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The Effect of Music Cadence on Step Frequency in the Recreational Runner

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by

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ABSTRACT

Music appears to have advantageous effects during exercise as it has been shown to increase motivation, decrease ratings of perceived exertion (RPE), and improve exercise performance. The improvement of running performance in particular, is the main effect recreational runners want to focus on as many want to improve their time in road races. Running velocity, indicated by a faster time to completion is thought to improve with an increase in step frequency, step length, or a combination of these variables. Currently, there is limited research that observes methods to help increase step frequency or step length. The manipulation of music cadence may be considered an effective training method that influences step frequency. The purpose of this study was to observe the effect of music cadence on step frequency in the recreational runner.

A total of 30 recreational runners (15 male, 15 female) with a mean age of 31.0 ± 5.8 (range= 20-39), a BMI of 24.0 ± 3.3 (range= 19-32), and an estimated VO_2 max of 49.6 ± 5.4 (range= 41-60) participated in this study. Individually, runners completed four 1600-meter time trials on an outdoor track at maximal effort. The first trial was a familiarization trial where participants ran 1600 meters with no music. Two music conditions were then created for each runner based on their natural step frequency obtained during the familiarization trial. The first condition represented music at natural step cadence and the second condition represented music at increased step cadence. The

next three 1600 meter time trials were randomized and included a control condition of no music, a natural cadence music condition at the runner's natural step frequency, and an increased cadence music condition of 10-20 beats per minute (bpm) above the natural cadence music condition.

Results indicated that step frequency was significantly higher during the increased cadence music condition compared to both the natural cadence music and no music conditions ($p < 0.05$). Additionally, time to completion was significantly lower in the increased cadence music condition compared to both the natural cadence music and no music conditions ($p < 0.05$). Lastly, there was no significant difference in step length among music conditions. These results indicate that music cadence had a positive influence on running performance as it was able to increase step frequency and improve time to completion in a group of recreational runners. Therefore, for practical application, recreational runners can alter music cadence to help improve running performance.

CHAPTER 1: INTRODUCTION

Rationale

Running has become an increasingly popular form of exercise for individuals of all ages who intend to improve their current level of cardiovascular health and fitness. Running USA statistics reveal that in the year 2012, there were approximately fifteen million road race finishers compared to the year 1990 where there were approximately five million road race finishers in the United States. The female population represented nearly half of this number in 2012 compared to only one quarter of this number in 1990 (Yoder & Lamppa, 2012). These survey results show that overall participation in road races from the general population has increased substantially.

The many weeks of training a runner endures prior to any registered road race are intended to achieve an improvement in running velocity, indicated by a faster time to completion. Running velocity is a product of step frequency and step length (Weyand, Sternlight, Bellizi, & Wright, 2000). Hunter and colleagues (2004) propose that in order for running velocity to improve, an increase in either step frequency or step length must occur without a decrease in the other. There is limited research however on ways to improve step frequency or step length, and music may be an effective method to help increase either of these.

Synchronous music is defined by Karageorghis et al. (2010) as the use of a rhythmic or a temporal aspect of music to regulate movement patterns. Currently in research, there is evidence to suggest that synchronous music may produce ergogenic and psychological benefits during exercise (Karageorghis & Priest, 2012). According to Terry and colleagues (2012), music may improve performance based on the individual's ability to synchronize movement to the tempo or beat of a song. It is also important for music to be motivational for the individual during exercise. The Brunel Music Rating Inventory Questionnaire-2 (BMRI-2) is one of the psychometric instruments used in research that assesses the extent of motivational impact that certain songs have during exercise. Motivation is considered the extent music will inspire an individual to exercise harder and longer (Karageorghis, Priest, Terry, Chatzisarantis, & Lane, 2006). During running, an individual may be able to adjust their step frequency to a faster cadence of music, resulting in improved running performance.

There is limited research that supports the relationship between step frequency, step length, and music cadence. If a significant relationship was found, training methods for running may be improved by manipulating music cadence to the runner's desired step frequency and subsequent intensity.

Problem Statement

Step frequency and step length are the two components that determine an individual's running velocity. Research suggests that an increase in one or both of these components may improve running performance (Marais, Galle, & Pelayo, 2003; Hunter, Marshall, & McNair, 2004 & Ballreich, 1976). It is very important however to observe step frequency and step length closely because an inverse relationship typically exists between the two (Hunter et al., 2004). Therefore, an increase in one may result in a decrease in the other, resulting in decreased or unchanged performance.

A vast majority of research indicates that music plays a significant role in improving exercise performance. According to Karageorghis and Priest (2012), motivational music produces an ergogenic effect by increasing work capacity and delaying the onset of fatigue. Most of this research however, uses questionnaires and focuses on subjective ratings of personal attitudes, moods, ratings of perceived exertion (RPE), and enjoyment (Barney, Gust, & Liguori, 2010; Karageorghis et al., 2006; Netherly, 2002 & Seath & Thow, 1995). Ecological validity is nearly absent in the current literature as most of this research is conducted in a laboratory setting measuring variables such as VO_2 max (Barwood et al., 2009), time to fatigue (Terry et al., 2012), power output (Yamamoto, Ohkuwa, Itoh, Kiton, Terasawa, Tsuda, Kitagawa, & Sato, 2003), and metabolic efficiency (Bacon, Myers, & Karageorghis, 2012). There needs to be additional field-based research on this topic in order to increase ecological validity. This can be accomplished by taking research outside to an environment where individuals typically exercise.

Study Variables

The independent variable in this study was music cadence represented as music tempo in beats per minute (bpm). There were three levels of this independent variable. These levels included a control condition of no music, a natural cadence music condition representing the runner's natural step cadence during a 1600-meter familiarization trial, and an increased cadence music condition of 10-20 beats per minute (bpm) above the natural cadence music condition for each song. The dependent variables in this study were step frequency, step length, time to completion, and predicted maximal oxygen consumption (VO_2 max). Step frequency was considered the number of steps taken in one minute by each runner. Time to completion was considered the amount of time in minutes the runner was able to complete 1600 meters at maximal effort. Step length was determined algebraically with the equation: step length=1600 meters / step frequency (steps/min) x time (minutes). VO_2 max was predicted with the equation: 2.5043+ (0.8400 x km/hour).

Hypotheses

H_{o1}: Music cadence does not have any effect on increasing step frequency in the 1600-meter run for the recreational runner. As a result, there will be no significant difference when comparing step frequency among the three music conditions.

H_{o2}: Music cadence does not have any effect on improving time to completion in the 1600-meter run for the recreational runner. As a result, there will be no significant difference in time to completion among the three music conditions.

H_{A1}: Music cadence will have a significant effect on increasing step frequency in the 1600-meter run. As a result, when music cadence is increased, step frequency will also be increased for the recreational runner.

H_{A2}: Music cadence will have a significant effect on improving time to completion in the 1600-meter run. As a result, when music cadence is increased, time trials will also be improved for the recreational runner.

Conceptual Framework

The conceptual framework behind the effects of music on exercise performance involves the brain's ability to take music from an outside source, process this music, and then generate movement that is synchronized to the music. The research of Schneider, Askew, Abel, and Struder (2010) proposes the presence of a central pattern governor within the brain that functions to regulate movement according to 'extrinsic' (music cadence) and 'intrinsic' (heart rate and brain activity) rhythmicity in motor activities. According to Schneider et al. (2010), oscillatory neurons located in the motor area of the brain are responsible for controlling human movement. This locomotor control is apparent during exercise and can transition with the presence of an extrinsic source (Schneider et al. 2010).

Karageorghis et al. (2010) further elaborates Schneider's conception of a central pattern governor and also correlated neural activity with an external stimulus. Karageorghis et al. (2010) describes that the central nervous system's neurons will synchronize the afferent stimulus of music with an efferent stimulus that goes to the muscles for movement. Therefore, during exercise, it is considered important to manipulate music cadence to the desired movement cadence in order to produce an ergogenic effect (Karageorghis et al., 2010). This study assumes that the individual would be able to adjust step frequency to the cadence of music, which would subsequently result in improved running performance.

Operational Definitions

A recreational runner is defined as an individual who runs during their leisure time to improve their current level of cardiorespiratory health and fitness, and to decrease all-cause mortality (Brill & Macera, 1995). These runners also typically train with an intention to improve time to completion in various distances (1600 meters and beyond).

Step frequency is defined as the amount of steps taken per minute, also known as running cadence, turnover rate, or step rate (Hunter et al., 2004). Step frequency was measured similarly to Daniels' technique in counting step frequency among elite athletes in the 1984 Olympics (Daniels, 1998). The researcher counted the number of times the left foot hit the ground in one minute and then multiplied that number by two to account for each foot. This measurement started at the 50-meter mark along the first straightaway and through the curve of each lap.

Step length is defined as the distance measured in meters between the touch down of one foot to the following touch down of the opposite foot, also known as stride length (Hunter et al., 2004). Step length was determined algebraically after all of the data collection was complete. This equation was: step length=1600 meters / step frequency (steps/min) x time (minutes).

Music cadence is defined as music tempo in beats per minute (bpm) (Karageorghis & Priest, 2012). In this study, natural cadence music was represented by the runner's natural step frequency during the familiarization trial where participants ran 1600 meters at maximal effort with no music. Increased cadence music was represented by a 10-20 beats per minute (bpm) increase above the natural cadence music condition for each song.

Time to completion was considered the overall time in minutes that the runner was able to run 1600 meters at maximal effort.

The motivational quality of music was assessed by The Brunel Music Rating Inventory Questionnaire-2 (BMRI-2). The BMRI-2 is an objective measure that rates each song based on its ability to inspire an individual to exercise harder and longer (Karageorghis et al., 2006). Songs with a higher score on the BMRI-2 were considered more motivational than songs with a lower score on the BMRI-2. Songs in each playlist were then arranged in the order of highest motivation to lowest motivation.

Assumptions

During this study, there were several assumptions that helped yield valid and reliable results. A primary assumption was that participants were running at maximal effort during each trial, and the presence of researchers or other individuals did not alter running performance. A second assumption was that the natural cadence music condition adequately reflected the natural step frequency of the runner. There was a familiarization trial conducted prior to actual data collection in which natural step frequency was determined. A third assumption was that the participant was running the same distance during each trial. In order to account for this, each runner started and ended at the same marked line on the track. Runners were also instructed to stay in the first lane through each lap of the time trial. A fourth assumption was that the stopwatch and countdown timers were accurate in providing the correct time for each runner. The same stopwatch and countdown timer were used for each time trial. A final assumption was that songs listed on the participant background survey were considered at least somewhat motivational for the runner.

Limitations

An initial limitation that could not be effectively controlled for in this study involves the environment. Since the track was outside, factors such as temperature, humidity, barometric pressure, wind, rain, thunder, lightning, etc. may have impacted running performance. All environmental conditions were recorded on the data collection sheet at the time of each trial.

Another limitation involves each runner's training schedule. During this study, runners may have been training for road races of varying lengths that may require different strategies in training. Training strategies may include long slow distance training in order to build endurance for a longer race such as a marathon compared to training to increase speed for a shorter race such as a 5K. As a result, in this study, improvement in time to completion may be due to each runner's specific training method rather than the effect of music cadence. Although this cannot be controlled, a benefit of this study was that music conditions were selected in a randomized order. This helped limit any training effect that individual training schedules may have over a given time period. It also decreased the advantage one music condition may have over another.

Finally, step frequency may have changed throughout the course of the 1600-meter run as step frequency can either increase or decrease along different laps, straightaways, and curves along an outdoor track. The natural cadence music condition was supposed to reflect natural step frequency during the run. If step frequency was increased or decreased at any point during a time trial, then the natural cadence music condition may not have accurately represented the natural step frequency of the runner.

Delimitations

A primary delimitation in this study included the criteria for participant selection based on the medical history questionnaire and participant background survey. Each runner who participated in this study was cleared based on his or her medical history questionnaire. The study's physician reviewed this questionnaire and qualified each runner for participation. The participant background survey was self-constructed by the researcher with an intent to gather demographic and background information. Based on the participant background survey, runners in this study were between the ages of 20 and 40. In addition, within the past six months, these individuals ran a minimum of three times per week on average and were able to run 1600 meters continuously under ten minutes. Another delimitation was based on the increased cadence music condition. In this condition, the researcher increased the beats per minute (bpm) of each song above what was used in the natural cadence music condition. As a result, the researcher's preference of music cadence may have influenced the cadence used in this condition.

Significance

Research indicates that during running, a higher step frequency and an increased or unchanged step length may be associated with an improved running velocity (Marais et al., 2003; Hunter et al., 2004 & Ballreich, 1976). Research also suggests that music is advantageous as it can potentially increase exercise performance (Barwood et al., 2009; Karageorghis et al., 2009; Karageorghis et al., 2012; Simpson & Karageorghis, 2006; Terry et al., 2012; & Vlist, Bartneck, & Maueler, 2011). Music cadence is considered an important component in music as it is used to create synchronized movement and locomotor rhythmicity (Schneider et al., 2010). It should be considered that a faster music cadence may result in an increased step frequency during running. If this is proven to be true, then it can significantly impact the way recreational runners train for an event. It would be beneficial for runners to know how to manipulate the music's cadence to help optimize the training effect (Karageorghis et al., 2010). Although research has been previously conducted on music cadence, step frequency, and step length, more focus needs to be placed in a real world setting. The vast majority of this research is basic in that it has been observed in laboratories, thus having limited application to everyday life. If applied research presents similar results and shows a potential ergogenic effect of music on exercise performance, ecological validity would be increased.

CHAPTER 2: LITERATURE REVIEW

One of the main goals for recreational runners is to improve their time in various road races. An improvement in time to completion, also known as running velocity, is an important indicator of increased running performance. Research suggests that running velocity may improve with an increase in step frequency or step length without a significant decrease in the other (Marais et al., 2003; Hunter et al., 2004 & Ballreich, 1976). Music cadence may be able to help increase step frequency and time to completion for a recreational runner. Other research indicates that music provides a potential ergogenic effect in exercise performance (Karageorghis & Priest, 2012). The research presented below describes multiple studies that have previously observed the relationship between step frequency, step length, and running velocity; and the effect of music on exercise performance.

Step Frequency, Step Length, and Running Velocity

Previous research has examined the relationship between step frequency, step length, and running velocity. A study by Hunter et al. (2004) describes the inverse relationship between step frequency and step length. The determinants of step frequency in this study were stance time and flight time measured in meters per second (m/s). Stance time was indicated by the amount of time the foot was in contact with the ground, and flight time was indicated by the amount of time both feet were in the air. The determinants of step length in this study were stance distance and flight distance measured in meters. Sixteen men participated in this study and completed seven to eight maximal effort sprints on a track located inside a laboratory. These sprints were 25 meters in length. A video camera was used to observe each participant's body mechanics during running along with step frequency and step length. Results revealed that at maximal effort, an inverse relationship existed between step frequency and step length ($p < 0.01$), as runners who had a longer step length had a lower step frequency and vice versa. This may be attributed to a runner's leg length. Hunter et al. (2004) describes a direct relationship between leg length and step length and an inverse relationship between leg length and step frequency. Hunter et al. (2004) also explains that step frequency is lower in individuals who have a long legs because of the increased inertia exerted on them during running, thus creating a longer stance time and stance distance. During this study, runners were separated into two different groups of step length and step frequency. Identical sprint velocity was observed from both groups, indicating that both step length and step frequency are both related to running velocity. Therefore, it is apparent that an increase in step frequency, step length, or both without a decrease in the other will improve sprint velocity (Hunter et al. 2004).

Hunter, Marshall, and McNair (2005) also found that an increased step frequency improves sprint velocity in runners. Hunter et al. (2005) explains that the acceleration phase of a run is optimized with a smaller flight time in the air, as there is more force exerted from the ground to increase acceleration. This is due to more ground reaction force applied on the runner when step frequency is increased, resulting in faster movement.

In contrast to the above study, Mackala (2007) observed the relationship between step frequency, step length, and running velocity in two groups of male sprinters running 100-meters along the curve of an outside track. Every ten meters was analyzed with a video camera. Results indicated that step length was the primary contributor to the increase in running velocity during this study. Mackala (2007) describes this running velocity increase as more ground being covered along the curve with a longer stride. Although this is true, it is important to point out that step frequency remained relatively constant throughout the 100-meter sprint. In addition, any ten-meter interval that running velocity decreased, step frequency and step length both decreased as well. This study provides some general insight into the relationship between step frequency and step length. According to Ballreich (1976), there are five relationships that exist between step frequency and step length that contribute to an improvement in running velocity for sprint performance. These relationships are presented in Table 2.1.

Table 2.1 Relationships between Step Frequency and Step Length (Ballreich, 1976)

Step Frequency	Step Length
Increases	Increases
Increases	Unchanged
Increases	Slightly decreases
Unchanged	Increases
Slightly decreases	Increases

Running Economy

The energy output of altering step length and step frequency is also an important consideration during running performance. A study by Hogberg (1952) found that shortening or lengthening a runner's stride causes an increase in oxygen consumption in well-trained runners. A Douglas bag was used to measure oxygen consumption and it was found that the most economical running step length was one freely chosen by the runner. A significant finding was that the speed of running had increased with a faster step frequency (Hogberg, 1952). In contrast, a study conducted by Cavagna, Mantovani, Willems, & Musch (1997) observed oxygen consumption in altering step frequencies. Results indicated that either increasing or decreasing a runner's natural step frequency required a higher mechanical power and energy expenditure from the runner. Therefore, the most economical run is based on the runner's freely chosen step frequency (Cavagna et al., 1997).

Injury Prevention

Daniels' Running Formula (1998) provides various training techniques for runners competing in different events. One of the important techniques mentioned was observing the step frequency in runners. Daniels describes that runners may have a higher chance of injury with a slower step frequency as more time is spent in the flight phase of running. This results in the body's mass being displaced higher in the air, causing a harder landing with each step, resulting in injury and joint pain. Therefore, it may be beneficial for the runner to develop a higher step frequency (Daniels, 1998).

To further elaborate on injury prevention with an increased step frequency, Heiderscheit, Chumanov, Michalski, Wille, and Ryan (2011) observed the loading absorption on specific joints with altered step frequency during running. It was hypothesized that when step frequency is increased, energy absorption by lower extremity joints at the hip, knee, and ankle would decrease. Forty-five recreational runners participated in this study and each runner had a preferred speed (2.9 ± 0.5 m/s) and corresponding step frequency (172.6 ± 8.8 steps/minute) on a treadmill. Each runner's step frequency was then increased and decreased by 5% and 10% using a digital metronome. Results indicated that during all five exercise conditions, less energy was absorbed at the knee joint with an increased step frequency of 5-10% above runners preferred step frequency. It was also statistically significant that hip joint absorption decreased when step frequency was increased 10% above preferred step frequency. These results indicate that there is an inverse relationship between step frequency and knee and hip joint absorption during running (Heiderscheit et al., 2011).

Step Frequency and Music Tempo

Research has been conducted that observes the relationship between step frequency and music cadence. Ahmaniemi (2007) observed the influence of both music cadence and the motivational rating of music on step frequency during running. Eight marathon runners rated 50 songs on motivational quality using a 1-100 Likert scale. Participants listened to 50 personal songs they selected and rated each song based on how motivational it was to exercise. The location of this study was on a sports field with a 350-meter running track. Participants ran around the track for 30 minutes while listening to six to ten different songs on a mobile phone that also had a sensor signal to calculate step frequency in five-second intervals. After data collection, all sessions were combined into one dataset and each song had a motivational rating, tempo, and step frequency coordinated with it. Results revealed that there was a significant relationship between the motivational rating of music and step frequency. It was also discovered that there was no significant relationship between music cadence and step frequency. These findings suggest that musical preference has a strong influence on step frequency, and this shows the importance of song selection in accordance to exercise (Ahmaniemi, 2007). Although this data shows no significant relationship between step frequency and music tempo, the sample used in this study was taken from an active marathon running group. Runners in this group may be trained to run at a particular step frequency with less influence from the music. Those who do not participate in active marathon training may have different results with music tempo and step frequency.

Motivational Qualities and Psychological Influence

One of the major limitations involving research with music and exercise is how to manipulate music to make it motivational for the individual being tested. This is because individuals will have very different associations of music from one another, as music tends to evoke certain feelings, thoughts, and emotions from past experiences and various sociocultural upbringings.

The Brunel Music Rating Inventory (BMRI) is a psychometric instrument used in research that determines the motivational quality of music. Karageorghis, Terry, and Lane (1999) define the BMRI as a thirteen question ten point Likert scale used to assess different elements of a song that can make an individual feel motivated. These elements include: familiarity, tempo, rhythm, lyrics, association of music with sport, chart success, association with a film or video, the artist(s), harmony, melody, simulative qualities of music, danceability, and date of release (Karageorghis et al., 1999). The BMRI was later redesigned as the Brunel Music Rating Inventory-2 (BMRI-2). Karageorghis et al. (2006) explain that this was mainly due to the fact that there were errored response trends observed in individuals completing the BMRI, as individuals tended to miscomprehend certain musical elements. According to Karageorghis et al. (2006), the BMRI was intended more for researchers and fitness instructors while the BMRI-2 is now more user friendly for the recreational individual as well.

In the BMRI, motivational quality was originally defined as the extent of which music inspires or stimulates physical activity (Karageorghis et al., 1999). In the BMRI-2, the definition of motivational quality changed to the extent of which music will make an individual want to exercise harder and longer (Karageorghis et al., 2006). The number of questions in the BMRI-2 is six compared to the original BMRI of thirteen. It is also now based on a seven point Likert scale comprised of three categories that include strongly disagree, in-between, and strongly agree. The aim of this questionnaire was to have individuals rate various musical elements such as rhythm, style, melody, tempo, instruments used, and beat. According to Karageorghis et al. (2006), these terms are more easily comprehended and may have less error in responses compared to the original BMRI. Based on the motivational quality of music assessed with the BMRI and BMRI-2, it strongly appears that music has an influential and motivational role in terms of exercise.

The preference of music cadence may be considered a motivational aspect during exercise. Karageorghis, Jones, and Stuart (2007) examined the motivation of exercise in three different music conditions consisting of a medium cadence of 120-140bpm, a fast cadence of >160, a mixed cadence, and no cadence as the control. A total of 29 men and women were tested and each individual walked on a treadmill at 70% of their heart rate reserve (HRR). The participants took the Intrinsic Motivation Inventory (IMI) as a subjective measure to rate the interest or enjoyment of the experience. Intrinsic motivation is the type of motivation individuals experience without any external pressures or influences on them. Overall, the scores were highest in the medium and fast conditions compared to the mixed condition and the control condition of no music. This finding suggests that music improves intrinsic motivation with the presence of a medium and fast cadence (Karageorghis et al., 2007).

A similar study by Priest, Karageorghis, and Sharp (2004) compared music cadence in the form of slow (80bpm), medium (120bpm) and fast (140bpm) music in participants exercising at 40%, 60%, and 75% heart rate reserve (HRR) on a treadmill. Cadence preference was analyzed, and results revealed that participants had a greater preference for a fast or medium cadence compared to a slow cadence (Priest et al., 2004). Another study by Lim, Atkinson, Karageorghis, and Eubank (2007) also revealed that participants preferred fast music cadence during high intensity exercise during a ten-kilometer cycle time trial. Performance did not improve in this study across three cadence conditions, however the overall rating of perceived exertion (RPE) was significantly lower in the fast cadence music condition (Lim et al., 2007).

Barney, Gust, and Liguori (2010) investigated exercise adherence motivation through the use of personal music players (PMP) such as iPods™, mp3 players, etc. in 200 college students. In this study, the students were not physically exercising, but were asked questions regarding usual exercise habits through a self-constructed questionnaire. The first question asked why the personal music player was used, and if they would exercise as frequently without it. The most popular answers to the first question were: "to work out harder", "exercise seems easier", "to work out longer" and "exercise is more fun" These responses indicate that listening to music has positive effects on motivating performance and improving psychological state with exercise. (Barney et al, 2010). Results showed that running was the most common mode of exercise in which PMP's were used followed by weight lifting. Forty percent of participants indicated they would not work out without their PMP. It was concluded that PMP's help college students work out more frequently, with more intensity, and for longer durations. (Barney et al., 2010).

Vlist, Bartneck, and Maueler (2011) observed intrinsic motivation in the context of its ability to capture attention and help individual's focus less on distress cues during exercise. Intrinsic motivation is considered the type of motivation that occurs when people engage in an activity without having an external pressure or influence on them (Vlist et al., 2011). A product called MoBeat™ was developed in this study that provides interactive music and training that encourages individuals to exercise at a particular intensity during workouts. The system used motivational lyrics and pitches to indicate whether intensities were reached or not. The study took 26 healthy men and women, ages 23-51 years. The protocol consisted of a five-minute warm-up followed by ten-minutes of interval training (each interval lasting 2.5 minutes in duration with an intensity between

60-85% of the individual's maximal heart rate), and a five-minute cool down on a stationary bike. Results on internal motivation were then analyzed based on the Intrinsic Motivation Inventory, the Attentional Focus Questionnaire, and RPE during the test. The Attentional Focus Questionnaire determined whether individuals were able to dissociate their attention from exercise. Other variables measured included time in the intensity zone (percent of max heart rate), time out of the intensity zone (percent of max heart rate), and revolutions per minute (rpms). Results indicated a significant effect on increasing individual fun/enjoyment, perceived competence, and dissociation from exercise. The MoBeat music system created higher intrinsic motivation for exercise based on the lower dissociation scores obtained by the Attentional Focus Questionnaire (Vlist et al., 2011). This study reveals that music is advantageous in the aspect of having individuals dissociate from exercise, thus drawing their attention from the exercise itself. It is also shown that music is able to increase intrinsic motivation for the individual.

Psychological, Psychophysical, and Ergogenic Effects

In research, it has been hypothesized that music has various psychological, psychophysical, and ergogenic effects on individuals while exercising. According to Karageorghis and Terry (2009), psychological effects refer to how music influences mood, emotion, pleasure, cognition, and behavior; psychophysical effects refer to music's ability to decrease ratings of perceived exertion (RPE); and ergogenic effects are when music is able to increase work output and yield higher levels of endurance, power, productivity, and strength (Karageorghis & Terry, 2009).

Karageorghis et al. (2009) found greater time to fatigue in participants walking at 75% of their maximum heart rate reserve (HRR) on a treadmill. Time to fatigue was measured with a stopwatch starting from when participants reached 75% maximal HRR, and stopping when participants reached voluntary fatigue. There were three music conditions used in this study that consisted of motivational music (highest score achieved on the BMRI), outdeterous music (lowest score achieved on the BMRI), and no music. Results indicated that time to fatigue was significantly higher in both music conditions compared to the control condition of no music. In addition, time to fatigue was significantly higher in the motivational music condition compared to the outdeterous music condition. There was no significant difference in RPE among music conditions. In this study, it was also found that the two music conditions elicited positive mood responses to a greater extent than the control condition of no music (Karageorghis et al., 2009).

Another study conducted by Barwood, Weston, Thelwell, and Page (2009) used music and video intervention in association with high intensity exercise. The study used six healthy men who performed three 15-minute maximal effort runs on a treadmill. There were three exercise conditions consisting of a control group with no music or video, a motivational group with preferred music selected by participants using the BMRI, and a non-motivational group with video of public speaking from a political trial that had no synchronous activity. Based on the BMRI, songs were selected for this study according to the highest ratings obtained in this questionnaire. Performance was determined by distance covered per trial. Results indicated that music enhanced running performance, as the farthest distance covered was achieved in the motivational music condition. In contrast, the video condition resulted in the least distance covered, even in comparison to the control condition of no music and video. Barwood et al. (2009) explains that this may be due to too many external distractions as participants were most likely focusing on the political content of the video. There was also no synchronous activity in this condition, meaning movement was not coordinated with any tempo or beat (Barwood et al., 2009).

In contrast to the findings by Karageorghis et al. (2009) and Barwood et al. (2009), there may not be a significant difference among music conditions in exercise performance. Simpson and Karageorghis (2006) investigated synchronous music during 400-meter sprint running. Twenty men participated in the study and rated 32 songs on motivational quality using the Brunel Music Rating Inventory-2 (BMRI-2). The highest scoring song from the BMRI-2 represented the motivational music condition while the lowest scoring song from the BMRI-2 represented the oudeterous music condition. Oudeterous music in this study represented a neutral condition where music was considered neither motivating nor demotivating. The first trial was conducted for runners to practice the experimental task, and to obtain natural step frequency. Based on their step frequency, runners were assigned to a specific lane for the duration of the study, and during time trials six people ran at one time. Runners completed a 400-meter time trial on an outdoors track under three conditions of motivational music, oudeterous music, and no music. Three researchers measured time with a handheld stopwatch, and a video camera was used for accurate measurement of step frequency. Results indicated that 400-meter times were faster in the motivational and oudeterous music conditions compared to the control condition of no music. There was however no significant difference between the motivational condition and oudeterous condition in 400-meter time trials. It was concluded that during a 400-meter sprint, the rhythmic aspect of music is what provides an ergogenic effect, thus increasing performance regardless of its motivational quality (Simpson & Karageorghis, 2006).

Oxygen Consumption and Blood Lactate Concentrations

Research has been conducted that observes the effect of music on physiological parameters such as oxygen consumption and blood lactate concentrations. Smoll and Schultz (1978) state that the synchronous music results in a reduced metabolic cost of exercise by promoting greater neuromuscular or metabolic efficiency. A study conducted by Bacon, Myers, and Karageorghis (2012) helps support this finding. Ten untrained men, ages 20-22 years, completed a 12-minute exercise test on a cycle ergometer. Participants exercised at 70% of their maximal heart rate with a pedal cadence of 65 revolutions per minute (rpms). The three music conditions included a slow asynchronous tempo, a fast synchronous tempo, and a control condition of no music. Measurements of VO_2, heart rate, and RPE were all analyzed during this study. Results indicated that there were no differences in heart rate or RPE among music conditions. VO_2 however, was found to be approximately 7% lower in the fast synchronous music condition compared to the slow asynchronous condition. This finding reveals that synchronous music with a fast tempo is advantageous over asynchronous music during submaximal exercise as it reduces overall effort exerted by the individual (Bacon et al. 2012).

A study conducted by Terry, Karageorghis, Saha, and Auria (2012) observed the effects of synchronous activity on high intensity exercise and blood lactate concentrations. This study consisted of treadmill running among 11 elite athletes (five women, six men). There was a motivational, neutral, and control condition, and music was rated on the BMRI. A higher score on the BMRI had a higher motivational rating compared to a lower score. In this study, songs were placed in the motivational category with a score > 36, and songs were placed in the neutral category with a score between 18-30. The control condition consisted of no music. Athletes completed a treadmill test with a five-minute warm-up, a four-minute submaximal intensity, a five-minute break, and a run to exhaustion at 110% of their lactate threshold. Results demonstrated that endurance performance improved significantly as athletes ran a full minute longer with motivational and neutral music. RPE was lower in both the motivational and neutral conditions. In addition to improved exercise performance, lower blood lactate concentrations were also discovered in this study. The lowest measurement of blood lactate concentrations was found in the motivational music condition. These findings reveal that motivational and neutral music can improve exercise performance and lower the physiological parameter of blood lactate during exercise (Terry et al., 2011).

Yamamoto et al. (2003) conducted a study that examined the effect of listening to slow and fast rhythm music before exercise on supramaximal cycle performance. The study also looked at blood lactate concentrations and catecholamines epinephrine, norepinephrine, and dopamine. Six men who regularly participated in recreational sports at least three times per week participated in this study. The two music conditions consisted of slow classical music and fast music. The students lay in a supine position for 20 minutes while listening to music. Afterwards, blood samples were taken and then participants mounted the bike. After a one-minute warm-up period, the subject performed a 45 second supramaximal cycle ergometer test. The resistance was set at 7.5% body weight in kilograms and performance was determined in revolutions per minute (rpms). Seven-milliliter blood samples were then taken post exercise. Results indicated that music had no effect on power output during testing, however there was a significant difference observed in epinephrine and norepinephrine concentrations. Before exercise, epinephrine concentrations were higher after listening to the fast rhythm, and norepinephrine levels were lower after listening to the slow rhythm. After exercise, there was no significant effect between fast or slow music on blood lactate concentrations. Yamamoto et al. (2003) describes the pre-exercise results as music affecting the sympathetic activation from the adrenal medulla. The slower rhythm decreased sympathetic activation while the faster rhythm increased sympathetic activation (Yamamoto et al., 2003).

Recommendations for Music and Exercise

Based on the magnitude of research that showcases music's effect on creating positive attitudes, increasing performance, and decreasing physical exertion with exercise, Karageorghis, Terry, Lane, Bishop, and Priest (2012) provided guidelines for the use of music during exercise. Some of the effects of music on exercise mentioned in this article include increasing attentional focus (Netherly, 2002), increasing work rate (Rendi, Szabo A., & Szabo T., 2008), strength (Karageorghis et al., 2011), and improving time to exhaustion by 15% compared to a no music control condition (Karageorghis et al., 2009). Guidelines for the use of music and exercise are provided by Karageorghis et al. (2012) in Table 2.2.

Table 2.2 Recommendations for Music and Exercise (Karageorghis et al., 2012)

1. Familiarity to the music (personal preferences)
2. Functional for the activity- rhythm mimics motor patterns involved
3. Tempo is specific to desired effects
4. Selected based on an objective measure such as the BMRI-2
5. Rhythm, melody, and harmony included for repetitive exercise tasks
6. Cadence of 125-140 for asynchronous music; Cadence synchronized to desired movement for synchronous music
7. Lyrics are motivational
8. Used in safe situations

The vast majority of research on music and exercise indicates that music provides individuals with psychological, psychophysical, and ergogenic effects that all contribute to an increase in exercise performance. Therefore, it appears that synchronous music used in the correct form can be added to an exercise session in order to improve running performance in recreational runners. This can be accomplished by the runner's ability to synchronize his or her own step frequency to the music cadence of the song.

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CHAPTER 3: METHODS

Participants

There were a total of 15 men and 15 women who participated in this study. These individuals were recreational runners who participated in an organized running group that met approximately two times per week. Over six months prior to the study, these individuals were able to run 1600 meters continuously under ten minutes. These participants also ran an average of 4.0 ± 0.78 (range 3.0-6.0) days per week. Based on the participant background survey, 37% indicated that they always listen to music, 50% indicated that they sometimes listen to music, and 13% indicated that they did not listen to music when training for a road race. Each runner was assigned a participant number in order to ensure privacy during and after data collection. Please refer to Table 3.1 for participant characteristics.

Study Incentives. Two incentives were provided to runners who participated in this study. The first incentive was a $20.00 gift card that could be used at a local running store in Wesley Chapel, Florida. The second incentive was a free VO_2 max test to be performed in the Health and Exercise Science Laboratory at University of South Florida.

Study Location. This study took place at a public middle school's outdoor track located in Tampa, Florida. This 400-meter track had an asphalt surface with start and finish line markings.

Table 3.1 Participant Characteristics

	Mean ± SD	Range
Age (years)	31.0 ± 5.8	20.0 - 39.0
Height (meters)	1.7 ± 0.1	1.6 - 1.9
Weight (kg)	71.8 ± 11.0	58.2 -102.3
Body Mass Index (kg/m^2)	24.0 ± 3.3	19.0 - 32.0
VO_2 max (ml/kg/min)	49.6 ± 5.4	41.0 - 60.6
Running Frequency (days/week)	4.0 ± 0.8	3.0 - 6.0

Instrumentation/Equipment

Participant Documents and Forms. Prior to participation, runners completed a medical history questionnaire. This questionnaire helped the researcher determine risk status of the participant (Appendix A). The study's physician reviewed the medical history and qualified runners for participation in the study.

Participants also completed an informed consent document. This document informed each runner of the research being conducted along with associated benefits and risks that may occur. Runners signed the document if they willingly agreed to participate.

A third form runners completed was the participant background survey (Appendix B). This survey was self-constructed by the researcher and was sent through email to gather demographic and background information on participants.

Before each trial, a copy of ACSM's Current Comment on Pre-Event Meals was provided to runners (Appendix C). This statement gave appropriate dietary information as well as recommendations on what to consume before an exercise-related event. Runners were encouraged to adhere to this statement 24-hours before each time trial.

The last form provided to runners included a list of materials indicating what to bring to the track (Appendix D). Runners were asked to wear similar clothing, shoes, and to bring the same items for each experimental trial.

Software Programs and the BMRI-2. The software program iTunes™ was used to download motivational songs for each runner. After songs were downloaded, they were imported into another software program, Audacity™. Once in Audacity™, the researcher was able to change the cadence of each song based on the natural step frequency obtained during each runner's familiarization trial. After songs had been manipulated, they were imported back into iTunes™, organized into playlists, and synced onto one portable iPod Nano™. Each runner used the iPod Nano™ during time trials that required music conditions. An armband was used to hold the iPod Nano™ in place.

Once music conditions were created, each runner rated the motivational quality of songs on their personal playlists with the Brunel Music Rating Inventory Questionnaire-2 (BMRI-2, Appendix F). A document to describe elements of music on the BMRI-2 such as rhythm, style, melody, tempo, instruments used, and beat was provided to runners in order to ensure appropriate understanding (Appendix E). A portable iHome™ device was used to play songs aloud for runners while they were completing the BMRI-2.

Data Collection Equipment. A Meade TE688W Weather Forecaster™ was used to record accurate environmental data during the time of the study. This environmental data included temperature, percent humidity, and barometric pressure.

A stopwatch was used to measure time to complete 1600 meters at maximal effort. A countdown timer set to 60 seconds was used to measure step frequency for each runner. The same stopwatch and countdown timer were used for each experimental trial.

A Polar heart rate monitor was used to assess each runner's heart rate response before and after exercise. Heart rate was recorded four times during each trial and included resting heart rate taken before the warm-up, pre-exercise heart rate taken after the warm-up, post-exercise heart rate taken immediately after the 1600-meter run, and recovery heart rate taken approximately five minutes after cool-down. Runners wore both the chest strap and watch, which provided accurate heart rate information during each time trial.

Procedures

Pre-Study Procedures and Forms. Runners from the recreational running group completed a medical history questionnaire, informed consent document, and participant background survey. The participant background survey asked runners to list the name and artist of 20 motivational songs that they typically listen to when training for a road race. If runners did not listen to music during training, then they were asked to list the name and artist of 20 motivational songs for personal enjoyment. This survey also gathered information regarding each runner's current running activity within the past six months.

Familiarization Trial. Each runner selected a convenient date and time for participation in the familiarization trial. This trial was held at the same time of day as experimental trials, no more than three weeks and no less than two days before data collection. Before this trial, runners were asked to read ACSM's Current Comment on Pre-event Meals. Participants were strongly encouraged to follow this comment 24 hours before their familiarization trial. At the time of the trial, runners were asked whether they adhered to ACSM's Current Comment, and this information was recorded on the data collection sheet. Runners who indicated that they did not adhere to ACSM's Current Comment still participated in the familiarization trial.

There were two main goals of the familiarization trial. The first goal was to acquaint runners with the experimental task. In this trial, runners completed a 1600-meter maximal effort run with no music. The same equipment, data collection sheet, and layout of actual research trials were implemented during this trial. The second goal of the familiarization trial was to gather each runner's baseline running information. This information included natural step frequency and time to complete the 1600-meter run. Natural step frequency was needed prior to actual data collection in order to generate the two music conditions.

Preparation of Music Conditions. Once the research technician had gathered all of the data from the familiarization trial, the researcher reviewed each runner's participant background survey that included the motivational song list. Two to five songs from this list were downloaded from iTunes™ according to how close the music cadence was to the natural step frequency of the runner. The number of songs downloaded was dependent on time length of the song and was based on the runner's time to completion during the familiarization trial. It was important that the length of time in each playlist was not shorter than the runner's time to completion during the familiarization trial. This was to ensure that music would not stop playing during any 1600-meter time trial.

The researcher then imported each song into Audacity™ and manually increased or decreased the original cadence of the song to match the designated cadence of the two music conditions. The first condition represented music at natural step cadence, while the second condition represented music at increased step cadence. Increased step cadence was represented by an increase of 10-20 beats per minute (bpm) above the natural step cadence condition. For example, if a runner had an average step frequency of 160 steps per minute (steps/min) during the familiarization trial, then the natural cadence music condition would be 160 beats per minute (bpm) and the increased cadence music condition would be between 170-180 beats per minute (bpm).

After songs were manipulated, they were then imported back into iTunes™ and organized into two separate playlists. The first playlist represented music at natural step cadence while the second playlist represented music at increased step cadence. Each runner was provided with his or her own two playlists representing both music conditions. These playlists were named according to the participant numbers. Songs were then synced onto one iPod Nano™.

After both playlists were created for each participant, each runner completed the BMRI-2 (Karageorghis et al., 2006). The researcher played one full minute of each song from both playlists on a portable iHome™ device, and runners completed the BMRI-2 while they were listening to each song being played aloud. At the time runners were taking the BMRI-2, they were provided with a handout that defined all of the terms in order to ensure appropriate understanding. These terms included rhythm, style, melody, tempo, instrumental sound, and beat. Runners were also allowed to ask the researcher to clarify any terms if necessary.

After each runner took the BMRI-2, the researcher reviewed the results and reorganized songs on the runner's playlist. Songs were placed in the order of most motivational to least motivational. Songs with a higher score were considered more motivational in comparison to songs with a lower score on the BMRI-2.

Data Collection. There were a total of three randomized trials during this study that took place no less than three days and no more than five weeks apart. During each trial, participants ran 1600 meters at maximal effort with one of the three music conditions. One was a control condition of no music. Another was a natural cadence music condition (playlist one). Lastly, there was an increased cadence music condition (playlist two).

There was a minimum of two researchers present during each time trial. Before the study began, researchers recorded the date, time, participant number, condition, and adherence to ACSM's Current Comment on the data collection sheet. After this was completed, researchers instructed the runner to put the Polar heart rate monitor on and offered assistance if necessary. Researchers then recorded the runner's resting heart rate after five minutes of sitting on the bleachers.

After the above information was recorded, researchers led the runner in a standardized warm-up. This warm-up included one light jog around the track followed by dynamic stretching. Dynamic stretches took place along the 50-meter straightaway on the outdoor track. Stretches included high knees, butt kicks, side-shuffle, karaoke, toe touches, lateral lunges, and a 50-90% effort strider run. Approximately one to two minutes following warm-up, researchers recorded pre-exercise heart rate.

Immediately before the runner was ready to begin, he or she lined up one to two feet behind the starting line. At this time, researchers used the Meade TE688W Weather Forecaster™ to record the environmental parameters of temperature, humidity, and barometric pressure. This information was recorded on the data collection sheet as well as any other environmental factors such as wind, rain, thunder, lighting, etc. If a trial was one with music, researchers would select the runner's playlist on the iPod Nano™, have the runner select an appropriate volume, and help secure the armband on the runner. The runner was then instructed to hit the play button before crossing the line to start.

Once the runner was ready, the researcher responsible for timing yelled, "Ready, set, go!" At this time, the runner completed 1600 meters (four laps around the track) in lane one at maximal effort. Official time started when both feet crossed the starting line, and official time ended when both feet crossed the finish line.

As the participant was running around the track, the researcher stood in the grassy area located in the center of the track and counted step frequency. Step frequency was measured for 60 seconds beginning at the 50-meter mark along the first straightaway and through the curve in each lap of the time trial. This accounted for distributing step frequency equally among straightaways and curves. The researcher used a countdown timer set to 60 seconds and counted the number of times the left foot hit the ground in one minute. This number was then multiplied by two in order to account for step frequency in both feet.

At the end of the fourth lap, the first researcher hit stop on the stopwatch at the time the runner had both feet cross the finish line. The researchers then recorded time in minutes and post-exercise heart rate on the data collection sheet. After the time trial was complete, the runner performed a light cool-down. This cool-down consisted of a light jog around the track followed by static stretching. Static stretches focused on hamstrings, quadriceps, calves, lower back, and shoulders. All stretches were held for 20 seconds. Researchers then recorded recovery heart rate after cool down which was approximately five minutes post exercise. Recovery heart rate had to be within 20 beats per minute (bpm) of resting heart rate before the runner was allowed to leave the track.

After the data collection sheet was complete, the researcher performed an algebraic equation in order to determine the runner's step length during each time trial. Step frequency, time to completion, and overall distance were the known variables in this equation. This equation was: 1600 meters / step frequency (steps/min) x time (min). The purpose of this calculation was to determine the relationship between step frequency, step length, and time to completion during a 1600-meter maximal effort run.

The final calculation performed was a 1600-meter run VO_2 max prediction equation. This equation was: 2.5043+ (0.8400 x pace in km/hour). The purpose of calculating a predicted VO_2 max was to determine the level of aerobic fitness for the recreational runner (Tokmakidis, Leger, Mercier, Peronnet, & Thibault, 1987).

Statistical Analyses

Statistical analysis was performed using the Statistical Package for Social Sciences, Version 22.0™ (SPSS). Three separate one-way ANOVAs were used to assess the difference in dependent variables (step frequency, step length, and time to completion during a 1600-meter maximal effort run) among the three levels of music cadence. In addition, three separate one-way ANOVA's were used to assess the difference in environmental conditions (temperature, humidity, and barometric pressure) among the three levels of music cadence. The p-value to determine significance was set at $p < 0.05$. Paired samples t-tests were then performed on any variable that showed significance ($p < 0.05$). Finally, after all statistical analyses was complete, effect sizes (ES) were calculated in order to determine the strength for each music condition on step frequency, step length, and time to completion.

CHAPTER 4: RESULTS

Statistical analysis was performed on each environmental condition as well as each dependent variable. These included temperature, humidity, barometric pressure, step frequency, step length, and time to completion. The results of this analysis are described and represented in tables and figures below.

Environmental Conditions

This study took place in an outside environment where there was limited control over certain factors such as temperature, humidity, and barometric pressure. A one-way ANOVA was performed on each of these parameters in order to ensure that there was no significant difference in the environment among music conditions. Results revealed that within-participants, there was no significant difference ($p > 0.05$) in temperature, humidity, or barometric pressure between experimental conditions. Please refer to Table 4.1.

Step Frequency

As predicted in H_{A1}, there was some variation in step frequency among the three music conditions. A one-way ANOVA was performed and results were significant ($p < 0.05$), indicating that there was a difference in step frequency among the three time trials. Follow-up paired samples t-tests were then performed in order to determine significance between each music condition. Results demonstrated that there was no significant difference ($p > 0.05$; ES = 0.16) in step frequency between the no music and natural cadence music conditions. There was however, a significant difference ($p < 0.05$; ES= 0.54) in step frequency between the no music and increased cadence music conditions. There was also a significant difference ($p < 0.05$; ES = 0.40) in step frequency between the natural cadence music and increased cadence music conditions. Step frequency was significantly increased ($p < 0.05$) during the increased cadence music condition. Please refer to Table 4.2, Table 4.3, and Figure 4.1.

Step Length

During this study, step length was not considered a major factor as it was assumed that step length would either remain the same or slightly decrease as a result of the change in step frequency. A one-way ANOVA was performed in order to determine whether step length was significantly different among the three music conditions. Results indicated that there was no significant difference ($p > 0.05$; ES range = 0.00 - 0.06) in step length. Please refer to Table 4.2, Table 4.3, and Figure 4.2.

Time to Completion

It was hypothesized in H_{A2} that music cadence would have a significant effect on improving time to completion during the 1600-meter run. A one-way ANOVA was performed and results were significant ($p < 0.05$), indicating that there was a difference in time to completion among the three time trials. Follow-up paired samples t-tests were then performed in order to determine significance between each music condition. Results demonstrated that there was no significant difference ($p > 0.05$; ES = 0.05) in time to completion between the no music and natural cadence music conditions. There was however, a significant difference ($p < 0.05$; ES = 0.17) in time to completion between the no music and increased cadence music conditions. There was also a significant difference ($p < 0.05$; ES = 0.12) in time to completion between the natural cadence music and increased cadence music conditions. Time to completion was significantly lower ($p < 0.05$) during the increased cadence music condition. Please refer to Table 4.2, Table 4.3, and Figure 4.3.

Table 4.1 Environmental Parameters Mean ± SD

	Temperature (°C)	Humidity (%)	Barometric Pressure (inches of Hg)
No Music	28.6 ± 6.1	55.9 ± 9.0	29.99 ± 0.07
Natural Cadence Music	28.5 ± 6.4	58.1 ± 9.5	29.99 ± 0.09
Increased Cadence Music	28.1 ± 6.1	59.9 ± 7.6	29.95 ± 0.07

Table 4.2 Exercise Performance Mean ± SD

	Step Frequency (steps/minute)	Step Length (meters)	Time to Completion (minutes)
No Music	179.7 ± 9.4*	1.25 ± 0.17	7:17 ± 0:59*
Natural Cadence Music	181.2 ± 9.3*	1.25 ± 0.16	7:14 ± 0:57*
Increased Cadence Music	185.5 ± 11.9	1.24 ± 0.17	7:07 ± 0:56

*Denotes significantly different than the increased cadence music condition

Table 4.3 Exercise Performance Effect Sizes

	Step Frequency	Step Length	Time to Completion
No Music vs. Natural Cadence Music	0.16	0.00	0.05
Natural vs. Increased Cadence Music	0.40	0.06	0.12
No Music vs. Increased Cadence Music	0.54	0.06	0.17

Figure 4.1 Step Frequency

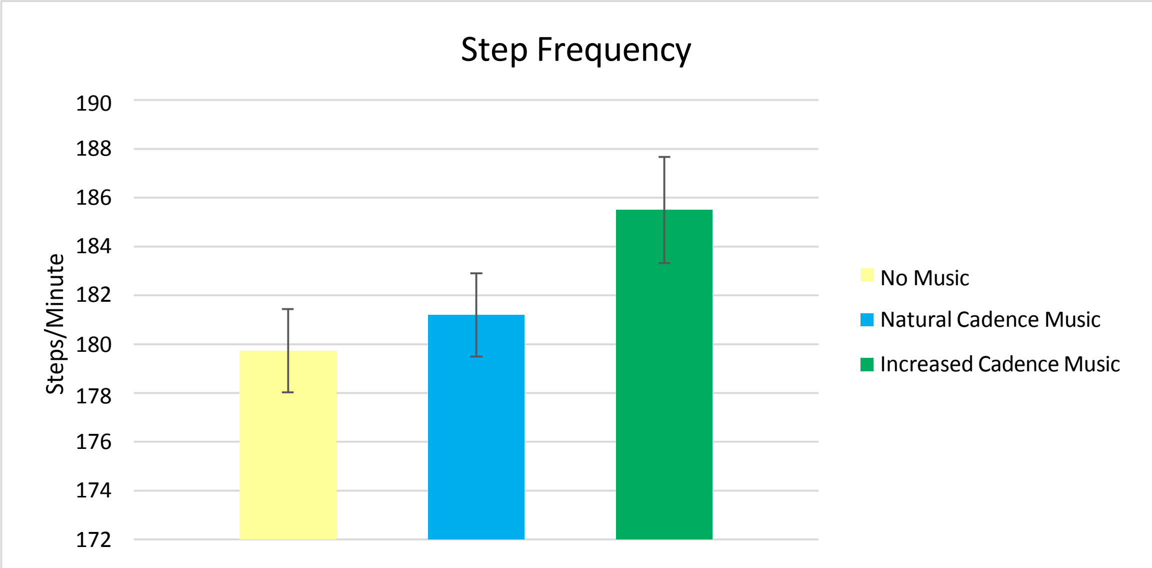


Figure 4.2 Step Length

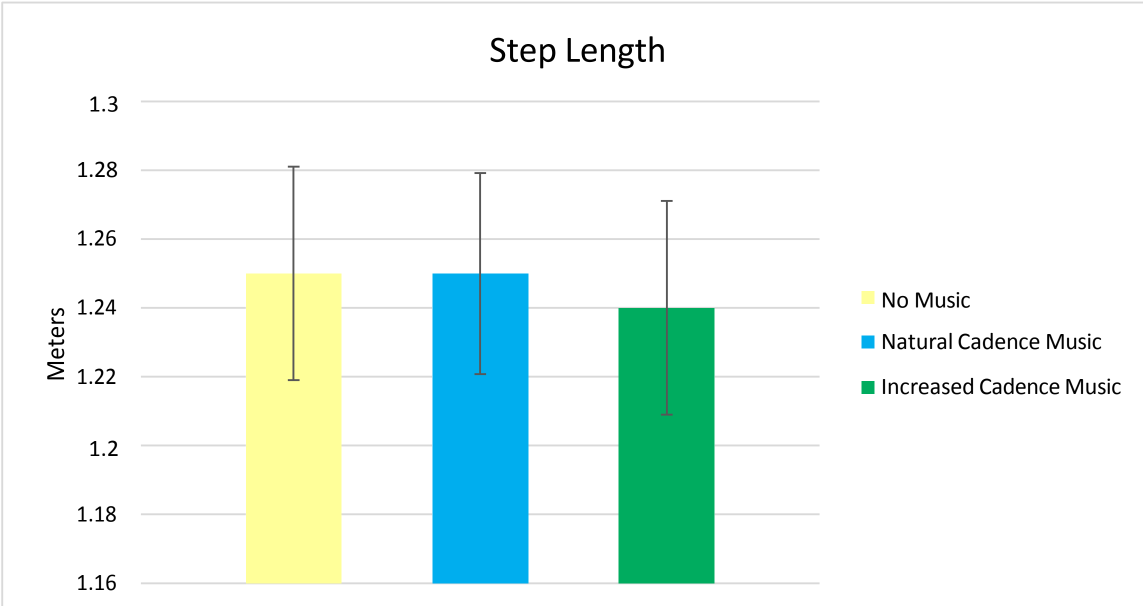
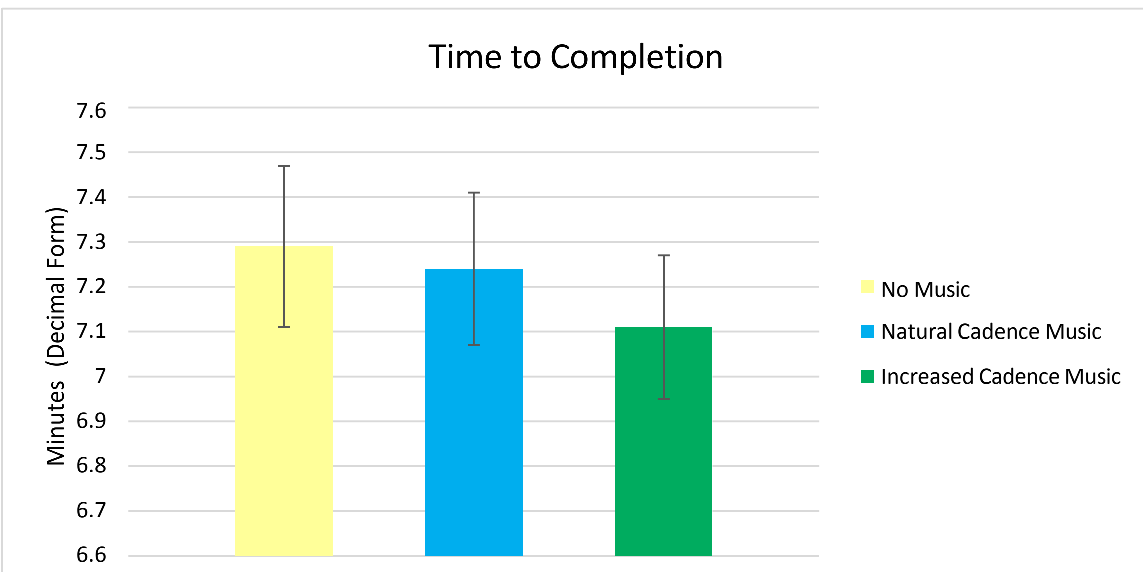


Figure 4.3 Time to Completion



CHAPTER 5: DISCUSSION

Previous research indicates that music is motivational and can help inspire an individual to exercise at a higher intensity and for a longer duration (Barney et al. 2010, Karageorghis et al. 2006). Recent studies have also demonstrated that music can improve exercise performance (Karageorghis et al., 2009, and Simpson & Karageorghis, 2006) and decrease ratings of perceived exertion (RPE) (Lim et al., 2007, Seath & Thow, 1995). It is unclear, however, just how music is able to produce these beneficial effects during exercise. Research by Schneider et al. (2010) and Karageorghis et al. (2010) provide a conceptual framework regarding the brain in terms of how music is able to positively influence an individual during exercise. According to their theories, the brain is able to process music that comes from an outside source and then synchronize movement that corresponds to the music.

In terms of increasing exercise performance, running velocity is improved with an increase in step frequency, step length, or a combination of the two (Marais et al. 2003, Daniels, 1988; Hunter et al., 2004; & Ballreich, 1976). Currently, there is limited research that observes methods that may help increase running velocity. Manipulating music cadence may be considered an effective training method that may significantly improve running performance due to its influence on step frequency. According to Karageorghis et al (2010), it is important for music cadence to be fast enough to cause an ergogenic effect. The purpose of this study was to observe the effect of music cadence on step frequency during a 1600-meter maximal effort run in a group of recreational runners. The main objective was to compare the difference in step frequency and time to completion between a natural cadence music condition and an increased cadence music condition. It was hypothesized that the increased cadence music condition may have more of an ergogenic effect compared to both the natural cadence and no music conditions. As a result of this research, altering music cadence may be considered an effective training method for recreational runners as music cadence can be manipulated to coincide with the runner's desired step frequency and subsequent intensity. Another purpose of this study was to increase ecological validity as this study took place in a real world setting where runners typically exercise.

Music and Exercise Performance

Music appears to have a potential ergogenic effect as it can help improve exercise performance. There is however, conflicting evidence in research regarding music and its overall influence on performance. This is especially true when comparing two types of music conditions. Results from the current study revealed that running performance was significantly improved during the increased cadence music condition compared to the natural cadence music and no music conditions. Similarly, Karageorghis et al. (2009) found that endurance was significantly higher when comparing motivational music to outdeterous music at 75% maximal heart rate reserve (HRR). Barwood et al. (2009) also discovered that the farthest distance covered on a treadmill was in the motivational music condition compared to a neutral video condition and a control condition of no music or video. These findings suggest that one music condition may be superior to another music condition in terms of increasing exercise performance.

In contrast to the above findings, exercise performance may not be significantly different when comparing two music conditions. Simpson and Karageorghis (2006) observed music conditions during a 400-meter maximal effort run. It was found that there was a significant improvement in running velocity in both the outdeterous and motivational music conditions compared to no music; however, no significant difference existed between the motivational and outdeterous music conditions. Simpson and Karageorghis (2006) explain that the rhythmic aspect of music is what facilitated this improvement and not its overall motivational rating. Another study by Terry et al. (2012) showed similar results as endurance performance was significantly improved in the motivational and neutral music conditions compared to no music; and no significant difference existed between the motivational and neutral music conditions.

The major difference between these results were that Simpson and Karageorghis (2006) and Terry et al. (2012) compared two music conditions based on the motivational quality on performance, whereas the current study compared two music conditions based on the cadence of music on performance. These results contribute to existing research of music and exercise, as an increase in music cadence was shown to help improve running performance. Another consideration involves the overall distance completed. In Simpson and Karageorghis's (2006) study, the distance was 400 meters in length while the distance in the current study was 1600 meters in length. During 400 meters, overall effort may have been higher compared to 1600 meters as various pacing strategies become more involved. Currently, there is limited research that observes the influence of music on performance when comparing a shorter versus a longer distance. It would be interesting to see whether results would differ if the distance covered was farther in Simpson and Karageorghis's (2006) study. Lastly, the study design by Simpson and Karageorghis (2006) had six participants run at one time rather than individually. This may have influenced runners to give more of an overall effort during time trials. In comparison, the current study focused more on the individual aspect of training in runners. This is an important consideration as most runners train individually and then compete against others in road races. If this study were repeated, results may differ if individuals ran at the same time as others. Further research should be conducted on running performance that compares running individually to running in a group setting.

Running Velocity

Previous research has observed the relationship between step frequency and step length. Based on this research, it is assumed that an increase in running velocity occurs with an increase in step frequency or step length without a significant decrease in the other (Hunter et al., 2004; & Ballreich, 1976). There are opposing views however, on whether to focus on increasing step frequency or step length in order to improve running velocity. Results from the current study indicate that step frequency contributes to an improvement in running velocity, as a higher step frequency resulted in an improvement in time to completion. Hunter et al. (2005) also discovered that step frequency was more associated with running velocity when observing runners perform 25-meter sprints on a track. Hunter et al. (2005) describes that the ground reaction force is the mechanism behind the improvement in acceleration during a sprint. Daniels (1998) and Heiderscheit et al. (2011) also believe that an increase in step frequency is more beneficial than step length due to its potential to decrease the occurrence of injury.

In contrast to the above findings, Mackala (2007) found that running velocity was increased during a 100-meter sprint when step frequency or step length was increased during particular ten-meter intervals. Step length was found to be the main contributor to the improvement in running velocity compared to step frequency. Cavagna et al. (1988) also observed an increase in step length with a higher speed as participants ran across a force plate.

A benefit of this current study is that it provides some insight into the relationship between step frequency and step length. Results indicated that step frequency was significantly increased and time to completion was significantly improved during the increased cadence music condition. These results support the notion from Hunter and colleagues (2005) that running velocity improves with an increase in step frequency. In this study, it was shown that step length did not significantly change throughout the course of the 1600-meter run. According to Hunter et al. (2004), there is an inverse relationship between step frequency and step length. Therefore, an increase in one results in a decrease in the other. Since step frequency was significantly increased and time to completion was significantly improved, this demonstrates that step length was not affected by music cadence to an extent that had a negative impact on running velocity.

The major difference between this study and previous research mentioned above is the overall distance covered. Mackala, (2007), Cavagna et al. (1988), Hunter et al. (2004), and Hunter et al. (2005) observed step frequency and step length during sprinting tasks. The current study was more endurance-based and observed participants run 1600 meters in length. Therefore, it appears that an increase in step frequency and step length without a significant decrease in the other will result in an improvement in running velocity for both sprinting and endurance related tasks.

Music Cadence and Step Frequency

In the current study, it was hypothesized that music cadence may have a significant influence on increasing step frequency. Results supported this hypothesis as step frequency was significantly increased ($p < 0.05$) during the increased cadence music condition. In contrast, a study by Ahmaniemi (2007) compared music cadence to music's overall motivational rating and step frequency on a 350-meter track. Results showed that there was no significant relationship between step frequency and music cadence. One of the reasons why these results differed may be due to the population being tested. The current study tested an organized running group of recreational runners whereas Ahmaniemi (2007) tested an active group of marathon runners. Recreational runners in this study actively participated in weekly speed workouts and ran races of varying distances (5K, 10K, 15K, half marathons, marathons) These runners also had different speeds as their time to completion in the 1600-meter run ranged from 5:29 to 9:16 minutes. In Ahmaniemi (2007), it is unclear how fit these marathon runners were in terms of speed, however training for a marathon is much different than training for races of shorter distances. This is especially true when concerning step frequency as it is recommended for marathon runners to train at a particular step frequency (Daniels, 1998).

Another consideration involves the number of participants selected. In Ahmaniemi (2007), there were only eight runners who participated whereas the current study had thirty. Results from Ahmaniemi (2007) may have been different if there was a larger sample size. Finally, the methods were very different when comparing the two studies. Ahmaniemi (2007) had participants run thirty minutes on an outdoor track where the measurement of performance was not a factor. In comparison, the current study had participants run a 1600-meter time trial, and time to completion was found to be significantly improved during the increased cadence music condition. If Ahmaniemi (2007) had a performance measure, it would be interesting to see if altering music cadence would have improved performance in this group of marathon runners. For future studies involving music cadence and exercise, it is important to consider the population being tested, the overall distance covered, the number of participants chosen, and the measurement of performance.

Design Strengths

Personal Selection of Music. One main advantage of our study was that recreational runners were able to select 20 motivating songs according to personal preference. Each song selected was based on how close the song's cadence was to the runner's natural step frequency obtained during the familiarization trial. This helped limit any subjectivity in song choice by the research technician who was responsible for creating each music condition. Runners also took the BMRI-2 in order to rate the motivational quality of music on each runner's playlist. This ensured that music selected was motivational for the runner.

Ecological Validity. Another main advantage of this study was that it took place in a real world setting. This particular track location was familiar to this group of recreational runners as the running group utilizes this track for speed workouts every week. In addition, the 1600-meter run is a common distance that these runners train with during these speed workouts.

Design Weaknesses

Music Cadence. One disadvantage of this study was that the research technician determined the music cadence for the increased cadence music condition. This condition was defined as an increase of 10-20 beats per minute (bpm) above the natural cadence music condition. Therefore, not every runner was exposed to the same increase in music cadence. The main reason for this was that when some songs were manipulated to a certain extent beyond the original cadence, the song might seem too fast, therefore making it difficult to keep up with the increase in music cadence. This may make music un-motivational for runners. In this study, the BMRI-2 was a favorable questionnaire to use in order to ensure that songs were motivational for the runner after the cadence was manipulated. Furthermore, based on the results of this questionnaire, songs were reorganized in each runner's playlist in the order of most motivational to least motivational.

Step Frequency. During this study, step frequency was measured with a countdown timer set to 60 seconds starting at the 50-meter mark along the first straightaway and through the curve of each lap. A major limitation in this method was that each runner would end at a different point along the track because each runner has a different speed. As a result, this causes variation in step frequency among straightaways and curves. Although this method was successful for the majority of runners, there were a select few where this measurement had to be altered. This was because these runners were faster and would start the next lap when step frequency was still being measured in the lap prior. This was considered a problem because if step frequency was measured starting at the 50-meter mark of the first straightaway in the fourth lap, then these individuals would have finished their time trial before the last measurement of step frequency was obtained. In these individuals, step frequency was counted earlier in the fourth lap starting approximately three quarters of the way through the first curve. This ensured that the measurement of step frequency was recorded before the runner crossed the finish line. As a result of this alteration, step frequency was not measured along the same intervals for everyone. This study may have been improved with the use of an accurate pedometer, or a video camera to measure step frequency.

Previous Music History. Although results in the current study demonstrated that both step frequency and time to completion during a 1600-meter run were significantly increased, the majority of runners indicated on their participant background survey that they either sometimes or always did listen to music when training for a road race. In fact, there were only four runners who indicated that they did not listen to music when training for a road race. This may have contributed to results in this study because the majority of runners were accustomed to using music. If this study were repeated, it would be interesting to see what would occur if the population of recreational runners were those who were not accustomed to listening to music. Therefore, more research needs to be conducted on the topic of music cadence and step frequency.

Study Location. Another limitation in the current study involves the location of the public, outdoor track. During this study, there were other runners, groups, and teams using the track during time trials that may have positively or negatively influenced each runner's performance, as it would ultimately interfere with each runner's pacing strategy. For example, if there were other runners not in the study using lane one, participants could decide to stay a particular distance from them or decide to pass them. In spite of this, the location of the outdoor track was familiar to this group of recreational runners as they perform speed workouts at this track every week. Therefore, it helped improve ecological validity.

Practical Application

The results of the current study contribute to research in the realm of music and exercise as music cadence was shown to be advantageous for recreational runners. These findings demonstrated that the increased cadence music condition was successful in improving time to completion in comparison to the no music condition or natural cadence music condition. This indicates that the cadence of music is what elicited this improvement in performance, not just music itself. Results from this study also revealed that the influence on running speed was due to an increase in step frequency with no effect on step length. During the increased cadence music condition, step frequency was significantly higher compared to the other conditions. Therefore, it would seem advantageous for music cadence to be fast enough to increase step frequency, thereby causing an ergogenic effect.

Based on these results, the manipulation of music cadence can serve as an effective training tool for recreational runners. In order to optimize running performance, runners should first determine their natural step frequency. This can be accomplished by counting the number of times the left foot hits the ground in one minute and then multiplying this number by two. Once runners know their natural step frequency, they can then select music from their personal playlists or manipulate music cadence to be approximately 10-20 beats per minute (bpm) above their natural step frequency. There is existing technology that makes it relatively easy for individuals to manipulate the cadence of music. Runners could use a software program such as Audacity™ to increase the cadence of music and sync songs onto their personal music player. Individuals could also download mobile applications such as MagicPro™ or Pace DJ™. Once effective music conditions are created, recreational runners will likely adjust their step frequency to the increased cadence of music, therefore leading to an improvement in running performance.

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APPENDICES

Appendix A: Medical History Questionnaire

MEDICAL HISTORY QUESTIONNAIRE

Study______________________________ Subject # _______________

Name________________________Sex_____Age______ DOB ____________

Street ____

City________________State_____ Zip__________Phone ____________

Email __________________________________

PLEASE ANSWER ALL OF THE FOLLOWING QUESTIONS AND PROVIDE DETAILS FOR <u>ALL</u> "YES" ANSWERS IN THE SPACES AT THE BOTTOM OF THE FORM.

YES	NO		
☐	☐	1.	Has your doctor ever said that you have a heart condition <u>and</u> that you should only do physical activity recommended by a doctor?
☐	☐	2.	Has your doctor ever denied or restricted your participation in sports or exercise for any reason?
☐	☐	3.	Do you ever feel discomfort, pressure, or pain in your chest when you do physical activity?
☐	☐	4.	In the past month, have you had chest pain when you were not doing physical activity?
☐	☐	5.	Do you lose your balance because of dizziness or do you ever lose consciousness?
☐	☐	6.	Does your heart race or skip beats during exercise?
☐	☐	7.	Has a doctor ever ordered a test for you heart? (i.e. EKG, echocardiogram)
☐	☐	8.	Has anyone in your family died for no apparent reason or died from heart problems or sudden death before the age of 50?
☐	☐	9.	Have you ever had to spend the night in a hospital?
☐	☐	10.	Have you ever had surgery?
		11.	Please check the box next to any of the following illnesses with which you have ever been diagnosed or for which you have been treated.

☐ High blood pressure	☐ Elevated cholesterol	☐ Diabetes
☐ Asthma	☐ Epilepsy (seizures)	☐ Kidney problems
☐ Bladder Problems	☐ Anemia	☐ Heart problems
☐ Coronary artery disease	☐ Lung problems	☐ Chronic headaches

YES	NO		
☐	☐	12.	Have you ever gotten sick because of exercising in the heat? (i.e. cramps, heat exhaustion, heat stroke)
☐	☐	13.	Have you had any other significant illnesses not listed above?
☐	☐	14.	Do you currently have any illness?

15. Do you know of any other reason why you should not do physical activity?

16. Please list all medications you are currently taking. Make sure to include over-the-counter medications and birth control pills.

Drugs/Supplements/Vitamins	Dose	Frequency (i.e. daily, 2x/day, etc.)

DETAILS:

17. Please list all allergies you have.

Substance	Reaction

18. Have you smoked?

	If yes, #/day	Age Started	If you've quit, what age?
Cigarettes			
Cigars			
Pipes			

19. Do you drink alcoholic beverages? If yes, how much? How often?

20. Do you have a family history of any of the following problems? If yes, note who in the space provided.

- High blood pressure
- High cholesterol
- Diabetes
- Heart disease
- Kidney disease
- Thyroid disease

21. Please check the box next to any of the following body parts you have injured in the past and provide details.

- Head
- Neck
- Upper back
- Lower back
- Chest
- Hip
- Thigh
- Knee
- Ankle
- Foot
- Calf/shin
- Shoulder
- Upper arm
- Elbow
- Hand/fingers

22. Have you ever had a stress fracture?

23. Have you ever had a disc injury in your back?

24. Has a doctor ever restricted your exercise because of an injury?

25. Do you currently have any injuries that are bothering you? ☐ ☐

26. Do you consider your occupation as?

- ☐ Sedentary (no exercise)
- ☐ Inactive-occasional light activity (walking)
- ☐ Active-regular light activity and/or occasional vigorous activity (heavy lifting, running, etc.)
- ☐ Heavy Work-regular vigorous activity

27. List your regular physical activities

Activity	How often do you do it?	How long do you do it?	How long ago did you start?
________	________	________	________
________	________	________	________
________	________	________	________
________	________	________	________

ADDITIONAL DETAILS: ____

Appendix B: Participant Background Survey

PARTICIPANT BACKGROUND SURVEY

1. What is your age? __________

2. What is your gender?

   Male ________

   Female ________

3. Within the past six months, how many times do you run per week on average excluding injury, illness, or extended travel?

____

____

4. Within the past six months, what is your fastest 1600-meter (mile) time in minutes?

____

____

5. Are you able to run this distance (1600-meters) continuously without stopping?

   Yes _____

   No _____

5. Do you typically listen to music while you run or train for a race?

   Yes________ No_________ Sometimes ________

6. Please take training runs into consideration when answering these next two questions.

a. What day(s) of the week are most convenient for you to participate in this research study?

____

____

____

____

____

____

____

____

b. What time of day is most convenient for you to participate in this research study? Please include am/pm hours.

____

____

____

____

____

____

____

7. Please list the name and artist of twenty motivational songs you typically listen to while you run. If you do not listen to music, please list the name and artist of ten motivational songs you typically listen to for personal enjoyment.

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________
6. ______________________________
7. ______________________________
8. ______________________________
9. ______________________________
10. ______________________________
11. ______________________________
12. ______________________________
13. ______________________________
14. ______________________________
15. ______________________________
16. ______________________________
17. ______________________________
18. ______________________________
19. ______________________________
20. ______________________________

Appendix C: ACSM's Current Comment on Pre-Event Meals

ACSM CURRENT COMMENT

Pre-Event Meals

It is well established that exercise performance can be affected by diet and, in order to maintain optimal training, the body must be properly refueled with appropriate nutrients. The pre-event meal is an integral part of the complete training plan. Of course, a single pre-event meal will not compensate for a poor training diet. For this reason, the active person should routinely follow basic nutrition guidelines. It is essential that the diet contain enough calories to cover the active person's daily energy expenditure. It is also advised that the diet be composed of a wide variety of foods to ensure adequate intake of vitamins and minerals. The training diet should be high in carbohydrate without compromising necessary protein and fat.

The pre-event meal should have a definite focus on carbohydrate intake. Prioritizing carbohydrates is supported by evidence that exercise performance is typically enhanced following a high carbohydrate meal as compared to a low carbohydrate meal. Carbohydrate in the liver and muscles (glycogen) can be metabolized to provide energy for the working muscle more rapidly than fat, allowing a person to sustain a higher intensity level of exercise. Therefore, its depletion would inevitably result in a need to reduce exercise intensity or discontinue exercise. Although the body's glycogen storage is limited, the diet should provide enough carbohydrate to maximize glycogen stores, particularly for those participating in endurance events. The basic goals of the pre-event meal are as follows: (1) prevent weakness and fatigue, whether due to low blood sugar levels or inadequate muscle glycogen stores, during the event, (2) ward off feelings of hunger yet minimize gastrointestinal distress from eating, and (3) guarantee optimal hydration. In addition, individual preferences must be considered. If a person truly believes that a specific food will improve performance, then the psychological effect of consuming that food may result in enhanced performance.

The meal should consist primarily of carbohydrates and fluids, as they can be easily digested. If the meal is small (400-500 Calories), it can be consumed approximately 2-3 hours prior to an event allowing enough time for digestion and absorption. If the meal is high in fat, protein, or fiber, extra time must be allowed for digestion. Also, as the amount of food consumed increases, so will the time needed for digestion. A large meal containing appreciable amounts of protein or fat may need to be eaten 5-6 hours before competition. Carbohydrates high in fiber and gas-forming (bran products, legumes, and certain vegetables, such as onion, cabbage and cauliflower) are not recommended as they may cause intestinal discomfort. A liquid source of carbohydrate can be taken prior to the event when schedules do not allow time for meals or for those who have a sensitive stomach or experience pre-competition anxiety. Liquid meals can include sports drinks, juices, low-fat smoothies and shakes.

Carbonated drinks should be avoided as they may cause stomach discomfort. Caffeinated drinks should be considered on an individual basis. For some individuals, caffeine may be ergogenic, most notably in sparing muscle glycogen and thereby prolonging fatigue during endurance events. However, for others it may cause nausea and anxiousness. In addition, an excess of caffeine can contribute to dehydration through its diuretic effect.

The pre-event meal is particularly important before a morning event, since as much as 12 hours or more may have passed since the last meal and liver glycogen levels could be sub-optimal. The pre-event meal could replenish glycogen stores and decrease chance of hypoglycemia (low blood sugar) and therefore, delay fatigue. Since early morning pre-event meals may need to be limited in size, it would be important to consume a substantial carbohydrate dinner the night before. Again, plenty of liquids should also be consumed to ensure maximum hydration status. Suggestions for pre-event food choices are listed below:

Morning events:
The night before, eat a high-carbohydrate meal. Early morning, eat a light breakfast or snack: cereal and non-fat milk, fresh fruit or juice, toast, bagel or English muffin, pancakes or waffles, non-fat or low-fat fruit yogurt, or a liquid pre-event meal

Afternoon events:
Eat a high-carbohydrate meal both the night before and for breakfast. Follow with a light lunch: salads with low-fat dressings, turkey sandwiches with small portions of turkey, fruits, juice, low-fat crackers, high-carbohydrate nutritional bars, pretzels, rice cakes

Evening events:
Eat a high-carbohydrate breakfast and lunch, followed by a light meal or snack: pasta with marinara sauce, rice with vegetables, light-cheese pizza with vegetable toppings, noodle or rice soups with crackers, baked potato, frozen yogurt

No one food or group of foods works for everybody; the person may need to experiment to find which foods, and the amount of food, that works best. Food choices may vary based on the type of exercise, as well as the intensity and duration of the exercise. However, it is important to experiment with new foods during training rather than around competition.

Written for the American College of Sports Medicine by Helen DeMarco, M.S., R.D.

Current Comments are official statements by the American College of Sports Medicine concerning topics of interest to the public at large.

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Appendix D: Items to Bring to the Track

Please bring the following items to the track for each time trial:

1. Light, comfortable running clothes. Please wear similar clothes for each experimental trial.
2. Comfortable running shoes (preferably the same shoes you run to train in)
3. Personal headphones
4. Rehydration Beverage

Appendix E: Items on the BMRI-2

The following terms are musical elements you will rate on the BMRI-2. Please read the definition of each term listed below prior to taking the questionnaire (Karageorghis et al., 2006; Karageorghis & Terry, 2009)

1. **Rhythm-** The distribution of notes overtime, in which they are organized in a specific pattern.
2. **Style-** The genre of music (rock, dance, hip-hop, country, etc.)
3. **Melody-** The tune of a piece of music that you may hum along to.
4. **Tempo-** The overall speed at which music is played, also known as cadence in beats per minute.
5. **Instrumental Sound-** The overall sound of different instruments used together (guitar, piano, drums, trumpet, synthesizer, etc.)
6. **Beat-** Repeated background sound that occurs spontaneously throughout the song.

Appendix F: The BMRI-2 (Karageorghis et al., 2006)

The Brunel Music Rating Inventory Questionnaire-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 circling one of the numbers to the right of each statement. 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.

Strongly disagree In-between Strongly agree

1	The rhythm of this music would motivate me during exercise	1	2	3	4	5	6	7
2	The style of this music (i.e. rock, dance, jazz, hip-hop, etc.) would motivate me during exercise	1	2	3	4	5	6	7
3	The melody (tune) of this music would motivate me during exercise	1	2	3	4	5	6	7
4	The tempo (speed) of this music would motivate me during exercise	1	2	3	4	5	6	7
5	The sound of the instruments used (i.e. guitar, synthesizer, saxophone, etc.) would motivate me during exercise	1	2	3	4	5	6	7
6	The beat of this music would motivate me during exercise	1	2	3	4	5	6	7

Appendix G: IRB Approval Letter

USF UNIVERSITY OF SOUTH FLORIDA

RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX (813) 974-7091

1/31/2014

Micaela Galosky,
School of Physical Education & Exercise Science
11711 North 50th St Apt 707
Tampa, FL 33617

RE: **Expedited Approval for Initial Review**
IRB#: Pro00012152
Title: The Effect of Music Cadence on Step Frequency in the Recreational Runner

Study Approval Period: 1/30/2014 to 1/30/2015

Dear Dr. Galosky:

On 1/30/2014, the Institutional Review Board (IRB) reviewed and **APPROVED** the above application and all documents outlined below.

Approved Item(s):

Protocol Document(s):

Protocol

Surveys and Questionnaires:

ACSM's Current Comment- Pre-Event Meals(0.01)
Medical History Questionnaire(0.03)
Participant Background Survey(0.01)
Data Collection Sheet(0.01)
VO2 Max Certificate(0.01)
Definition of Terms on BMRI-2(0.01)
Items to Bring(0.01)

Recruitment Materials:

Recruitment Email

Consent/Assent Document(s)*:

Informed Consent.pdf

*Please use only the official IRB stamped informed consent/assent document(s) found under the "Attachments" tab. Please note, these consent/assent document(s) are only valid during the approval period indicated at the top of the form(s).

It was the determination of the IRB that your study qualified for expedited review which includes activities that (1) present no more than minimal risk to human subjects, and (2) involve only procedures listed in one or more of the categories outlined below. The IRB may review research through the expedited review procedure authorized by 45CFR46.110 and 21 CFR 56.110. The research proposed in this study is categorized under the following expedited review category:

(7) Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

As the principal investigator of this study, it is your responsibility to conduct this study in accordance with IRB policies and procedures and as approved by the IRB. Any changes to the approved research must be submitted to the IRB for review and approval by an amendment.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-5638.

Sincerely,

John Schinka, Ph.D., Chairperson
USF Institutional Review Board