = 1.754$, $p = 0.0515$, $r = 0.43$. Subjects experienced a higher average heart rate of 5.2 beats per minute faster with the music condition, although the increase was not statistically significant, $t(12) = -1.637$, $p = 0.064$, $r = 0.42$. The music condition significantly lowered subjects' RPE by 0.5 points on a scale of 0-10, $t(13) = 2.446$, $p = 0.029$, $r = 0.56$. The present study did not find a significant difference in performance time or heart rate during the motivational music condition, but the significantly lower RPE was confirmed by the study.

The findings of the study may help competitive athletes who use music during training for maximal performances. Although there was not a significant difference in performance time, the motivational music did help lower the performance time by 11 seconds, which athletes may find to be a competitive advantage. More importantly, the thesis confirmed that motivational music helps to lower the RPE during maximal intensity exercise. As the body of research continues to grow and provide evidence that high intensity exercise may help improve health markers, it will be of vital importance for exercise scientists to find ways for people to benefit from maximal intensity exercise.