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A Mixed-methods Approach to Understanding the Relationship Between Mental Toughness and the Effect of Music on Exercise Performance

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A MIXED-METHODS APPROACH TO UNDERSTANDING THE RELATIONSHIP BETWEEN MENTAL TOUGHNESS AND THE EFFECT OF MUSIC ON EXERCISE PERFORMANCE

by

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ABSTRACT

Previous research has investigated the use of music as an ergogenic aid for exercise performance; however, the effect of music on exercise may differ between individuals of varying levels of mental toughness (MT). **Purpose:** The purpose of this study is to examine the moderating effect of MT on the effect of listening to music during exercise. **Methods:** The current study used a counter-balanced design, utilizing a mixed-methods approach. Thirty-one recreationally-active individuals (22.13 ± 2.11 yrs, 1.73 ± .10 m, 75.68 ± 14.67 kg, 42.89 ± 5.31 $mL \cdot kg \cdot min^{-1}$; 65.5% males) were recruited for this study. Participants completed an initial visit to complete a MT questionnaire and create a personalized music playlist of at least 15 songs. Participants completed two familiarization trials and a VO_{2max} test on the treadmill, all on separate days. The experimental trials consisted of two separate conditions: 1) no music (NM); and 2) self-selected music (SSM). For each experimental trial, participants performed a time-to-exhaustion (TTE) run at 80% of their VO_{2max}, separated by at least 48 hours, followed by a post-study interview. Pearson product-moment correlations were used to investigate relationships between performance variables and MT. Moderated regression analysis was used to determine a potential order effect, as well as a potential moderating effect of MT on change in performance between NM and SSM groups. Linear regression analysis was used to determine a potential relationship between MT and change in performance between NM and SSM groups. An alpha level of $p \leq 0.05$ was used to determine statistical significance. All qualitative data from post-study interviews was transcribed, coded, and categorized into primary themes. All statistical analyses was conducted via the Statistical Package for Social Science (SPSS) software for Windows version 21 (SPSS Inc., Chicago, IL). **Results:** Averages were calculated for MT (156.39 ± 9.38),

TTE_{SSM} (14.18 ± 4.79 minutes), and TTE_{NM} (12.23 ± 5.24 minutes). Correlations were found between VO_{2max} and TTE_{SSM}, TTE_{NM}, and MT (r = 0.390, p = 0.030; r = 0.519, p = 0.003; r = 0.404, p = 0.024; respectively). Moderated regression analysis revealed a non-significant interaction between MT, music, and order, indicating no order effect ($\beta = -0.416$, $p = 0.735$). Independent samples t-tests revealed no significant difference in MT, performance, or VO_{2maz} between groups of participants who received music first or music second, indicating no effect of order (F = 0.388; p = 0.538; F = 0.537; p = 0.470; F = 0.070; p = 0.794; respectively. Moderated regression analysis, via linear regression, determined no significant moderating effect of MT on the change in performance between trials (ΔTTE) (F (3, 58) = 0.958, r = 0.217, p = 0.498). Linear regression, however, revealed a significant main effect of MT, indicating an inverse relationship between MT and ΔTTE (F (1, 29) = 4.417, r = -0.634, p = 0.044). **Discussion:** The results from the current study indicate that greater levels of MT were associated with less change between the two performance trials, however, there were no significant relationships between MT or performance with self-selected music. This finding suggests that individuals with greater MT may demonstrate consistent patterns of performance, irrespective of the presence of external factors. Understanding the effects of MT and how external and internal stimuli affect performance may allow exercise professionals to tailor their training or rehabilitation programs to each individual, therefore increasing exercise performance and adherence.

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LIST OF ACRONYMS/ABBREVIATIONS

BMI	body mass index
bpm	beats per minute
CO_2	carbon dioxide
GXT	graded exercise test
HPL	Human Performance Laboratory
HR	heart rate
mph	miles per hour
MT	mental toughness
NM	no music
O_2	oxygen
PAR-Q	Physical Activity Readiness Questionnaire
RCP	respiratory compensation point
RER	respiratory exchange ratio
RPE	Rating of Perceived Exertion
RPE_f	final rating of perceived exertion
RPE_{fSSM}	final rating of perceived exertion during SSM group
RPE_{fNM}	final rating of perceived exertion during NM group
ΔRPE_f	change in ratings of perceived exertion between $RPE_{final-SSM}$ and $RPE_{final-NM}$
RPE_s	starting rating of perceived exertion
RPE_{sSSM}	starting rating of perceived exertion during SSM group

RPE_{sNM}	starting rating of perceived exertion during NM group
ΔRPE_s	change in ratings of perceived exertion between $RPE_{start-SSM}$ and $RPE_{start-NM}$
SD	standard deviation
SSM	self-selected music
TTE	duration of time-to-exhaustion
TTE_{SSM}	duration of time-to-exhaustion during SSM group
TTE_{NM}	duration of time-to-exhaustion during NM group
VCO_2	carbon dioxide production
VE	ventilatory equivalent
VO_2	oxygen consumption
VO_{2max}	maximal oxygen consumption

CHAPTER ONE: INTRODUCTION

The physical activity recommendations as stated by the Center for Disease Control and Prevention (CDC) include approximately 60 minutes per day, or 420 minutes per week, of aerobic exercise and at least three days per week of muscle-strengthening or strength-based exercise (Center for Disease Control and Prevention, n.d.). Currently in the United States, however, roughly only one half of young adults meet the minimum guidelines for aerobic exercise per week, and only 25-30% meet the minimum guidelines for aerobic and muscle strengthening exercise combined (Center for Disease Control and Prevention, n.d.). It is well documented that low levels of exercise may lead to negative physical and mental consequences, including obesity, chronic disease, depression, anxiety, stress, and low self-confidence (Booth, Roberts, & Laye, 2012; Strohle, 2009; de Moor, Beem, Stubbe, Boomsma, & Geus, 2006). In young and college-aged adults specifically, researchers have found that in addition to too much homework, studying requirements, or lack of time, one of the primary reasons for these low levels of exercise is a lack of motivation (Darin, Almeida, Carneiro, Silva, & Sanchez, 2015; Wilson, Mack, & Grattan, 2008; Lindsey, Conway, Crawford, Daniels, & Dibenedetto, 2006). For exercise providers, creating a motivating environment for clients is crucial; however, not every individual is motivated in a similar manner. One of the most common forms of exercise motivation is through the use of an external stimulus, such as listening to music or motivational cheering (Barney, Gust, & Liguori, 2012; Harmon & Kravitz, 2007; Darin, Almeida, Carneiro, Silva, & Sanchez, 2015). In fact, research has shown that over half of college-aged individuals state that if they were to listen to music through use of a personal music player (e.g., phone, iPod) during exercise, they would be more likely to exercise at a higher frequency each week (Barney, Gust, & Liguori, 2012).

Music as a motivating factor for exercise has been studied in previous research, with the majority of studies suggesting that music may enhance exercise performance (Bigliassi, Estanislau, Carneiro, Kanthack, & Altimari, 2013; RamezanPour, Moghaddam, & Sadifar, 2012; Karageorghis, Jones, & Low, 2006; Brownley, McMurray, & Hackney, 1995). This may be due a number of factors, including the distraction and emotional stimulation provided by listening to music (Karageorghis, Terry, Lane, Bishop, & Priest, 2012; Nethery, 2002; Karageorghis, Terry, Lane, Bishop, & Priest, 2012; Priest & Karageorghis, 2008; Terry, Karageorghis, Mecozzi Saha, & D'Auria, 2012). Specifically, previous studies have shown that listening to music may serve as a distraction for the exercising individual, minimizing any feelings of discomfort, pain or exertion from the activity being performed (Karageorghis, Terry, Lane, Bishop, & Priest, 2012; Nethery, 2002). In fact, Priest and colleagues (2004) showed that 91% of individuals stated that listening to music took their mind off of the exercise at hand (Priest et al., 2004). Additionally, listening to music during exercise may bring out a series of emotions that might influence or inspire the individual to perform at a higher intensity or for a longer duration of time (Karageorghis, Terry, Lane, Bishop, & Priest, 2012; Priest & Karageorghis, 2008; Terry, Karageorghis, Mecozzi Saha, & D'Auria, 2012). For example, music that brings on feelings of inspiration may increase an individual's will to perform for a longer duration or at a higher intensity (Priest & Karageorghis, 2008).

On the basis of exercise performance, researchers have shown increases in both aerobic and anaerobic exercise performance in individuals who listened to music of their preference, showing improvements in anaerobic power (during Running Anaerobic Sprint Tests), aerobic power (during 1600-meter runs), sprint performance (during 60-meter sprints), and muscular endurance (during push-up tests to failure) (Arazi, Ghanbari, Zarabi, & Rafati, 2017). In addition to improvements in actual exercise performance, psychological factors may also be affected by music during exercise. Research has demonstrated that listening to music during exercise may decrease ratings of perceived exertion (RPE), indicating that music may alter an individual's perception of effort during exercise (Barney, Gust, & Liguori, 2012; Karageorghis, Terry, Lane, Bishop, & Priest, 2012; Bharani, Sahu, & Mathew, 2004). This decrease in perceived exertion may be due to the distraction mechanism that music provides, allowing individuals to focus primarily on the music as opposed to physical exertion or body aches and pains associated with exercise (Karageorghis, Terry, Lane, Bishop, & Priest, 2012; Nethery, 2002). Additionally, a study by Sharman and Dingle (2015) revealed that listening to music during exercise increased ratings of happiness and feelings of inspiration in participants (Sharman & Dingle, 2015), while a study by Karageorghis et al. (2009) demonstrated that during steady-state aerobic exercise, music improved participants' affect by approximately 15% (Karageorghis et al., 2009). These specific improvements may be due to the emotional stimulation that listening to music provides.

Not all individuals may be motivated externally; certain individuals may actually rely on internal factors for motivation, or may be primarily intrinsically motivated. Intrinsic motivation relies on personal satisfaction that comes from exercising, facing challenges, and being stimulated (Darin, Almeida, Carneiro, Silva, & Sanchez, 2015; Sansone & Harackiewicz, 2000; Ryan, Frederick, Lepes, Rubio, & Sheldon, 1997). Individuals who are primarily intrinsically motivated have also been shown to be linked to greater mental toughness, resilience, and hardiness (Gucciardi, 2010). Therefore, previous research may lead us to believe that individuals of differing levels of mental toughness may respond differently to external motivating factors (Andersen, 2011; Tenenbaum et al., 2004).

Due to the complex and multidimensional nature of the term “mental toughness”, for the purposes of the current study, mental toughness will be operationally defined by the 4Cs model proposed by Clough et al. (2002) which consists of four components: 1) control; 2) commitment; 3) challenge; and 4) confidence (Nicholls, Polman, Levy, & Backhouse, 2008; Crust & Clough, 2005; Clough et al., 2002). More specifically, these components include an individual’s ability to: 1) have control over one’s emotions and in one’s life; 2) have the tendency to face encounters head on, create and set goals, and follow through with reaching one’s goals; 3) be flexible and opportunistic when changes in life occur, and view setbacks as opportunities to learn and grow; and 4) have a high level of self-belief in one’s abilities or one’s competences to develop certain abilities needed to complete a task or goal (Nicholls, Polman, Levy, & Backhouse, 2008; Crust & Clough, 2005; Clough et al., 2002).

Though research is limited on the effects of mental toughness on exercise performance, previous findings have demonstrated that greater levels of mental toughness may have a positive effect on exercise performance in individuals (Jones, 2002; Crust & Clough, 2005). Significant correlations have been shown between self-reported mental toughness and endurance performance, including running performance ($r = -0.21$, $p < 0.01$) and isometric muscular endurance ($r = 0.31$, $p < 0.05$), in adolescents and young adults (Mahoney, Gucciardi, Ntoumanis, & Mallet, 2014; Crust & Clough, 2005), as well as sport performance, including basketball, rugby, and bowling (Maddi & Hess, 1992; Golby & Sheard, 2004; Thomas, Schlinker, & Over, 1996). Additionally, associations between reductions in perceived exertion and greater reported mental toughness have been observed during a 30-minute steady-state cycling protocol in college-age adults (Clough, Earle, & Sewell, 2002). These studies suggest that individuals with greater mental toughness may experience enhanced exercise performance, which could be a potential driving factor for exercise adherence (Jones, 2002; Clough, Earle, & Sewell, 2002; Crust & Clough, 2005; Mahoney, Gucciardi, Ntoumanis, & Mallet, 2014)

The effects of music on exercise performance have been unexplored in individuals who have been classified as “mentally tough.” Possibly, individuals with greater mental toughness may not respond positively, if at all, to music to enhance performance. A potential explanation for this may be that individuals with greater mental toughness require less reliance on external stimuli for motivation (Tenenbaum et al., 2004). Furthermore, individuals with greater mental toughness may enjoy the act of exercise itself more than their less mentally tough counterparts, therefore reducing the effect of music on exercise performance (Cox, Roberts, Cates, & McMahon, 2018). This may indicate that individuals with lower mental toughness might need to utilize an external motivating factor as an incentive to exercise and maintain exercise adherence. Additionally, limited research exists on mental toughness and exercise performance and, more specifically, in a general population (Crust, 2008). Previous literature has focused primarily on mental toughness in athletes or in sport, whereas researchers state that mental toughness is not a characteristic that should be solely examined in an athletic population (Crust, 2008). Therefore, there is a need for this type of research in a general population. Finally, the effects of music as a motivating factor for exercise performance have been unexplored in individuals of differing or varying mental toughness in itself. For exercise providers, such as exercise physiologists, physical therapists, coaches, and personal trainers, understanding the effect of mental toughness on exercise motivation can serve as a beneficial strategy for increasing exercise performance, and therefore potentially adherence and enjoyment, on a more individualized level. Therefore, the purpose of this study is to examine the moderating effect of mental toughness on exercise performance with and without listening to music.

Research Question

The following is the research question for this study:

1. Does mental toughness moderate the effect of listening to music on exercise performance?

Specific Aims

The following is the purpose of this study:

1. To determine the moderating effect of mental toughness on the effect of listening to music during exercise.
    a. It was hypothesized that there would exist a significant moderating effect of mental toughness on the effect of music on exercise performance, suggesting that greater levels of mental toughness would attenuate the effects of music on exercise performance.
2. To gather in-depth information regarding the effects of music during exercise performance through the use of semi-structured interviews.
    a. It was hypothesized that post-study interviews would provide insight into individuals with differing levels of mental toughness and the effect of listening to music on exercise performance.

CHAPTER TWO: REVIEW OF LITERATURE

The Effect of Music on Exercise Performance

In the United States, approximately 73-84% of young adults listen to music every day (Priest et al., 2004). Specifically, the use of music during exercise has been shown to be a motivating factor for the general population or individuals just beginning an exercise program (Barney, Gust, & Liguori, 2012; Brownley, McMurray, & Hackney, 1995; Karageorghis & Terry, 2012). The effects of music on exercise performance have been shown to include creating a distraction from the exercise itself (e.g., minimizing feelings of discomfort, pain or exertion from the activity) and eliciting emotions that may be beneficial for performance (Karageorghis, Jones, & Low, 2006; Nethery, 2002; Priest & Karageorghis, 2008; Terry, Karageorghis, Mecozzi Saha, & D'Auria, 2012; Barney, Gust, & Liguori, 2012). Previous findings have indicated that by listening to music, and thereby using an external factor as a distraction mechanism from exercise, perceived effort and fatigue may be decreased by 12% (Karageorghis, Terry, Lane, Bishop, & Priest, 2012; Bharani, Sahu, & Mathew, 2004). Interestingly, a study conducted by Sharman and Dingle (2015) found that listening to extreme music (e.g., heavy metal, death metal) increased levels of happiness and feelings of inspiration in participants (Sharman & Dingle, 2015); however, most studies have not explored the effects of different types, or genres, of music as a way to enhance performance. Instead, many studies examining the effects of music during exercise have emphasized the differences in tempo (e.g., fast-tempo versus slow-tempo) (Karageorghis, Jones, & Low, 2006; Karageorghis, Jones, & Stuart, 2008).

As suggested by Daniels (2013), a running stride rate of 180 steps per minute is ideal for optimal running performance to decrease the landing shock and time spent in the air (Daniels, 2013). Therefore, for the current study, it may be appropriate to utilize songs with a cadence, or tempo, of 180 beats per minute in speed (i.e., utilizing synchronous music to running stride rate), allowing researchers to observe the effects of music type or genre, irrespective of music tempo (Simpson & Karageorghis, 2006). Additionally, music loudness may also have an effect on performance (Bigliassi, Estanislau, Carneiro, Kanthack, & Altimari, 2013; Edworthy & Waring, 2006). Edworthy & Waring (2006) showed that music played at a higher loudness resulted in greater running performance (Edworthy & Waring, 2006). This may be attributable to the idea that louder noises will produce faster movements in part due to a sense of perceived urgency (Edworthy & Waring, 2006). Therefore, utilizing a consistent volume level to control for the potential influence of music loudness on exercise performance may be an important factor to consider during research, as well.

Researchers have also identified that music may serve as an ergogenic aid at different time points during exercise, potentially having a greater benefit to exercise performance near the beginning of exercise compared to the end (Hutchinson & Sherman, 2014; Tenenbaum et al., 2004; Yamashita, Iwai, Akimoto, Sugawara, & Kono, 2006). This may be an indicator that music enhances performance more optimally when exercise intensities are lower, as compared to high-intensity, anaerobic exercise. In fact, a study by Atan (2013) examined the effects of music on anaerobic performance and showed no significant effect of music on power output or heart rate during Running Anaerobic Sprint Tests and Wingate Anaerobic Tests when utilizing fast- and slow-paced music (Atan, 2013). Therefore, for the current study, moderate-intensity exercise will be utilized in order to examine potential effects of music.

Furthermore, the emotional influence of music may play a large role in determining the performance benefits of listening to music during exercise (Lane, Davis, & Davenport, 2011; Priest & Karageorghis, 2008; Sharman & Dingle, 2015). Researchers have attempted to explain the reasoning behind what makes music so emotionally influential and why this emotional influence of music may play a large role in performance changes during exercise (Lane, Davis, & Davenport, 2011; Priest & Karageorghis, 2008; Sharman & Dingle, 2015). Karageorghis and colleagues (1999) determined that the emotional influence is based on how a person interprets music on an individualized level (Karageorghis, Terry, & Lane, 1999). These personal interpretations of music are derived from different musical elements, including tempo and accentuation, melody and harmony, cultural impact, and psychophysical processing (e.g., music bringing upon feelings of nostalgia or stimulation of inspiring thoughts) (Karageorghis, Terry, & Lane, 1999). These music factors (e.g., rhythm and musicality) along with an individual's personal factors (e.g., cultural impact) come together to create motivational qualities of music, which has been shown to be performance enhancing by ways of arousal control, decreased perceived exertion, and improved mood, consequently improving exercise adherence (Karageorghis, Terry, & Lane, 1999). In participants who experience a greater influence from music, exercise performance may increase to a greater degree than in participants who do not experience a large influence from music. The importance of this for exercise professionals is that clients or individuals who are emotionally inspired by music may be able to considerably utilize music as a motivating factor during exercise.

In addition to the psychological response, music may also have a physiological impact on exercise performance, such as decreased cortisol and blood lactate levels, indicating decreased fatigue and a greater capacity for exercise (Ghaderi, Nikbakht, Chtourou, Jafari, & Chamari, 2015; Ooishi, Mukai, Watanabe, Kawato, & Kashino, 2017). In a study by Ghaderi et al. (2015), researchers found that cortisol levels decreased from immediately-prior to exercise to immediately-after exercise in the music listening groups compared to the non-music listening groups (Ghaderi, Nikbakht, Chtourou, Jafari, & Chamari, 2015). Furthermore, Ooishi and colleagues (2017) examined the differences between slow-tempo and fast-tempo music on salivary cortisol levels, showing a decrease in cortisol response in the fast-tempo group, with this decrease being related to participants' arousal level (Ooishi, Mukai, Watanabe, Kawato, & Kashino, 2017). However, this study did not examine the effects of music on the cortisol response during exercise. In fact, minimal research has been conducted in this area.

Similarly, a limited amount of research has been done investigating the blood lactate response to listening to music during exercise. Blood lactate has been shown to be lower in individuals who listen to music during exercise compared to those who don't during 15 minutes of running at 70% of VO_{2max}, indicating a potentially greater metabolic demand for those who do not listen to music during exercise (Szmedra & Bacharach, 1998). Additionally, in a study by Eliakim et al. (2012), blood lactate levels cleared at a faster rate after exercise in participants who listened to music during exercise compared to those who did not; however, no change in blood lactate levels were seen between groups immediately after exercise (Eliakim, Bodner, Eliakim, Nemet, & Meckel, 2012). It is apparent that in order to better understand the physiological effect of listening to music during exercise, further research is required.

The Effect of Mental Toughness and Exercise Performance

Mental Toughness

Mental toughness is used as a fairly broad term in research; however, mental toughness is quite complex and multidimensional. There are many different facets and characteristics of mental toughness, such as resilience, self-efficacy, and confidence (Crust, 2009; Nicholls, Polman, Levy, & Backhouse, 2009; Crust & Clough, 2005). In fact, much of the research surrounding exercise performance and mental toughness does not adhere to the same definition of mental toughness. Furthermore, inconsistencies exist in research with regard to the assessment tools used to measure characteristics related to mental toughness. For example, researchers have utilized a multitude of different scales, such as the Mental Toughness Questionnaire-48 (Clough, Earle, & Sewell, 2002), Sports Mental Toughness Questionnaire (Cowden & Meyer-Weitz, 2015), Psychological Performance Inventory (Wieser & Thiel, 2014), and Mental Toughness Index (Mahoney, Gucciardi, Ntoumanis, & Mallet, 2014); however, to accurately determine the effect of mental toughness or create interventions to potentially increase mental toughness, it is imperative that the tool used to measure this variable is consistent among researchers.

For the purposes of this study, mental toughness will be operationally defined by the 4Cs model proposed by Clough et al. (2002) which consists of four components: 1) control; 2) commitment; 3) challenge; and 4) confidence (Nicholls, Polman, Levy, & Backhouse, 2008; Crust & Clough, 2005; Clough et al., 2002). More specifically, these components include an individual's ability to: 1) have control over one's emotions and in one's life; 2) have the tendency to face encounters head on; 3) be flexible and opportunistic when changes in life occur; and 4) have a high level of self-belief in one's abilities Nicholls, Polman, Levy, & Backhouse, 2008; Crust & Clough, 2005; Clough et al., 2002). Additionally, the Mental Toughness Questionnaire (MTQ48) will be utilized in the current study as proposed by Clough et al. (2002).

Additionally, the subject of how mental toughness is developed in individuals is still in question; limited research has been conducted to investigate the development of mental toughness as an inherited trait or as a result of environmental factors and whether mental toughness is a characteristic that can be developed through training (Crust, 2007). It appears that, according to the research currently published, many researchers agree that certain experiences, influences, and environments may help in the development of mental toughness (Gould & Dieffenbach, 2002; Jones, 2002; Thelwell & Weston, 2005; Gordon & Sridhar, 2005; Bull, Shambrook, James, & Brooks, 2005). In a study by Bull and colleagues (2005), researchers generated a "mental toughness pyramid" which illustrates the development of mental toughness. At the base of the pyramid, environmental influence serves as the most prominent factor in developing mental toughness (including influence of parents and childhood), while tough character, tough attitudes, and tough thinking make up the middle and top of the pyramid (including self-confidence and working well under pressure) (Bull, Shambrook, James, & Brooks, 2005). These researchers emphasized the importance of creating tough environments to increase mental toughness; however, there is currently not enough research to provide adequate backing for this recommendation.

Mental Toughness and Exercise Performance

Previous, but limited, literature has demonstrated the importance of mental toughness on exercise performance; however, researchers have just recently begun to explore this topic to a greater extent. A study by Mahoney et al. (2014) determined a statistically significant negative correlation between mental toughness (measured via the Mental Toughness Index) and cross-country running performance, indicating that the athletes with a greater level of mental toughness had a lower (or faster) race time (Mahoney, Gucciardi, Ntoumanis, & Mallet, 2014). In addition, Crust & Clough (2005) showed that college-aged males with higher levels of mental toughness (measured via the Mental Toughness Questionnaire-48) had greater times to exhaustion during isometric muscular endurance tests (Crust & Clough, 2005). Strong relationships have also been shown between certain characteristics of mental toughness, such as hardiness, resilience, concentration, focus, and coping skills, and basketball performance (Maddi & Hess, 1992), bowling performance (Thomas, Schlinker, & Over, 1996), and cognitive performance (Clough et al., 2002). These previous findings indicate that greater levels of mental toughness characteristics may have a positive effect on exercise performance.

As mental toughness is complex and multidimensional, including characteristics such as resiliency, self-efficacy, and emotional intelligence, Nicholls and colleagues (2015) aimed to examine the mediating effect of mental toughness (measured via the Mental Toughness Questionnaire-48) on the relationship between resiliency and emotional intelligence. The results of this study determined that mental toughness was a positive predictor of resiliency and emotional intelligence, and was also positively predicted by both resiliency and emotional intelligence, resulting in a significantly positive path model (Nicholls et al., 2015). Additionally, mental toughness was also found to be a positive predictor of self-efficacy. Researchers concluded that individuals with high levels of mental toughness may not only have greater coping skills, but may also be able to excel during exercise of higher intensities or longer durations (Nicholls et al., 2015).

In conclusion, much of the research surrounding exercise and mental toughness does not adhere to the same definition of mental toughness nor utilize the same assessment tools to measure it. For example, mental toughness can be broken up into subcategories, including self-efficacy, resiliency, visualization, emotional control, life control, and confidence (Crust, 2009; Nicholls, Polman, Levy, & Backhouse, 2009; Crust & Clough, 2005). Due to the many ways of analyzing mental toughness, whether it be via measures of self-efficacy or self-confidence, there is a lack of consistency in the current research. This is a concern regarding mental toughness research; in order to accurately determine the importance of mental toughness in exercise or create interventions to increase mental toughness, it is imperative that the measurement of this variable is consistent across studies. Additionally, the measurement *tools* used to assess mental toughness vary between studies. Researchers have utilized a multitude of different scales, such as the Mental Toughness Questionnaire-48 (Nicholls et al., 2015), Sports Mental Toughness Questionnaire (Cowden & Meyer-Weitz, 2015), Psychological Performance Inventory (Wieser & Thiel, 2014), and Mental Toughness Index (Mahoney, Gucciardi, Ntoumanis, & Mallet, 2014). Therefore, consistent measurements should be required to appropriately understand the effect of mental toughness on athletic performance. Finally, regardless of these inconsistencies in the current literature, researchers seem to agree that greater mental toughness is associated with improved exercise performance; however, further research is required to better understand these associations and underlying mechanisms of mental toughness.

The Combined Effects of Mental Toughness and Music Listening on Exercise Performance

Minimal research has been conducted to examine the relationships between mental toughness and the effect of listening to music during exercise. In individuals with greater mental toughness, it is possible that music may not have as large of an ergogenic effect on exercise performance as individuals with lower levels of mental toughness. A possible reason for this could be due to individuals with greater levels of resilience needing to rely less on external stimuli for motivation (Tenenbaum et al., 2004). A study by Tenenbaum et al. (2004) reported no significant difference in time-to-exhaustion during running at 90% of VO_{2max} between listening to music and not listening to music during exercise; however, participants did report that listening to music was more beneficial during the beginning of the run compared to the end (Tenenbaum et al., 2004). Exercise at intensities greater than 80% have also been shown to diminish the effects of listening to music during exercise (Karageorghis et al., 2011). These results are potential indicators that music may not act as an ergogenic aid during exercise that primarily relies on the anaerobic energy system. In fact, researchers concluded that listening to music once exercise exceeds anaerobic threshold may not be ergogenic at all. Tenenbaum et al. (2004) stated that external stimuli, such as listening to music, may distract the exercising individual from perceived pain and symptoms of physical exertion, but only up to the point of anaerobic threshold. Once this threshold is reached, researchers claim that an external stimulus is not capable of providing enough of a distraction against the pain and symptoms of physical exertion of exercising at a high enough intensity, as also demonstrated by a small number of other studies (Tenenbaum et al., 2004; Pujol & Langenfeld, 1999; Rejeski, 1985).

Gaps in Literature

Limited research exists surrounding mental toughness and exercise performance, specifically in the general population (Crust, 2008). A large majority of existing literature on this topic seems to explore the effects of mental toughness on sports performance in athletes, while there is a lack of information regarding exercise performance in the general public (Maddi & Hess, 1992; Golby & Sheard, 2004; Thomas, Schlinker, & Over, 1996). To add to this, the effects of music on exercise performance have been unexplored in individuals of differing levels of mental toughness. Previous literature has shown mental toughness to be a factor in performance outcomes; however, if an external motivating factor is utilized, we may be able to see a moderating effect of mental toughness on performance. Overall, more research is required on this subject to fully understand the effects of mental toughness and music on exercise in a general population. Understanding these effects may benefit both exercise professionals and their clients; recognizing an individual's own motivations for exercise may allow for more customizable exercise or rehabilitation programs tailored to each individual's needs.

CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

Participants and Initial Screening

Participants included 31 males and females between the ages of 18-35 currently residing in the Central Florida area. All participants were considered recreationally-active, as defined by the American College of Sports Medicine (ACSM) guidelines ("ACSM's Guidelines for Exercise Testing and Prescription", 2008). All participants were recruited by flyer or word of mouth (Appendix K). To be included in this study, participants were required to be free of any physical limitations as determined by the Confidential Medical and Activity Questionnaire (CMAQ; Appendix F) and Physical Activity Readiness Questionnaire (PAR-Q+; Appendix E). Additionally, participants were excluded if any history of cardiovascular disease, metabolic, renal, hepatic, or musculoskeletal disorders was determined, or if participants were taking any other medication or nutritional supplements that may limit their ability to perform the exercise testing, as determined by the Confidential Medical and Activity Questionnaire. Exclusion criteria further includes the inability to perform an incremental exercise test on a treadmill, as determined by the PAR-Q+.

Following an explanation of all procedures, risks and benefits, each participant was asked to give his or her informed consent prior to participation in this study (Appendix D). All study procedures were approved by the University of Central Florida's Institutional Review Board (Appendix C).

Research Design

The research design of this investigation was a counter-balanced study, utilizing a mixed-methods approach. Individuals were asked to report to the University of Central Florida's Human

Performance Laboratory (HPL) on six separate occasions to complete questionnaires, perform two familiarization trials on the treadmill, perform one incremental exercise test to determine VO_{2max}, perform two exercise trials to measure time TTE, and participate in a semi-structured interview (Figure 1). The following sections describe the measurements and instrumentation that were used in the proposed study, followed by a description of the study procedures.

Measures and Instrumentation

Questionnaires (Independent Variables)

Mental Toughness

The MTQ48 is a 48-item self-report psychometric measure of mental toughness that measures an individual's mindset based on six subscales, including: 1) Challenge (e.g., learning from everything, stretching oneself); 2) Commitment (e.g., delivery oriented, goal oriented); 3) Emotional Control; 4) Life Control; 5) Confidence in Abilities; and 6) Interpersonal Confidence (Perry, Clough, Crust, Earle, & Nicholls, 2013; Appendix H). Previous research supports factorial and internal validity of the MTQ48 in non-athletes and students, a population similar to the current study's sample (Vaughan, Hanna, & Breslin, 2017; Perry, Clough, Crust, Earle, & Nicholls, 2013). Furthermore, measures of validity have been determined to be greater for a non-athletic population (confirmatory factor analysis (CFA) = 0.827; Omega (Ω) = 0.84) (Vaughan, Hanna, & Breslin, 2017; Perry, Clough, Crust, Earle, & Nicholls, 2013). Overall means for the MTQ49 were used for scoring.

Regarding confirmatory factor analysis (CFA), previous research shows that this type of analysis should only be used when sample sizes of greater than 200 are used, or sample sizes that are of a 1:10 "question:participant" ratio are used, meaning that for the current study, 480 participants would be required for CFA analysis (Myers, Ahn, & Jin, 2011). Additionally, the MTQ48 was given to participants in its original form (i.e., the wording of questions was not altered in any way). Specifically, CFA has shown a stronger degree of validity in non-athletes than in both amateur and elite athletes (CFA = 0.827) (Perry, Clough, Crust, Earle, & Nicholls, 2013). Additionally, only a handful of studies regarding the MTQ48 have used CFA to measure validity. Furthermore, these studies utilized participant sample sizes of approximately 500 participants to over 8,000 participants (Perry et al., 2013; Nicholls et al., 2009; Nicholls et al., 2015; Nicholls et al., 2008).

Regarding Cronbach's alpha and measures of internal consistency, approximately half of the studies regarding the MTQ48 have determined internal reliability when using participant samples sizes of 100 or more (Crust, 2009; Crust & Azadi, 2010; Kaiseler, Polman, & Nicholls, 2009; Crust et al., 2014; Stamp et al., 2015; Tham, Kong, & Lee, 2015; Gerber et al., 2015; Stamp, Crust, Swann, & Perry, 2017; Estandarnejad, 2015; Perry et al., 2015; Brand et al., 2014; van der Meulen et al., 2017; Vaughan, Hanna, & Breslin, 2017). When using smaller sample sizes, however, internal reliability of the MTQ48 was simply referenced from previous literature rather than re-run in the study itself (Gerber et al., 2013; Houwer et al., 2017; Ragab, 2015). These studies specifically utilized sample sizes of 21, 6, and 18 (Gerber et al., 2013; Houwer et al., 2017; Ragab, 2015). Regarding using Cronbach's alpha as a measure of internal consistency, previous research, including Cronbach himself, has shown this alpha coefficient to not be an appropriate measure of internal consistency reliability, especially when used for psychometric scales, such as the MTQ48 (Cronbach & Shavelson, 2004). Additionally, if items are deleted when using Cronbach's alpha, one could not make inferences in the implied population being examined in the study (Dunn, Baguley, & Brunsden, 2014; Raykov, 1997). Therefore, Cronbach's alpha was not utilized in the current study. Instead of utilizing Cronbach's alpha as a measure of internal reliability, researchers have found that using the Omega coefficient is a much better test of reliability, specifically because it not does underestimate internal reliability, like Cronbach's alpha (Ercan et al., 2007). Additionally, the Omega coefficient is a much better measure for psychometric scales, specifically ones that utilize a Likert scale, like the MTQ48. However, sample size does play a role, with previous research indicating that a sample size of at least 50 is required to use Omega as a measure of internal consistency (Ercan et al., 2007). For these reasons, internal consistency was not measured in the current study of 31 participants; however, previous literature has shown a greater internal reliability in non-athletes than in athletes when using the Omega coefficient ($\Omega = 0.84$) (Vaughan, Hanna, & Breslin, 2017).

<u>Music Selection</u>

Participants were asked to choose a total of at least 15 songs of their personal preference from a database of songs of varying genres via the Spotify® application (Figure 2). Previous research has demonstrated that permitting participants to self-select their own music during exercise allows for a more realistic, or real-life, approach to examining the influence of music as a potential motivating factor (Crust, 2007). The songs selected by the participants were used during the self-selected music (SSM) condition. As suggested by Daniels (2013), a running stride rate of 180 steps per minute is ideal for optimal running performance (Daniels, 2013); therefore, all songs on the database had a cadence, or tempo, of 180 beats per minute (i.e., utilizing synchronous music to running stride rate). This allows researchers to observe the effects of self-selected music, irrespective of music tempo (Simpson & Karageorghis, 2006). Additionally, music loudness may have an effect on performance (Bigliassi, Estanislau, Carneiro, Kanthack, & Altimari, 2013, Edworthy & Waring, 2006); therefore, the current study utilized a consistent volume during trials to control for the potential influence of music loudness on exercise performance.

<u>Exercise Testing (Dependent Variable)</u>

Incremental Exercise Test (VO_{2max})

A standardized and individualized treadmill protocol was utilized for the VO_{2max} test, using increments of 0.5 km/hour every two minutes for the first six minutes, followed by increases of 0.5 km/hour every one minute until exhaustion (Billat, Hill, Phinoteau, Petit, & Koralsztein, 1996; Kasch, Wallace, Huhn, Krogh, & Hurl, 1976). Previous research has shown no differences in valid VO_{2max} measurements when utilizing a horizontal or incline treadmill test (Kasch, Wallace, Huhn, Krogh, & Hurl, 1976). Additionally, previous research has also demonstrated that utilizing speed increments of 0.5 km/hour each minute will result in an accurate VO_{2max} test when determining maximum velocity (Billat, Hill, Phinoteau, Petit, & Koralsztein, 1996). Specifically, this is crucial for the current study due to experimental trials utilizing a percentage of maximum velocity obtained during VO_{2max} testing. VO_{2max} was determined to be the highest 30-second VO_2 value during the test and coincide with at least two of the following three criteria: (a) 90 % of age-predicted maximum heart rate (HR); (b) respiratory exchange ratio > 1.1; and/or (c) a plateau of oxygen uptake (less than 150 $mL \cdot min^{-1}$ increase in VO_2 during the last 60 seconds of the test). Each test was terminated once participants reached volitional exhaustion.

Gas Exchange Analysis

All gas exchange data was collected using open circuit spirometry (True One Metabolic Cart, Parvo Medics, Inc., Sandy, UT, USA). Twenty minutes prior to each VO_{2max} test, open-circuit spirometry was calibrated with room air and gases of known concentration to estimate VO_2 ($mL \cdot kg^{-1} \cdot min^{-1}$) by sampling and analyzing breath-by-breath expired gases. Flowmeter calibration was also completed before testing to determine accuracy of flow volume during data collection. Participants wore a head unit and breathing mask that stabilized a one-way valve around their mouth. Oxygen (O_2) and carbon dioxide (CO_2) was analyzed through a sampling line after the gases pass through a heated pneumotach and mixing chamber. Respiratory gases (VO_2, VCO_2, ventilatory equivalent (VE), and respiratory exchange ratio (RER)) were monitored continuously.

Instrumentation

A motorized treadmill (Woodway 4Front™, Waukesha, Wisconsin, United States) was used to complete VO_{2max} testing. Open-circuit spirometry and a metabolic cart (True One 2400® Metabolic Measurement System, Parvo Medics, Inc., Sandy, Utah, United States) was used to analyze oxygen and carbon dioxide parameters in order to estimate volume of consumed oxygen (VO_2) ($ml \cdot kg^{-1} \cdot min^{-1}$) by sampling and analyzing breath-by-breath expired gases. A wireless HR monitor (Polar® RS800CX, Kempele, Finland) was used to measure HR throughout each assessment. A calibrated physician's scale (Patient Weighing Scale, Model 500 KL, Pelstar, Alsip, IL, USA) was used to measure participants' body weight and height prior to each testing session. Weight and height were also used to calculate body mass index (BMI) of participants.

Time to Exhaustion (TTE)

Two experimental trials were conducted, consisting of two separate conditions: 1) no music (NM); and 2) self-selected music (SSM). Participants listened to music through a set of headphones that were provided to them (ErgoFit In-Ear Earbud Headphones, Panasonic Corporation of North America). For each experimental trial, participants performed a 5-minute warm-up at a self-selected intensity on a motorized treadmill (Woodway 4Front™, Waukesha, Wisconsin, United States). Following the warm-up, participants completed a TTE on a motorized treadmill (Woodway 4Front™, Waukesha, WI) to examine the responses to music and no music during exercise, where HR and ratings of perceived exertion (RPE; via Borg Scale, ranging from "0 = nothing" to "20 = very, very hard"; Tenenbaum et al., 2004) were measured every minute.

Each TTE included steady-state running at 80% of the participant's $VO_{2max.}$ Previous research has indicated that the effect of music on exercise performance is diminished during exercise exceeding anaerobic threshold, including intensities exceeding 80% and 90% VO_{2max}(Karageorghis, Terry, Lane, Bishop, & Priest, 2012; Karageorghis et al., 2011; Tenenbaum et al., 2004; Tenenbaum, 2001). For this reason, the current study utilized an intensity of 80% VO_{2max} for TTE trials to avoid diminishing the ergogenic effect of music on performance (Karageorghis et al., 2009; Karageorghis, Terry, Lane, Bishop, & Priest, 2012; Tenenbaum et al., 2004; Tenenbaum, 2001). Experimental trials were conducted in a counter balanced manner (Figure 3). A minimum of 48 hours between each trial was used in order to minimize residual fatigue. Participants were weighed on a calibrated physician's scale prior to each trial. HR was monitored continuously throughout each trial using a HR monitor (Polar FS1, Polar Electro, Inc., Lake Success, NY, USA), and RPE was recorded every minute during each trial. Finally, participants were not able to see their speed, distance, or time during the TTEs.

Reliability of TTE Protocol

Prior to the current study, pre-study pilot testing was conducted to determine the reliability of the TTE protocol described in the previous section. Ten recreationally-trained males and females between the ages of 18-35 were recruited (40% male; BMI [males] = 26.01±1.72; BMI [females] = 23.34±2.36). Participants performed a VO_{2max} test on a motorized treadmill. Heart rate, respiratory gases, and speeds were recorded. Speeds for each individual time-to-exhaustion were determined by first calculating 80% of VO_{2max} and then defining the corresponding speed at 80% intensity. This intensity was specifically chosen to elicit time-to-exhaustion trials that would not be excessively lengthy in duration, potentially promoting boredom. Following the VO_{2max} test and subsequent determination of running speed, participants completed two TTE trials, separated by a minimum of 48 hours to reduce carryover effects. Intraclass correlation coefficients (ICC) were used to determine reliability of TTE trials. Average VO_{2max} values were 48.75±0.65 for males and 37.62±2.80 for females. Average speeds for time-to-exhaustion trials were 6.93±0.25 mph for males and 5.53±0.49 mph for females, while time-to-exhaustion trials lasted, on average, 28.04±8.07 minutes for males and 19.14±6.49 minutes for females. A high degree of reliability was found between TTE trials ($ICC_{3,1}$ = 0.94; SEM = 2.85). Therefore, utilizing speeds corresponding to 80% of VO_{2max} appears to be an appropriate and reliable method of developing TTE trials.

Interviews

Following the TTE on the fourth visit, participants completed a post-study interview to provide insight into why listening to music during exercise may affect performance. The type of interview that was administered for this study was a direct, standardized interview, consisting of a mix of both open and closes-ended questions. Each interview took place immediately after the second TTE, where the interviewer was face-to-face with the participant, using a voice recorder to audio record the dialogue (Bowling, 2005). The approach used to develop the interview questions was based on a framework developed by Castillo-Montoya (2016), called the Interview Protocol Refinement framework, which targets the development of semi-structured interviews (Castillo-Montoya, 2016). This framework utilizes a four-step process to construct a successful interview protocol. Specifically, the four steps, or phases, used in this framework include confirming that the interview questions support the research questions being investigated, developing an interview protocol that breeds an "inquiry-based conversation", having the protocol reviewed by others, and piloting the protocol (Castillo-Montoya, 2016). The development of these questions was based off of the Emotional Influence of Music questionnaire, which is a 9-item dichotomous questionnaire (Sharman & Dingle, 2015). Examples of questions from this questionnaire include "When you are sad, do you listen to music to fully experience your sadness?" and "Do you think that listening to music enhances your wellbeing?"

The procedures involved in administering the interview included gaining trust with participants and asking clear and quality questions that have been ordered appropriately (Rubin & Rubin, 2012). Additionally, prior to administering interviews, the order of the questions being asked was arranged in an attempt to create an organized protocol with clear and concise objectives. Interviews were conducted in a private room in order to minimize any outside or external influences (e.g., peers or others listening to participants' answers). Interviews included questions to address participants' personal history, such as "Do you typically listen to music when you exercise?", "Do you listen to music to enhance or intensify your emotions?", "What types of emotions motivate you the most during intense exercise?", and "Does exercise have any effect (either positive or negative) on your exercise performance?" (Appendix I). A list of follow-up suggestions were available for prompting participants, if needed. These qualitative interviews allowed for better insight into participants' personal experiences, further permitting a deeper exploration of the overall aim of this study (Jones, 2010).

Once interviews were completed, transcription was utilized in order to export the dialogue from the audio recorder to an electronic document. All interviews were transcribed from beginning to end, and all transcripts were mined for usable data (Weiss, 1994). Once the process of transcribing was complete, a codebook was created in order to generate themes for participants' responses (Bernard, Wutich, & Ryan, 2016). Two research assistants independently coded transcripts and met to discuss any discrepancies and further refine codes. Coding was used to organize and better understand the transcribed data (Basit, 2003). Codes (or tags) were assigned to each theme or each part of the text where the specific themes were mentioned (Bernard, Wutich, & Ryan, 2016). Reoccurring themes and patterns were identified and categorized into summary tables. Grounded theory was used to determine patterns in the data and establish comparisons within themes. Additionally, independent coders evaluated interview transcriptions to reach the same conclusion to establish intercoder reliability, a critical component of qualitative analysis (Lombard, Snyder-Duch, & Bracken, 2010). Cohen's kappa coefficient (κ) was used to determine the measure of agreement, which examined inter-rater reliability for qualitative data and took into account the possibility of an agreement happening by chance (McHugh, 2012).

Procedures

First Visit – Consent, Screening, & Questionnaires

The first visit was a preliminary visit for participants to complete the Confidential Medical and Activity Questionnaire, Physical Activity Readiness Questionnaire Plus (PAR-Q+), and informed consent form, and to address any questions of the participant. Once signed informed consents are obtained, participants completed questionnaires to measure mental toughness (via the MTQ48). Participants also chose their song selections for exercise trials during this time. Additionally, participants were informed of all procedures and familiarized with all performance measures in order to decrease any possible learning effects.

Second and Third Visits

During the second and third visits, participants performed two separate familiarization trials on the treadmill while running at participants' self-selected pace for 20 minutes. The purpose of these trials was to allow the participant to become accustomed to the treadmill prior to completing experimental trials. For each familiarization trial, participants performed a 5-minute warm-up at a self-selected intensity on a motorized treadmill (Woodway 4Front™, Waukesha, Wisconsin, United States). Following the warm-up, participants ran for 20 minutes at a self-selected pace on a motorized treadmill (Woodway 4Front™, Waukesha, WI). A minimum of 48 hours between each trial was used in order to minimize residual fatigue.

Fourth Visit – Incremental Test to Exhaustion

During the fourth visit, participants performed an incremental test to exhaustion on a motorized treadmill (Woodway 4Front™, Waukesha, WI) to measure VO_{2max}, HR, RER, ratings of perceived exertion (RPE; via Borg Scale, ranging from "0 = nothing" to "20 = very, very hard"), and TTE. Participants were weighed on a calibrated physician's scale prior to testing. Open-circuit spirometry and a metabolic cart (True One 2400® Metabolic Measurement System, Parvo Medics, Inc., Sandy, Utah, United States) was used to analyze oxygen and carbon dioxide parameters in order to estimate volume of consumed oxygen (VO_2) ($ml \cdot kg^{-1} \cdot min^{-1}$) by sampling and analyzing breath-by-breath expired gases. Participants completed a five-minute warm-up on the treadmill at a self-selected speed prior to testing. HR was monitored continuously using a HR monitor (Polar FS1, Polar Electro, Inc., Lake Success, NY, USA), and RPE was recorded every minute during each trial. Finally, participants were not able to see their speed, distance, or time during this treadmill test.

Fifth Visit – Experimental Trial 1 (either music/no music)

The fifth visit included the first experimental trial in one of two conditions: 1) no music (NM); or 2) self-selected music (SSM). For this trial, participants performed a TTE run on the treadmill at 80% of their VO_{2max} while either listening to self-selected music or no music.

Sixth Visit – Experimental Trial 2 (either music/no music)

A minimum of 48 hours was utilized between the fifth and sixth visits to minimize residual fatigue. During the sixth visit, participants completed the second experimental trial in one of two conditions: 1) no music (NM); or 2) self-selected music (SSM). In other words, participants completed the second trial in the condition that was not completed during the first trial. For this trial, participants performed a TTE run on the treadmill at 80% of their VO_{2max} while either listening to self-selected music or no music. Following this trial, participants completed a post-study interview. Interviews included questions regarding participants' influence of music on exercise.

Statistical Analysis

Power Analysis

Power analysis revealed that a sample size of 25 participants would be required to obtain a power of 0.81 with an expected large effect ($f^2 = 0.35$). Due to an anticipated attrition rate of 25%, 31 participants were recruited for the current study.

Data Analysis

Descriptive Statistics and Frequency Distribution

Prior to statistical procedures, data was assessed for normal distribution. In order to check for any discrepancies in the data, two independent researchers ran frequencies on all variables in the study to determine the presence of outliers or missing data, and to examine the distribution and variability of all variables used in the study. All performance factors were compared to normative values of similar populations to illustrate the generalizability of the current sample. A comparison of dropouts with compliant participants was completed to demonstrate no significant differences between dropouts and included participants. Additionally, individual and mean ± standard deviation values for performance variables were calculated.

Regarding normative values for Mental Toughness (MT), there have been no validated cutoff normative data for the MTQ48, specifically (van der Mailen, Bosmans, Lens, Lahlah, & van der Velden, 2018). Many researchers have used specific classifications for the MTQ48 through use of Standard Ten (STEN) scores (Crust & Swann, 2011; Crust et al., 2014; Clough & Strycharczyk, 2012; Jackman, Swann, & Crust, 2016). These STEN scores can be calculated by first standardizing scores, through the equation: "(s-mean) / SD" and then using the following equation to calculate STEN scores: "(standardized score * 2) + 5.5" (Russell & Karol, 2002). The "2" in this equation is the standard deviation of the STEN scores, while 5.5 is the mean. The reasoning for this is because STEN scores range from one to ten; therefore, the average of scores ranging one through ten is 5.5, and the standard deviation would be 2. According to Crust et al. (2014) who utilized STEN scores to classify MT scores from the MTQ48, scores of 1-3 are considered low, 4-7 are considered moderate, and 8-10 are considered high (Crust et al., 2014).

Correlational Analyses

Pearson product-moment correlations were used to investigate relationships between performance variables and mental toughness.

Order Effect

Due to the counter-balanced design of the current study, data was also analyzed for a potential order effect. Order effect was initially run through use of hierarchical linear regression. This was done by creating four separate interaction variables: 1) Music & Order; 2) Music & Mental Toughness; 3) Mental Toughness & Order; and 4) Music, Order, and Mental Toughness. This created three 2-way interactions and one 3-way interaction. Through use of linear regression, Block 1 included the variables themselves (Music, Order, and MT), Block 2 included all 2-way interactions, and Block 3 included the one 3-way interaction.

Additionally, order effect was tested through use of independent t-tests for MT, TTE performance, and VO_{2max} (Appendix L).

Moderated Regression

Moderated regression analysis, via linear regression, was used to determine a potential moderating effect of mental toughness on change in performance between NM and SSM groups (Hayes, 2017; Baron & Kenny, 1986; Figure 4). For this analysis, the original MTQ48 scale was used. If there was no significant order effect, the interaction variables including order were removed. Therefore, one 2-way interaction variable would be left, including Music & Mental Toughness. Hierarchical regression analysis was run with Block 1 including the individual variables themselves (Music and MT), and Block 2 including the 2-way interaction variables (Music*Mental Toughness). Data was organized so that, although there were 31 participants, there were 62 time points, so that each participant acted as their own control due to the counter balanced design of the study. The dependent variable was performance (or TTE), while the independent variables were those explained in Blocks 1 and 2 (Appendix L).

Additionally, linear regression was used to determine a potential relationship between MT and performance, with MT as the independent variable and performance as the dependent variable. Performance was considered to be the change scores for $TTE_{SSM} - TTE_{NM}$.

An alpha level of $p \leq 0.05$ was used to determine statistical significance. All qualitative data from post-study interviews was categorized into primary themes and coded prior to statistical analyses. All statistical analyses were conducted via the Statistical Package for Social Science (SPSS) software for Windows version 21 (SPSS Inc., Chicago, IL).

CHAPTER FOUR: RESULTS

Participant Descriptives

Thirty-one participants (22.13 ± 2.11 years; 65.5% males) performed a VO_{2max} test (average VO_{2max} [males] = 45.58 ± 2.57 mL·kg·min^{-1}; average VO_{2max} [females] = 37.51 ± 5.34 mL·kg·min^{-1}), lasting an average of 9.56 ± 1.79 minutes for males and 9.32 ± 2.78 minutes for females. Participant characteristics are displayed in Table 1. Shapiro-Wilk tests for normality revealed non-significance for all variables, indicating that samples were normally distributed. Frequency distribution indicated no missing data points or outliers, and all values were within the normative ranges. An initial sample of 38 participants were recruited; however, 6 participants dropped out of the study due to scheduling conflicts, while 1 dropped out of the study due to comfortability while wearing the VO_{2max} mask. No significant differences were seen for MT between dropouts (M = 163.60 ± 12.16) and compliant participants (M = 155.80 ± 6.80) (p = 0.154). As there are no validated normative data for the MTQ48, raw scores were translated into STEN scores. For mental toughness (MT), approximately 19% of participants fell in the low category, 68% fell in the moderate category, and 13% fell in the high category for MT. All participants fell within a normal range for VO_{2max} scores, as well, indicating that all participants were healthy and of average cardiorespiratory fitness (Pescatello, Riebe, & Thompson, 2013).

Performance Characteristics

Moderated regression analysis revealed a non-significant interaction between MT, music, and order, indicating no order effect (β = -0.416, p = 0.735). Independent samples t-tests revealed no significant difference in MT, performance, or VO_{2maz} between groups of participants who received music first or music second, indicating no effect of order (F = 0.388; p = 0.538; F

= 0.537; $p = 0.470$; F = 0.070; $p = 0.794$; respectively). Individual and mean ± standard deviation values for time-to-exhaustion (TTE) for self-selected music (SSM) and no music (NM) groups (TTE_{SSM} and TTE_{NM}, respectively) and final ratings of perceived exertion (RPE) (RPE_f) for SSM and NM groups (RPE_{fSSM} and RPE_{fNM}, respectively) are shown in Figures 5 and 6. Table 2 displays the minimums, maximums, and means ± standard deviations for TTE_{SSM}, TTE_{NM}, RPE_{fSSM}, and RPE_{fNM}. For descriptive purposes, MT scores were converted to Standard Ten (STEN) scores via linear transformation to differentiate between low, moderate, and high levels of MT (Crust et al., 2014; Crust & Swann, 2011; Russell & Karol, 2002; Figure 7). Additionally, correlations were found between VO_{2max} and TTE_{SSM}, TTE_{NM}, and MT (r = 0.390, $p = 0.030$; r = 0.519, $p = 0.003$; r = 0.404, $p = 0.024$; respectively; Table 3). Moderated regression analysis, via linear regression, determined no significant moderating effect of MT on the change in performance between trials (ΔTTE) ($F(3, 58) = 0.958$, r = 0.217, $p = 0.498$). Linear regression, however, revealed a significant main effect of MT, indicating an inverse relationship between MT and ΔTTE ($F(1, 29) = 4.417$, r = -0.634, $p = 0.044$; Figure 8).

Qualitative Analysis

Post-study interviews provided further insight into emotions felt during exercise and motivating factors associated with exercise performance. Cohen's kappa coefficient (κ) was used to determine the measure of agreement, which examined inter-rater reliability for qualitative data and took into account the possibility of an agreement happening by chance (κ = 0.92). Analysis of the interview content revealed three primary themes: 1) Emotions and Exercise; 2) Music and Exercise; 3) Methods of Self-Motivation. Subcategories were further identified from participant responses regarding emotions, music and exercise. Table 4 outlines the primary themes and subcategories for participant response rates for the close-ended questions asked during the post-study interview. Figures 9-11 display the themes and participants' percentage of responses from the open-ended questions asked during the post-study interview.

Emotions and Exercise

Effects of Emotions on Exercise

About half of participants reported that their workouts were affected by their emotional state, while the other half did not report emotions affecting their exercise performance (Table 4). As one participant remarked, *"There's not a specific emotion that I really utilize for specific workouts. It's kind of just whatever I'm feeling the day of."* A number of participants spoke about focusing less on their emotions, and more on the exercise at hand; however, others indicated using exercise as a way to let out emotions: *"Sometimes I'll go to the gym to let out emotion, but not every time."* Another participant stated that, *"I don't do sad emotions when I'm exercising, but I've used joy and anger before."* Some participants reported actually being demotivated by emotions: *"If I'm upset about something, my workout is much worse. I'm thinking about something else instead of what I'm doing."* While some participants indicated using emotions to fuel their workouts and let out emotions, others were put off by the idea of working out when their emotions were running high.

Emotions that Motivate Exercise

To further investigate the relationship between emotions and exercise, participants were asked to expand on their responses regarding emotions and exercise. Although approximately half of participants reported not experiencing any specific emotions during exercise, 32.3% of the sample identified anger as a motivational emotion, and 16.1% indicated using happiness or excitement (Figure 10). Anger was an emotion than many of the participants indicated utilizing during exercise to fuel their workouts. One participant stated that, *"I feel like anger can kind of trigger you to go harder in the gym because you're using physical outlets instead of having to…hold it in."* Another participant reported that, *"I get angry which helps me work through something strenuous."* Conversely, several individuals also claimed that anger did not motivate them to exercise; instead, happiness or excitement got them to the gym: *"If I'm feeling really happy or just extremely inspired or motivated, then I'll just put a little more work in."* The individuals who did not appear to use emotions as a motivational tool for exercise mentioned steering clear of mixing emotions with performance, stating that *"I try not to bring anger into a workout."*

Music and Exercise

Listening to Music during Exercise

Approximately 87.1% of participants reported listening to music during exercise, while 12.9% of participants stated that they did not listen to music during exercise. One participants stated, *"If I don't have music, I don't like to exercise,"* while another said, *"If I don't have music on, I can't go to the gym. I'll leave or just…I can't. It doesn't work."* More specifically, it was stated for one individual that, *"It's like I'm closing out the world…put the music in and I'm in my own world right there."* Conversely, of the participants that did not indicate listening to music during exercise, one stated, *"Sometimes when I'm squatting I listen to music, but [it's] just not necessary"* (Table 4).

Music Characteristics

Participants were asked about the characteristics of music that contribute to its ergogenic effect during exercise, The majority of participants indicated that the beat of the music was the primary contributor to the motivational quality of music, stating "*[The beat] helps me to stay focused on what I'm doing"* (Figure 11). Another participant stated that, *"I feel like the beat and having something that can zone you out in the music…that really helps a lot."* Simply stated, another participant said, *"The beats…they'll amp you up."* Musical lyrics were also highly reported to be a motivational aspect of music, with one participant stating, *"Heavy metal…it's just so powerful, you know…It's not even really that angry; it's just the words driving you. I kind of can relate to some of the lyrics."* Another participant added, *"I'm thinking about the lyrics and they make me feel a certain way. For me, I specifically listen to metal so a lot of the themes are…trying to feel like you're more than what you are."* For these participants, it appeared that these musical lyrics were a type of self-talk that aided in motivating them to keep running.

Effect of Music on Emotions

While examining the effect of music on participants' emotions, 61.3% of participants indicated using music to enhance or intensify their emotions, with one participant stating, *"If I'm sad, I'll definitely listen to sad music."* Another individual noted that *"If I'm in a happy mood, I'll play some music that accentuates that and that brings me to a happier mood. I've definitely been known, if I'm frustrated, to play some Disturbed."* Conversely, 29.0% of participants reported never listening to music to enhance their emotions (Table 4), including one participant who stated, *"I just listen to it because I just love the music."*

Effect of Music on Exercise

To determine the potential ergogenic effect of music on exercise performance, participants were asked to elaborate on their experience of listening to music during exercise. While 6.5% of participants were indifferent to positive or negative effects on a workout when listening to music, approximately 84% of participants reported that music helped their exercise performance: *"Yes, it helps the performance and then I'm not so concentrated on time. I feel like time just flies by and I don't really have to worry about it, but if I don't have music, I'm constantly looking for something else to distract me."* One participant even reported that, *"I remember my first time I ran 10 miles and it was because I was listening to music."* A topic came up during this interview question with multiple participants, pointing to a theory that music may be more beneficial during the beginning and towards the end of a workout, but not as helpful in the middle: *"[Music] can [help]. Usually at the very beginning it will and towards the end, but in the middle…not really. It's mostly in the beginning and the end when I'm starting to tire out."* This talking point came up multiple times, initiated by participants indicating that they did not experience many ergogenic effects of music during the middle of the TTE trials*: "I felt it was boring in the middle."* Although none of the participants indicated music as being harmful towards exercise performance, one individual did state that, *"I feel like [music] helps me focus on what I'm doing…I'm kind of in my own world and I'm thinking about what I'm doing instead of what's going on around me. But I do get annoyed when the gym is loudly playing music that I don't like because that is not motivational."*

Ergogenic Effect of Music during TTE_{SSM}

Responses indicated that 80.6% of participants believed that listening to music helped their TTE performance, 16.1% believed that music did not help their TTE performance, and 3.2% were unsure (Table 4). One participant reported that, *"I would say that the music did help me not focus on the pain on my shins and stuff like that."* This may be another factor to consider, as participants were recreationally-trained adults with no competitive running background, indicating that bodily pains and aches may be more prevalent in this population. Additionally, another participant stated that*, "Yes, when I run with music, I sing the songs so then I don't get as tired because I don't focus on getting tired as much."*

Methods of Self-Motivation

Participants were asked about any methods utilized to create their own motivation to continue running when they were not able to listen to music (Figure 12). Approximately one third of participants indicated that Distraction was the primary method used to get through the TTE_{NM}, stating that *"Honestly, I kept reading the same word over and over on that sign. I read the word 'Personal' like a billion times."* Visualization was another method utilized by participants to motivate themselves to keep running: *"I put a vision in my head…say I'm going up against a guy or an opponent for a ball so I'm trying to beat him as fast as I can."* As one participant remarked, *"I reminded myself of my football days…coaches yelling, 'dig dig dig dig dig!'"* The curious similarity between participants who used visualization was that many of these individuals played sports growing up, whether it be soccer, football, basketball, etc., and they reported visualizing themselves on the field either during a game or during practice. Participants also reported using self-talk and reflection as methods to motivate themselves as well, stating that they used *"really just a lot of self-talk and motivation…'Come on, you want to do better,'"* and *"just reflection about life, looking forward and past."* Several participants, however, did not report using mental imagery or self-talk; instead, they indicated focusing on how they were physically feeling: *"My breathing the whole time. I thought I was dying. That's what it sounded like."* It is apparent that a divide exists between individuals who utilize methods to motivate themselves, such as visualization, self-talk, or reflection, while others tend to focus on the run itself and how they feel in the moment. There is no evidence from the current study thus far to determine which is more beneficial for performance, as individuals who are more focused on their body and running form may improve performance to a greater extent compared to someone attempting to distract themselves from the task at hand, or vice versa.

CHAPTER FIVE: DISCUSSION

The current study aimed to examine the moderating effect of mental toughness (MT) on the association between music and exercise performance in healthy, recreationally active, college students. Specifically, it was hypothesized that individuals with greater MT would be less affected by music during exercise, which would result in less of a change in performance between time-to-exhaustion (TTE) trials with self-selected music (TTE_{SSM}) and no music (TTE_{NM}) (Andersen, 2011; Tenenbaum et al., 2004). Although the results from this study did demonstrate that individuals with greater levels of MT experienced less of a change between TTE trials, the hypothesized moderation effect of MT was not observed. While MT levels were associated with performance, the presence of a music stimulus was neither associated with performance on the TTE trials nor MT levels.

The finding that individuals with greater MT had less of a change between their TTE trials is supported by previous literature that report a positive relationship between individuals with greater MT and consistent exercise performance (Andersen, 2011; Gucciardi, 2010; Tenenbaum et al., 2004). This could be due to the naturally higher level of enjoyment or internal motivation for exercise that individuals with greater MT possess, according to research (Cox, Roberts, Cates, & McMahon, 2018); however, these attributes were not specifically assessed in the current study. Interestingly, the post-study interviews revealed that half of participants in the current study preferred focusing on the exercise at hand, rather than be distracted by other factors. Additionally, participants reported the use of several techniques that have been defined as characteristics of MT (Crust et al., 2007). For example, several participants mentioned using visualization techniques during TTE trials to motivate themselves during exercise, which have been considered a primary component of MT in previous research (Sheard, 2009; Kuan & Roy, 2007; Crust, 2011). Furthermore, participants reported using past sports experiences to motivate them as they ran (Crust, 2009; Nicholls, Polman, Levy, & Backhouse, 2009; Crust & Clough, 2005). This was particularly interesting because those individuals who had a previous history of sports participation, especially with team sports, such as soccer or football, stated that they visualized themselves at practice or during a game during their exercise trials. Specifically, participants mentioned envisioning themselves against an opponent or their coach verbally motivating them to keep pushing, giving researchers further insight into participants' enjoyment for exercise. Future studies should consider comparing the use of different MT strategies, such as visualization and self-talk, during exercise or sports performance (Sheard, 2009; Kuan & Roy, 2007; Crust, 2011). It should be noted, however, that although previous activity history was not accounted for in this study, approximately 75% of the sample mentioned having a history of sports participation, which could have skewed the results towards a high utilization of MT techniques during the exercise trials. Thus, future studies should account for current and previous sports history, especially with regards to level of competitiveness and duration of participation.

In individuals with lower levels of MT, a greater difference between TTE trials was observed, however, given the lack of evidence regarding an interaction effect between music and MT, it cannot be concluded that music had any effect on their exercise performance. This may be due to several factors. The length of exercise may not have been long enough and intensity may not have been low enough for participants to require an external stimulus for motivation, as supported by previous research suggesting that music may enhance performance more optimally when exercise intensities are lower (Hutchinson & Sherman, 2014; Tenenbaum et al., 2004;

Yamashita, Iwai, Akimoto, Sugawara, & Kono, 2006; Pujol & Langenfeld, 1999; Rejeski, 1985). Additionally, data from the current study indicates that level of aerobic fitness or VO_{2max} may play a role in the moderating effects of MT and affect the influence of music on performance. Future research should further examine whether differing characteristics of exercise (e.g. modalities, duration) may be effected by the presence of music.

Despite the lack of evidence to support an effect of music on performance, during the end-of-study interviews, approximately 81% of participants felt that music improved their exercise performance, attributing their perceived improvement to be dependent on specific characteristics of music (e.g. beat, song lyrics). Additionally, participants emphasized the importance of music preference, suggesting that non-preferred music may actually have a negative effect on exercise performance (Crust, 2007). Although the current study provided participants with an extensive playlist of song selections, it is possible that participants were unable to select their "favorite" songs or the music that they typically select during exercise. Unfortunately, the current study did not assess similarities or differences between the music selections provided in the current study with participants' actual music selections in their natural environment. Future studies should further examine how music preferences could either positively or negatively affect exercise performance, and whether levels of MT may play a role in these relationships (e.g. high levels of MT may negate negative effects of non-preferred music).

Despite the lack of findings regarding the influence of music on exercise performance, the present study supports previous literature that emphasizes the relationship between MT and exercise performance. For exercise professionals, understanding the relationship between MT and exercise performance is important for optimizing the design of individualized training programs, whether for training, clinical, or rehabilitation settings. Through determination of an individual's MT level, professionals may be able to recognize the effect of MT on exercise motivations. Although the current study did not find an association between music, MT, and performance, further research examining the use of external or internal stimuli on exercise performance, and how these associations may differ according to levels of MT, is warranted. For individuals with lower MT, use of external factors for motivation may improve performance, as well as improve exercise enjoyment and adherence (Karageorghis, Terry, & Lane, 1999). Additionally, associations between MT and experience during exercise has been demonstrated in previous research (Gucciardi, Gordon, & Dimmock, 2009; Nicholls, Polman, Levy, & Backhouse, 2009; Crust, 2007; Middleton, Marsh, Martin, Richards, & Perry, 2004). This is important to acknowledge because if exercise professionals can, through use of external motivation, improve exercise adherence, enjoyment, and performance, it may be possible to simultaneously improve MT (Butt, Weinberg, & Culp, 2010). If MT can be improved through this method, then individuals may begin to also rely less on extrinsic motivation and more on intrinsic motivation, which is linked to greater sustainability of the behavior (Andersen, 2011; Gucciardi, 2010; Tenenbaum et al., 2004).

Strengths and Limitations

The current study had numerous strengths. This was the first study to examine potential moderating effects of MT on exercise performance when utilizing an external motivator, such as music. Pilot testing was completed prior to the start of the current study to determine and confirm high reliability of a TTE protocol utilizing speed corresponding to 80% of VO_{2max}.

Previous research has determined factorial validity and internal consistency of the MTQ48 to be high for the population used in the current study (Vaughan, Hanna, & Breslin, 2017; Perry, Clough, Crust, Earle, & Nicholls, 2013). Additionally, two familiarization trials were utilized prior to VO_{2max} testing or TTE trials to acquaint participants with the specific treadmill used for experimental trials. All participants were blinded to their speed, time, and distance on the treadmill for all trials, decreasing the risk of external factors to impact performance. All trials were completed in a laboratory room with no external distractions, such as other individuals, side conversations, talking, or other research studies. This helped to narrow down any exercise motivations to either the individual's internal motivation or the music given during the TTE_{SSM}. Finally, the current study utilized a mixed-methods approach which allowed for greater insight into the motivations associated with exercise. Several limitations did exist as well. Specifically, maximal effort was expected during the VO_{2max} testing and TTE trials of participants, and while it was easier to determine maximal (or near maximal) effort during VO_{2max} testing due to it being a direct measurement with a metabolic cart, monitoring maximal exertion during TTE trials was simply done via ratings of perceived exertion (RPE), a subjective measurement. Additionally, due to our sample including both men and women, menstrual cycle was not accounted for in women. There were no criteria for body composition; however, average body mass index (BMI) for all participants fell under a normal classification. Data from the post-study interviews should be interpreted with caution as the format and structure of the questions could generate participant bias. Although these questions were developed based off of prior interviews and relevant surveys (Sharman & Dingle, 2015), the leading nature of the questions could influence participant response. Regarding the MTQ48, although previous literature has determined strong validity and internal reliability for non-athletes, the current study was not able to calculate these measures due to small sample size and potential skewing, or underestimation, of internal consistency measures. Additionally, sport history was not taken into account, which may have been a contributing factor to greater MT for certain individuals. Furthermore, several participants were shown to have higher levels of MT than compared to previously reported MT scores for non-athletes (Vaughan, Hanna, & Breslin, 2018). A potential reason for this may be due to the sample consisting of several participants with a sport background. Finally, sample size was not large enough to comfortably take into consideration sex differences; future research should utilize a larger sample size for further analysis purposes.

Practical Implications

A number of implications can be gathered from the current study. A better understanding of how MT plays a role in exercise motivations may allow exercise professionals to more optimally tailor their training or rehabilitation programs to each individual. For example, coaches, personal trainers, or physical and occupational therapists may find it beneficial to utilize a MT questionnaire before creating exercise protocols, therefore creating a more individualized plan for each athlete or client. Further, having the knowledge of where an individual lies on the MT scale may allow exercise professionals to create an exercise program that either enhances or maximizes their MT potential (Weinberg, Feysinger, & Mellano, 2016; Jones, Hanton, & Connaughton, 2007). Previous research has indicated exercise training methods for maintaining and improving MT, as a relationship has been shown between exercise experience and MT (Gucciardi, Gordon, & Dimmock, 2009; Nicholls, Polman, Levy, & Backhouse, 2009; Crust, 2007; Middleton, Marsh, Martin, Richards, & Perry, 2004).

Future Research

Future research should consider utilizing a larger sample size which may permit more advanced statistical analyses and comparisons between males and females to be conducted. Additionally, utilizing different modes of exercise, such as resistance training or cycling which are two commonly used forms of exercise, may provide further insight into any potential effects of music on exercise performance, as previous research has shown music to have a motivational effect on these exercise modalities (de Abreu Araujo et al., 2018). Additionally, future research should further examine whether other types of external stimuli, such as verbal forms of encouragement, may affect exercise performance, especially with individuals who may have low levels of MT. Finally, although we chose to develop the pre-determined playlist based off of previous research that suggested standardization of the music tempo, it would be important to determine whether an observed effect of music on exercise performance may exist in a participant's natural setting.

Conclusions

Based on the results from the current study, individuals with greater MT exhibited less of a change in exercise performance during the exercise trials, although there was no observed relationship between MT, music, and exercise performance. As exercise professionals, it is important to understand the effects of MT on exercise motivations and how external and internal stimuli affect performance. Understanding this may allow for more optimally tailored and individualized training or rehabilitation programs. Through utilizing different motivation strategies tailored to each individual, it may be possible to simultaneously increase exercise performance, enjoyment, and adherence, as well as overall MT. Additional research is warranted to provide further information on the moderating effect of MT on the effect of an external stimulus on exercise performance.

APPENDIX A
FIGURES

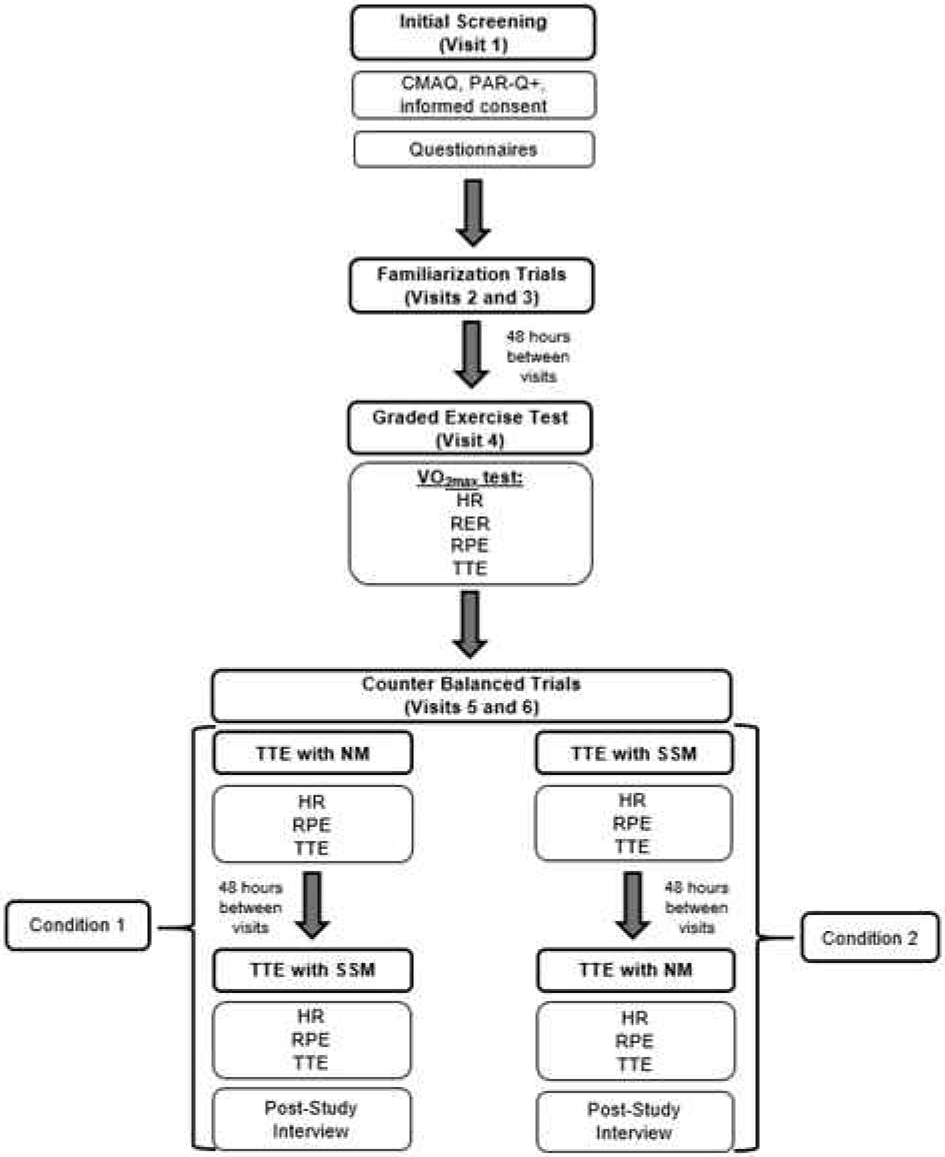

Figure 1. Study Protocol; confidential medical and activity questionnaire (CMAQ), physical activity readiness questionnaire (PAR-Q+), heart rate (HR), respiratory exchange ratio (RER), ratings of perceived exertion (RPE), time to exhaustion (TTE), no music (NM), self-selected music (SSM).

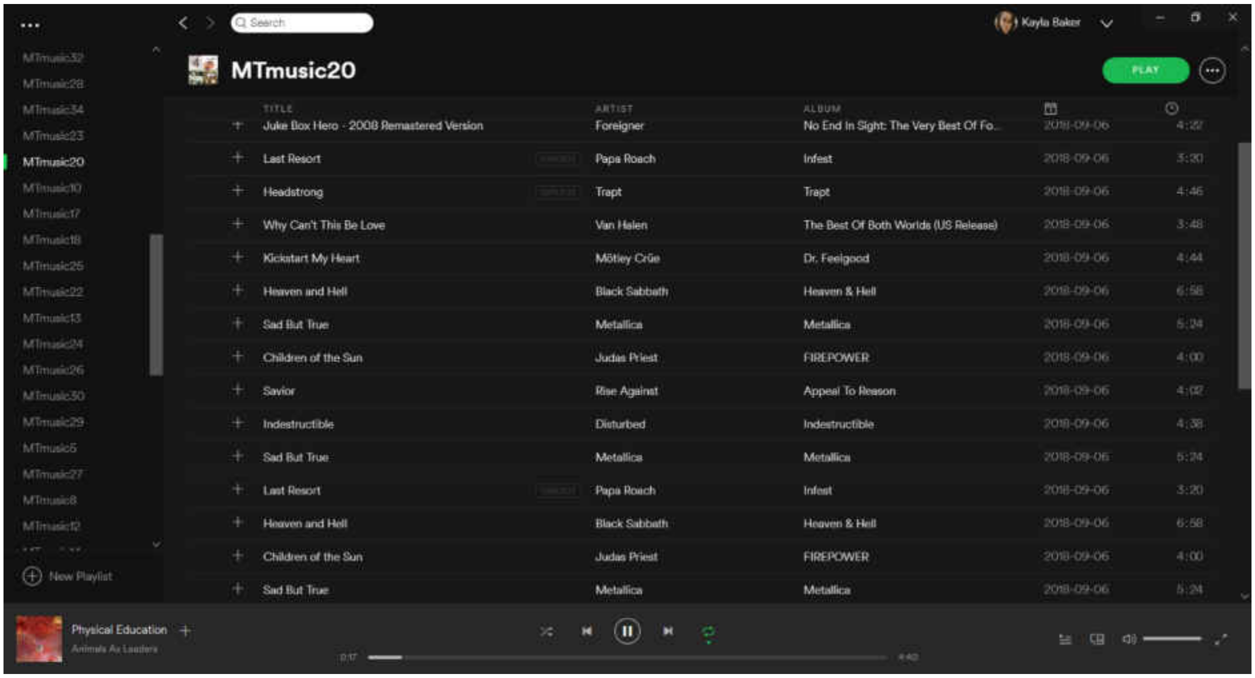

Figure 2. Example of self-selected playlist in Spotify®.

Participant Number	Trial – Day 1	Trial – Day 2
Participant 1	NM	SSM
Participant 2	SSM	NM
Participant 3	NM	SSM
Participant 4	SSM	NM
Participant 5	NM	SSM
Participant 7	SSM	NM
Participant 8	NM	SSM
Participant 9	SSM	NM
Participant 10	NM	SSM

Figure 3. Counter-balanced design.

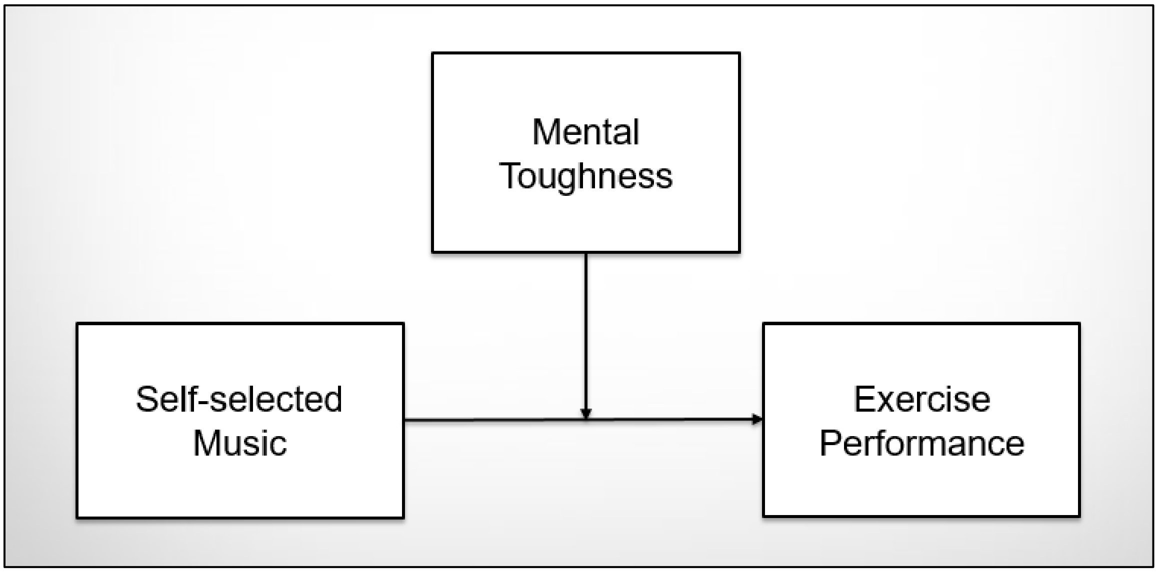

Figure 4. Moderated Regression Model

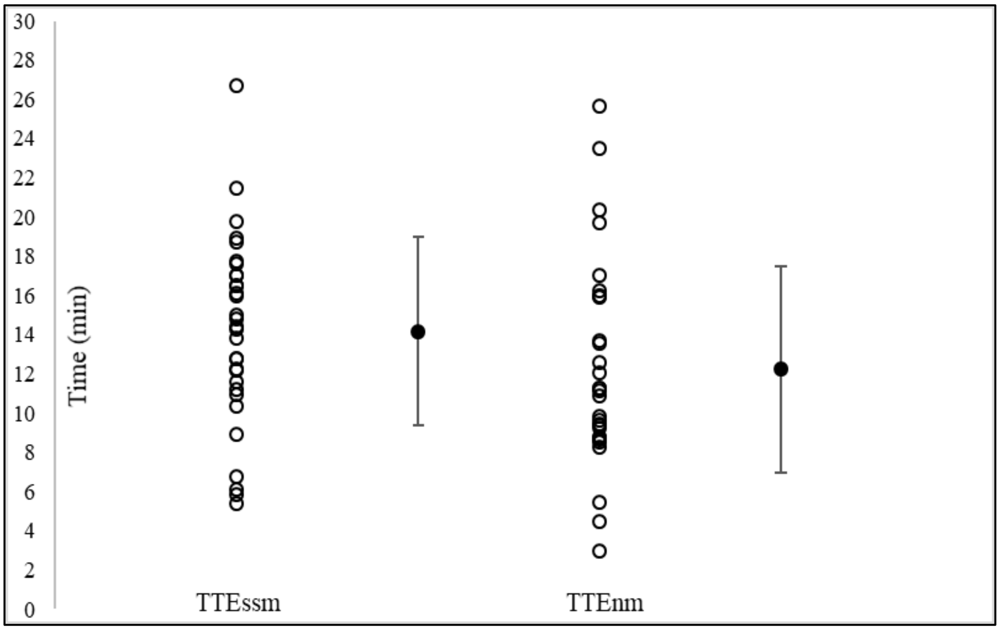

Figure 5. Individual and mean ± SD values for TTE_{SSM} and TTE_{NM}.

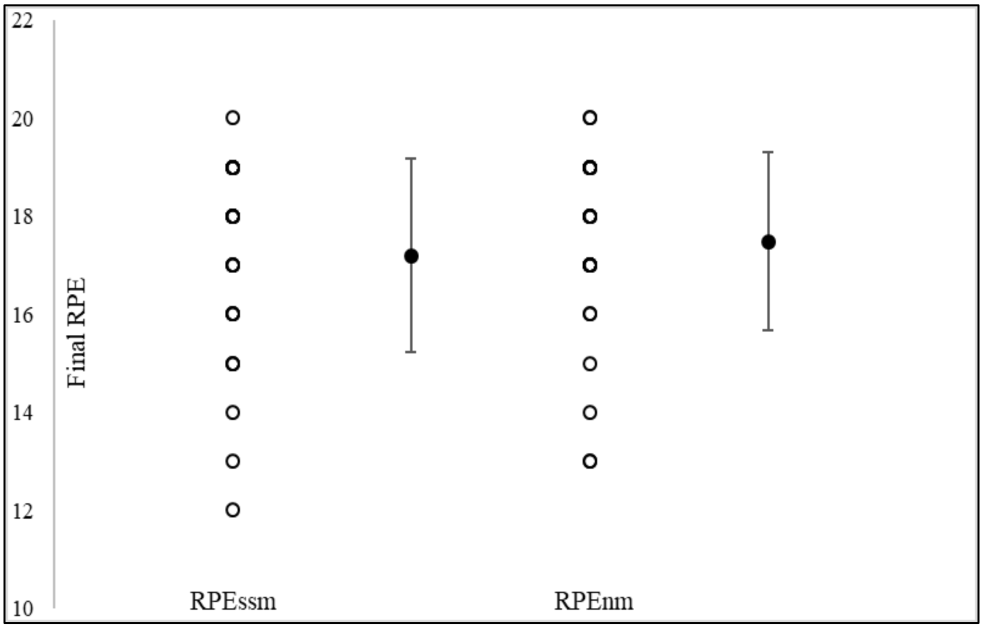

Figure 6. Individual and mean ± SD values for RPE_{fSSM} and RPE_{fNM}.

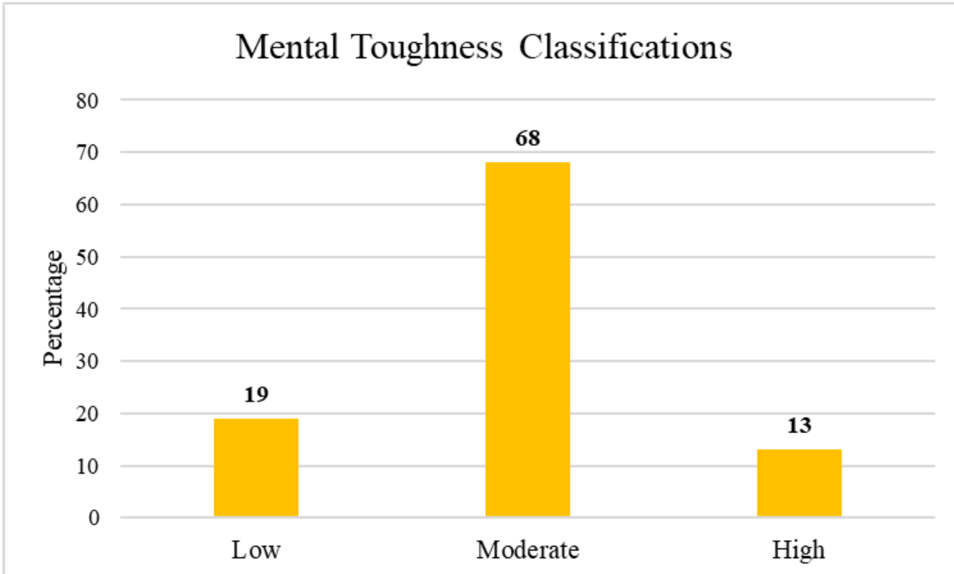

Figure 7. Classification of participants into low, moderate, and high levels of MT based on STEN scores, with a STEN score of 1-3 indicating low MT, 4-7 indicating moderate MT, and 8-10 indicating high MT.

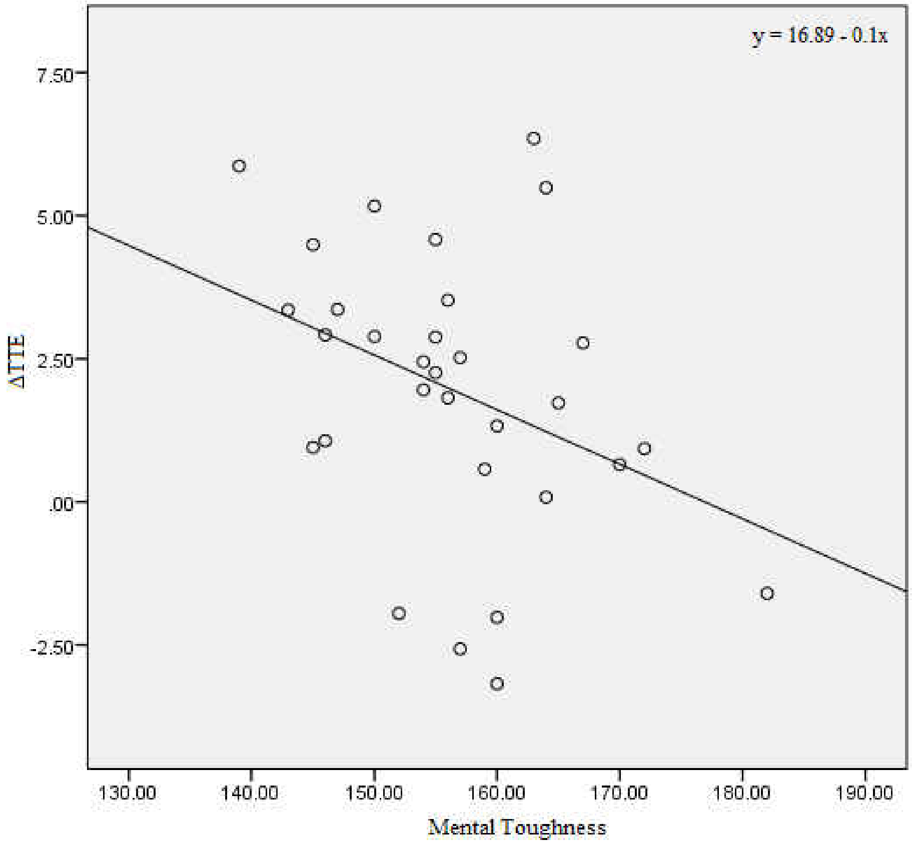

Figure 8. Relationship between mental toughness and the change in performance between TTE_{SSM} and TTE_{NM} (ΔTTE).

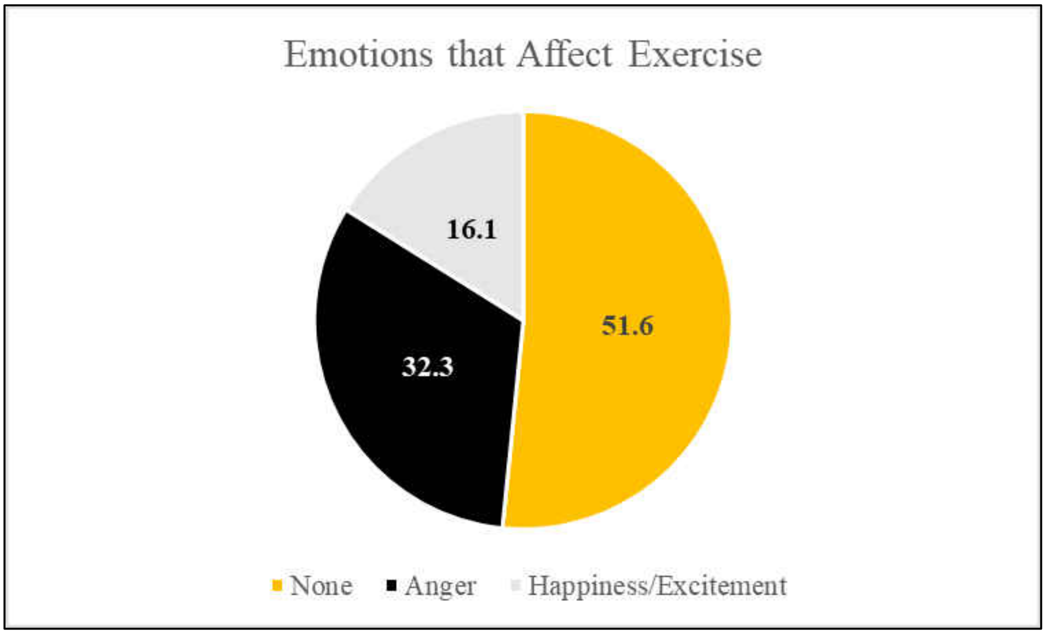

Figure 9. Participant responses to emotions (if any) that motivate them during exercise.

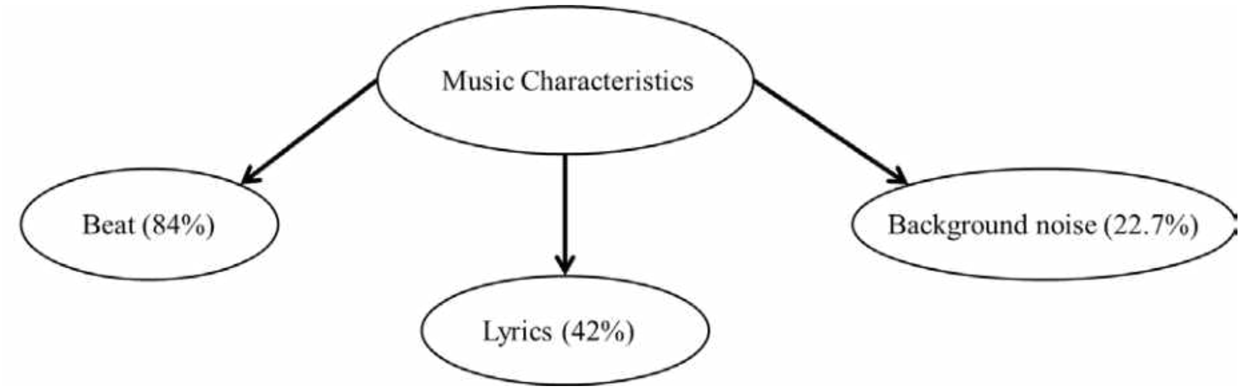

Figure 10. Characteristics that contribute to the ergogenic effect of music and participant responses.

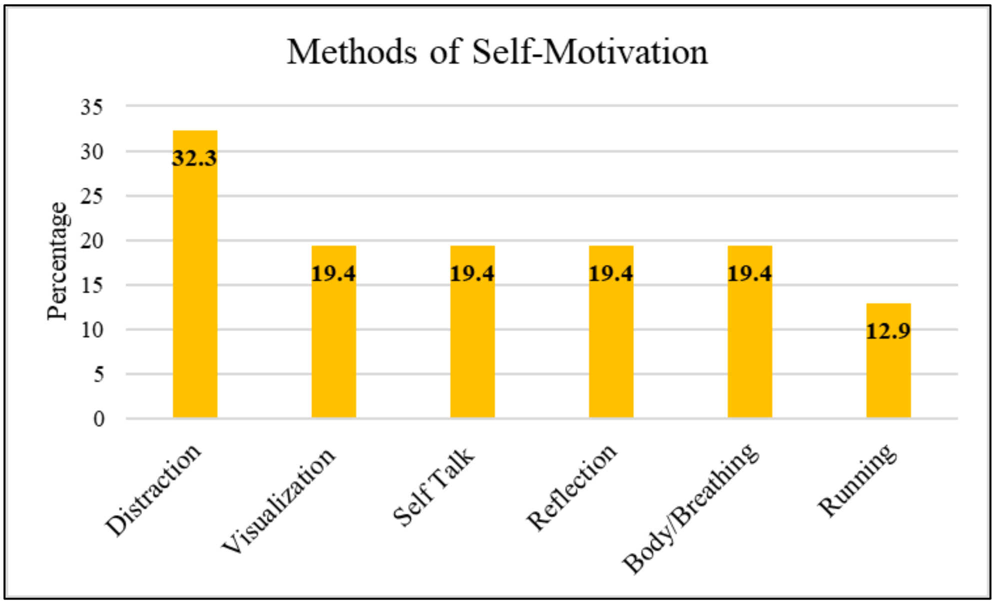

Figure 11. Participant responses to what motivated them to continue running during the TTE_{NM}.

APPENDIX B
TABLES

Table 1. Participant characteristics expressed as mean ± standard deviation.

N	**31**
Age (yrs)	22.13 ± 2.11
Height (m)	1.73 ± .10
Weight (kg)	75.68 ± 14.67
BMI	25.15 ± 2.94
VO_{2max} (ml·kg·min^{-1})	42.89 ± 5.31
MTQ48	156.39 ± 9.38

Table 2. Performance statistics: mean (standard deviation) and range (minimum – maximum) (n=31).

	Mean (SD)	**Range**
$TTE_{time-SSM}$ (min)	14.18 (4.79)	5.38 – 26.72
$TTE_{time-NM}$ (min)	12.23 (5.24)	3.00 – 25.65
$RPE_{final-SSM}$	17.19 (1.97)	12.00 – 20.00
$TPE_{final-NM}$	17.48 (1.82)	13.00 – 20.00

Table 3. Correlations between VO_{2max} and TTE_{SSM}, TTE_{NM}, and MT.

	r	***p*-value**
TTE_{SSM}	0.390	0.030
TTE_{NM}	0.519	0.003
MT	0.404	0.024

Table 4. Themes and participant response rate for close-ended questions asked during post-study interview.

Theme	Yes	No	Sometimes
Effect of Emotions during Exercise	38.7%	48.4%	12.9%
Music and Exercise	87.1%	0.0%	12.9%
Effect of Music on Emotions	61.3%	29.0%	9.7%
Ergogenic Effect of Music on Exercise	83.9%	6.5%	9.7%
Ergogenic Effect of Music during TTE_{SSM}	80.6%	16.1%	3.2%

APPENDIX C
IRB APPROVAL

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/ib.html

Approval of Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Kayla Baker** and Co-PIs: **Jeanette Garcia, Justine M Renziehausen, Paola Rivera, Tal Belity**

Date: **September 11, 2018**

Dear Researcher:

On 09/11/2018 the IRB approved the following modifications until 08/01/2019 inclusive:

Type of Review:	IRB Addendum and Modification Request Form Expedited Review
Modification Type:	Increase study population to 50
Project Title:	A Mixed-Methods Approach to Understanding the Relationship between Mental Toughness and the Effect of Music on Exercise Performance
Investigator:	Kayla Baker
IRB Number:	SBE-18-13971
Funding Agency:	National Strength and Conditioning Association(NSCA)
Grant Title:	
Research ID:	N/A

The scientific merit of the research was considered during the IRB review. The Continuing Review Application must be submitted 30 days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form **cannot** be used to extend the approval period of a study. All forms may be completed and submitted online at https://iris.research.ucf.edu .

If continuing review approval is not granted before the expiration date of 08/01/2019, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

Use of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

All data, including signed consent forms if applicable, must be retained and secured per protocol for a minimum of five years (six if HIPAA applies) past the completion of this research. Any links to the identification of participants should be maintained and secured per protocol. Additional requirements may be imposed by your funding agency, your department, or other entities. Access to data is limited to authorized individuals listed as key study personnel.

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

This letter is signed by:

Signature applied by Racine Jacques on 09/11/2018 09:39:04 AM EDT

Designated Reviewer

APPENDIX D
IRB FORM

PROTOCOL TITLE:

A Mixed-Methods Approach to Understanding the Relationship between Mental Toughness and the Effect of Music on Exercise Performance

PRINCIPAL INVESTIGATOR:

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Richard McHugh

VERSION NUMBER:

1.0

DATE:

June 18, 2018

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1.0 Objectives*

1.1 The purpose of this study is to determine the moderating effect of mental toughness on the effect of listening to music during exercise.

1.2 It is hypothesized that: 1) A significant moderating effect of mental toughness will exist on the effect of music on exercise performance, suggesting that individuals with greater mental toughness will attenuate the effects of listening to music on exercise performance; and 2) Post-study interviews will provide insight into individuals with differing levels of mental toughness and the effect of listening to music on exercise performance.

2.0 Background*

Currently in the United States, approximately only one half of young adults meets the minimum guidelines for aerobic exercise per week, and only 25-30% meet the minimum guidelines for aerobic and muscle strengthening exercise combined (Center for Disease Control and Prevention, n.d.). In young and college-aged adults specifically, researchers have found that one of the primary reasons for these low levels of exercise is lack of motivation (Wilson, Mack, & Grattan, 2008; Lindsey, Conway, Crawford, Daniels, & Dibenedetto, 2006). It is well documented that low levels of exercise may lead to negative physical and mental consequences, including obesity, chronic disease, depression, anxiety, stress, and low self-confidence (Booth, Roberts, & Laye, 2012; Strohle, 2009; de Moor, Beem, Stubbe, Boomsma, & Geus, 2006). For exercise providers, creating a motivating environment for clients is crucial; however, not every individual is motivated the same. One of the most common forms of exercise motivation is through the use of an external stimulus, such as listening to music (Harmon & Kravitz, 2007). Music as a motivating factor for exercise has been studied in previous research (Bigliassi, Estanislau, Carneiro, Kanthack, & Altimari, 2013; RamezanPour, Moghaddam, & Sadifar, 2012; Karageorghis, Jones, & Low, 2006; Brownley, McMurray, & Hackney, 1995). Psychologically, music has been shown to enhance exercise performance due to a number of factors. Listening to music may create a distraction for the exercising individual, minimizing any feelings of discomfort, pain or exertion from the activity being performed (Karageorghis, Terry, Lane, Bishop, & Priest, 2012; Nethery, 2002). Additionally, listening to music during exercise may bring out a series of emotions that might influence or inspire the individual to perform at a higher intensity or for a longer duration of time (Karageorghis, Terry, Lane, Bishop, & Priest, 2012; Priest & Karageorghis, 2008; Terry, Karageorghis, Mecozzi Saha, & D'Auria, 2012). Specifically, researchers have shown increases in both aerobic and anaerobic exercise performance in individuals who listened to music of their preference, showing improvements in anaerobic power (during Running Anaerobic Sprint Tests), aerobic power (during 1600-meter runs), sprint performance (during 60-

meter sprints), and muscular endurance (during push-up tests to failure) (Arazi, Ghanbari, Zarabi, & Rafati, 2017).

Research has demonstrated that listening to music during exercise may decrease ratings of perceived exertion (RPE), indicating that exercise may feel less hard while listening to music (Barney, Gust, & Liguori, 2012). In a study by Sharman and Dingle (2015), researchers found that listening to music during exercise increased levels of happiness and feelings of inspiration in participants (Sharman & Dingle, 2015), while a study by Karageorghis et al. (2009) demonstrated that during steady-state aerobic exercise, music improved affective states by approximately 15% (Karageorghis et al., 2009). Previous findings have also indicated that by listening to music, and thereby using an external factor as a distraction mechanism from exercise, perceived effort and fatigue may be decrease by 12% (Karageorghis, Terry, Lane, Bishop, & Priest, 2012; Bharani, Sahu, & Mathew, 2004).

Conversely, previous research may lead us to believe that individuals of differing levels of mental toughness may be motivated differently by an external stimulus (Andersen, 2011; Tenenbaum et al., 2004). For the purposes of the current study, mental toughness will be operationally defined by the 4Cs model proposed by Clough et al. (2002) which consists of four components: 1) control; 2) commitment; 3) challenge; and 4) confidence (Nicholls, Polman, Levy, & Backhouse, 2008; Crust & Clough, 2005; Clough et al., 2002). More specifically, these components include an individual's ability to: 1) have control over one's emotions and in one's life; 2) have the tendency to face encounters head on; 3) be flexible and opportunistic when changes in life occur; and 4) have a high level of self-belief in one's abilities (Nicholls, Polman, Levy, & Backhouse, 2008; Crust & Clough, 2005; Clough et al., 2002).

Though research is more limited on the effects of mental toughness on exercise performance, previous findings have indicated that greater levels of mental toughness may have a positive effect on exercise performance in individuals (Jones, 2002; Crust & Clough, 2005). Significant correlations have been shown between self-reported mental toughness and endurance performance, including running performance and isometric muscular endurance, in adolescents and young adults (Mahoney, Gucciardi, Ntoumanis, & Mallet, 2014; Crust & Clough, 2005). Additionally, decreased ratings of perceived exertion have been shown during 30-minute steady-state cycling in individuals with greater reported mental toughness (Clough, Earle, & Sewell, 2002). These studies suggest that individuals with greater mental toughness may experience enhanced exercise performance, which could be a potential driving factor for exercise adherence.

Contrary to what much of the literature indicates regarding music as a motivational factor for exercise, it is possible that individuals with greater mental toughness may not respond positively to, if at all, music to enhance performance. A potential explanation for this may be that individuals with greater mental toughness require less reliance on external stimuli for motivation (Tenenbaum et al., 2004). Furthermore, individuals with greater mental toughness may enjoy the act of exercise itself more than their less mentally tough counterparts, therefore reducing the effect of music on exercise performance (Cox, Roberts, Cates, & McMahon, 2018). This may indicate that individuals with lower mental toughness might need to utilize an external motivating factor as an incentive to exercise and maintain exercise adherence. For exercise providers, such as exercise physiologists, physical therapists, coaches, and personal trainers, understanding the effect of mental toughness on exercise motivation can serve as a beneficial strategy for increasing exercise adherence and enjoyment on a more individualized level. More research is necessary to better understand the effect of music as a motivating factor on exercise in individuals with differing levels of mental toughness. Therefore, the purpose of this study is to examine the moderating effect of mental toughness on exercise performance with and without listening to music.

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3.0 Inclusion and Exclusion Criteria*

- Inclusion Criteria:
    - Free of any physical limitations as determined by the Confidential Medical and Activity Questionnaire (CMAQ)
    - Between the ages of 18 and 35 years old
    - Recreationally active
- Exclusion Criteria:
    - Inability to perform a graded exercise test on a treadmill, as determined by the CMAQ and Physical Activity Readiness Questionnaire (PAR-Q+)
    - Taking any type of prescription or over-the-counter medication
    - Having any chronic illness causing the individual to seek medical care
    - Answering "yes" to any question on the PAR-Q+
- Indicate specifically whether you will include or exclude each of the following special populations:
    - Adults unable to consent- exclude
    - Individuals who are not yet adults (infants, children, teenagers)- exclude
    - Pregnant women – exclude
    - Prisoners- exclude

4.0 Study-Wide Number of Subjects*

4.1 30 participants

5.0 Study-Wide Recruitment Methods*

5.1 N/A

6.0 Multi-Site Research*

6.1 N/A

7.0 Study Timelines*

7.1 Following the preliminary visit and prior to VO_{2max} testing, participants will complete two familiarization trials on the treadmill, running at a self-selected pace for 20 minutes. Experimental trials will be completed on a treadmill consisting of two separate conditions: 1) no music; and 2) self-selected music. A total of six testing visits will be required to the University of Central Florida's Human Performance Lab. The objective of this study is to begin participant recruitment in August 2018 and complete data collection in November 2018. Primary analyses is estimated to be completed by December 2018.

8.0 Study Endpoints*

8.1 The study will be completed when participants have finished both experimental trials and completed the post-intervention interview. We anticipate that total testing for each individual should be completed within two weeks.

9.0 Procedures Involved*

- The research design will be counter balanced, utilizing a mixed-methods approach. Participants will be asked to report to the University of Central Florida's Human Performance Laboratory (HPL) on six separate occasions. The first visit will be a preliminary visit for participants to complete the CMAQ, PAR-Q+, and informed consent form, and to address any questions of the participant. Once signed informed consents are obtained, participants will complete questionnaires to measure mental toughness, self-efficacy, resilience, emotional intelligence, and the emotional influence of music on participants. Participants will also be asked to choose a total of 10 songs of their personal preference from a database of songs all with a cadence, or tempo, of 180 beats per minute (Daniels, 2013). These songs will be used during the self-selected music condition. The second and third visits to the HPL will be to complete two separate familiarization trials on the treadmill while running at participants' self-selected pace for 20 minutes. The fourth visit will be to perform a VO_{2max} test on the treadmill, where heart rate (HR), respiratory exchange ratio (RER), ratings of perceived exertion (RPE; via Borg Scale, ranging from "6 = very, very light" to "20 = very, very hard"), and time to exhaustion (TTE) will be measured. During the fifth and sixth visits, participants will complete experimental trials in two separate conditions: no music (NM) and self-selected music (SSM). A minimum of 48 hours between each experimental trial will be required to minimize fatigue. Following the TTE on the last visit, participants will complete a post-intervention interview. Interviews will include open-ended questions regarding participants' personal history and motivation during exercise.

- **Procedures:** Measures and procedures used during the proposed study are described below:
  - **Preliminary Visit:** Following consent to participate in the study and after completion of the CMAQ and PAR-Q+, participants will complete questionnaires to measure mental toughness, self-efficacy, resilience, emotional intelligence, and the emotional influence of music on participants. Descriptions of these questionnaires are detailed below.
    - Self-reported questionnaires to be filled out by participants include:
      - **Mental Toughness.** The MTQ48 is a 48-item self-report psychometric measure of mental toughness that measures an individual's mindset based on control (e.g., emotional control, life control), commitment (e.g., delivery oriented, goal oriented), challenge (e.g., learning from everything, stretching oneself), and confidence (e.g., confidence in abilities, interpersonal confidence) (Perry, Clough, Crust, Earle, & Nicholls, 2013). Previous research supports factorial and internal validity of the MTQ48 (Perry, Clough, Crust, Earle, & Nicholls, 2013).
      - **General Self Efficacy Scale (GSE).** The GSE is a 10-item self-report questionnaire used to asses an individual's self-efficacy. Examples of questions include "It is easy for me to stick to my aims and accomplish my goals" and "I can usually handle whatever comes my way." Responses range from "not at all true" to "exactly true." Total scores are calculated by summing up all 10 items, with a higher score indicating greater amounts of self-efficacy (Schwarzer & Jerusalem, 2010).
      - **Brief Resiliency Scale (BRS).** The BRS is a 6-item self-report questionnaire used to assess an individual's level of resiliency. Examples of questions include "I tend to bounce back quickly after hard times" and "It is hard for me to snap back when something bad happens." Responses range from 1 (strongly disagree) to 5(strongly agree). Total scores are calculated by summing up all 6 items and dividing the sum by the total number of questions answered (Smith et al., 2008).

- **Emotional Intelligence (Trait Emotional Intelligence Questionnaire – Short Form).** The Trait Emotional Intelligence Questionnaire – Short Form (TEIQue-SF) is a 30-item self-report measure of emotional intelligence. Examples of questions include “I normally find it difficult to keep myself motivated” and “I usually find it difficult to regulate my emotions”. Responses range from 1 (completely disagree) to 7 (completely agree) (Petrides, 2009).
- **Emotional Influence of Music.** A 9-item dichotomous questionnaire, as used by Sharman and Dingle (2015), will be used to determine participants’ emotional influence of music (Sharman & Dingle, 2015). Examples of questions include “When you are sad, do you listen to music to fully experience your sadness?” and “Do you think that listening to music enhances your wellbeing?” This questionnaire will be used to determine the possible relationship between participants’ emotional influence of music and the influence of music on exercise performance.

- **Second and Third Visits:** During the second visit, participants will perform two separate familiarization trials on the treadmill while running at participants’ self-selected pace for 20 minutes. The purpose of these trials is to allow the participant to become accustomed to the treadmill prior to completing experimental trials. For each familiarization trial, participants will perform a 5-minute warm-up at a self-selected intensity on a motorized treadmill (Woodway 4Front™, Waukesha, Wisconsin, United States). Following the warm-up, participants will run for 20 minutes at a self-selected pace on a motorized treadmill (Woodway 4Front™, Waukesha, WI). A minimum of 48 hours between each trial will be used in order to decrease fatigue.
- **Fourth Visit:** During the fourth visit, participants will perform an incremental test to exhaustion on a motorized treadmill (Woodway 4Front™, Waukesha, WI) to measure VO_{2max}, heart rate (HR), respiratory exchange ratio (RER), ratings of perceived exertion (RPE; via Borg Scale, ranging from “6 = very, very light” to “20 = very, very hard”), and time to exhaustion (TTE).
    - **VO_{2max} testing:** Participants will be weighed on a calibrated physician’s scale prior to testing. Participants will complete a five-minute warm-up on the treadmill at a self-selected speed prior to testing. All gas exchange data will be collected using open circuit spirometry (True One Metabolic Cart, Parvo Medics, Inc., Sandy, UT, USA). Twenty minutes prior to each VO_{2max} test, open-circuit spirometry will be calibrated with room air and gases of known concentration to estimate VO_2 ($mL \cdot kg^{-1} \cdot min^{-1}$) by sampling and analyzing breath-by-breath expired gases. Flowmeter calibration will also be completed before testing to determine accuracy of flow volume during data collection. Participants will wear a head unit and

mask that stabilizes a one-way valve around their mouth for analysis of oxygen (O_2), carbon dioxide (CO_2), and respiratory exchange ratio (RER), which will be monitored continuously. The protocol for the VO_{2max} test will utilize increases in speed on the treadmill, with increments of 0.5 km/hour every two minutes for the first six minutes, followed by increases of 0.5 km/hour every one minute (Billat, Hill, Phinoteau, Petit, & Koralsztein, 1996; Kasch, Wallace, Huhn, Krogh, & Hurl, 1976). VO_{2max} will be determined to be the highest 30-second VO_2 value during the test and coincide with at least two of the following three criteria: (a) 90 % of age-predicted maximum heart rate (HR); (b) respiratory exchange ratio > 1.1; and/or (c) a plateau of oxygen uptake (less than 150 mL·min−1 increase in VO_2 during the last 60 seconds of the test). Test-retest reliability for VO_{2max} has been shown to be ICC = 0.96 (SEM 1.4 $mL{\cdot}kg{\cdot}min^{-1}$) from previous work in our laboratory. Heart rate will be monitored continuously using a heart rate monitor (Polar FS1, Polar Electro, Inc., Lake Success, NY, USA), and RPE will be recorded every minute during each trial. Finally, participants will not be able to see their speed, distance, or time during this treadmill test.

- **Experimental Trials:** Following the fourth visit, two experimental trials will be conducted, consisting of two separate conditions: 1) no music (NM); and 2) self-selected music (SSM). All music will be self-selected by participants. All music selections will be at a tempo of 180 beats per minute, and volume of music will remain consistent between trials and participants to maintain consistency of music loudness (Daniels, 2013; Edworthy & Waring, 2006). Participants will listen to music through a set of headphones that will be provided to them. For each experimental trial, participants will perform a 5-minute warm-up at a self-selected intensity on a motorized treadmill (Woodway 4Front™, Waukesha, Wisconsin, United States). Following the warm-up, participants will complete a time-to-exhaustion (TTE) on a motorized treadmill (Woodway 4Front™, Waukesha, WI) to examine the responses to music and no music during exercise, where HR, RPE, and TTE will be measured. Each TTE will include steady-state running at a speed of 80% of the participant's VO_{2max} (Karageorghis et al., 2009). Experimental trials will be conducted in a counter balanced manner. A minimum of 48 hours between each trial will be used in order to decrease fatigue. Participants will be weighed on a calibrated physician's scale prior to each trial. Heart rate will be monitored continuously throughout each trial using a heart rate monitor (Polar FS1, Polar Electro, Inc., Lake Success, NY, USA), and RPE will be recorded every minute during each trial. Finally, participants will not be able to see their speed, distance, or time during the TTEs.
- **Post-Intervention Interviews:** Following the TTE on the third visit, participants will complete a post-intervention interview to provide insight into why listening to music during exercise may affect performance. The type of interview that will be administered for this study will be a verbal interview, where the interviewer

will be face-to-face with the participant, using a voice recorder to audio record the dialogue (Bowling, 2005). Interviews will be conducted in a private room in order to minimize any outside or external influences (e.g., peers or others listening to participants' answers). Interviews will include open-ended questions such as "Do you typically listen to music when you exercise?", "Does listening to music enhance your wellbeing?", "Do you listen to music to enhance or intensify your emotions?", "What types of emotions motivate you the most during intense exercise?", and "Does exercise have any effect (either positive or negative) on your exercise performance?" Once interviews are completed, all interviews will be transcribed from beginning to end, and all transcripts will be mined for usable data (Weiss, 1994).

The study protocol is portrayed in Figure 1 below.

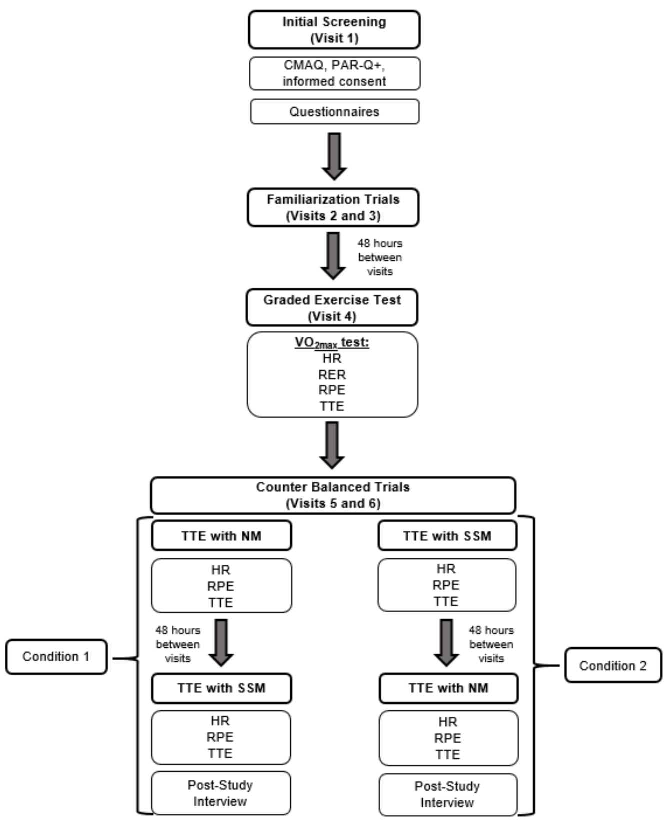

Figure 1. Study Protocol; confidential medical and activity questionnaire (CMAQ), physical activity readiness questionnaire (PAR-Q+), heart rate (HR), respiratory exchange ratio (RER), ratings of perceived exertion (RPE), time to exhaustion (TTE), no music (NM), self-selected music (SSM)

10.0 Data and Specimen Banking*

10.1 All questionnaires and data collection sheets will be kept in a locked cabinet during and following the study. All electronically-entered data will be saved in an encrypted file, and access will be limited to appropriate lab personnel only. Participant folders will be marked with an I.D. number to protect against a breach of confidentiality; participant names and ID numbers will be stored separately.

11.0 Data Management* and Confidentiality

11.1 All information attained from the preliminary visit (including CMAQ, PAR-Q+, informed consent), familiarization visits, testing visit, experimental trials (including any and all data from performance testing), and post-intervention interviews will be held in strict confidence. Individual results will remain confidential and only be related to the participant upon request once the study is completed. All questionnaires, data collection sheets, and audio recorders will be kept in a locked cabinet during and following the study. Data that is electronically stored will be kept on a password protected laptop in the office of the PI. All information will be destroyed five years from the end of the study and not used for other research purposes. Participant folders will be marked with an I.D. number to protect against a breach of confidentiality. Participant names and I.D. numbers will be stored apart from the subject folders.

11.2 Prior to statistical procedures, data will be assessed for normal distribution. All data will be analyzed to provide descriptive statistics for measures derived from VO_{2max} testing, TTEs, and questionnaires. Cronbach's alpha will be used to measure internal consistency within the MTQ48. Moderated regression will be used to determine the moderating effect of mental toughness on change in performance between NM and SSM groups, and factor analysis will be used to further determine relationships between variables. An alpha level of $p \leq 0.05$ will be used to determine statistical significance. All quantitative statistical analyses will be conducted via the Statistical Package for Social Science (SPSS) software for Windows version 21 (SPSS Inc., Chicago, IL). All qualitative data from post-study interviews will be categorized and analyzed via NVivo qualitative data analysis Software (QSR International Pty Ltd. Version 10.0, 2012).

11.3 Power analysis revealed that a sample size for repeated measures designs of 24 participants would be required to obtain a power of 0.81. Due to an anticipated attrition rate of 25%, 30 participants will be recruited for the current study.

11.4 Describe how data or specimens will be handled study-wide:

- All participant records and paperwork (e.g., informed consent documents and data collection sheets) will be destroyed five years from the end of the study and will not be used for other research purposes.

- Participant folders will be marked with an I.D. number to protect against a breach of confidentiality, and the I.D. number will be removed upon disposal. Further, all identifiable information will be stored separately from any data collection sheets.

12.0 Provisions to Monitor the Data to Ensure the Safety of Subjects*

12.1 All testing sessions will be supervised by HPL personnel who are Certified Strength and Conditioning Specialists. All Human Performance Lab Staff currently hold American Red Cross Adult CPR/AED certifications. An Automated External Defibrillator (AED) is located in the Wellness Research Center within the Education Complex Building located approximately 200 feet from the Human Performance Lab.

13.0 Withdrawal of Subjects*

13.1 Participants have the right to discontinue participation without penalty, regardless of the status of the study. In the event that a participant is asked to withdraw or voluntarily withdraws from the study, their data will be removed from the study results and destroyed. Participants will also be instructed that participation in the study may be terminated at any time by the researchers in charge of the project. Possible reasons for removal include:

- Inability to adhere to the study protocol. This includes:
  - Participant is unable to complete the VO_{2max} test.
  - Participant is unable to complete experimental trials.
- Failure to adhere to any requirements
- Failure to complete all visits to the Human Performance Lab
- Participant refuses to take part in either familiarization or experimental trial assessment measures

14.0 Risks to Subjects*

14.1 No risks are associated with completing questionnaires or post-intervention interviews.

14.2 The performance assessments carry the same inherent risks as participating in any physical activity, such as muscle soreness and fatigue and possibly muscle strains, and/or joint sprains. To minimize these risks, participants will be instructed on appropriate technique for the performance assessments. Participants will be instructed to immediately stop and report any injury or discomfort associated with the performance assessments to a member of the investigative team. The extent of the injury/discomfort, as well as the ability of the participant to continue with the study, will be subsequently be determined by the investigative team. If it is deemed that the discomfort/injury will prevent the participant from completing the study, or if the injury/discomfort may be exacerbated by further participation in the study, the investigative team will suspend the individual's participation in the study.

15.0 Potential Benefits to Subjects*

15.1 N/A

16.0 Vulnerable Populations*

16.1 This study does not include any vulnerable populations.

17.0 Community-Based Participatory Research*

17.1 N/A

18.0 Sharing of Results with Subjects*

18.1 The principal investigators do not intend to share results with participants; however, results will be provided upon participant request following completion of the study.

19.0 Setting

19.1 All assessment measures and post-intervention interviews will take place in the University of Central Florida's Strength and Conditioning Lab and Human Performance Lab.

19.2 Recruitment of participants will take place at the University of Central Florida.

19.3 All research will be conducted at the University of Central Florida.

20.0 Resources Available

20.1 The primary investigator of this study has been a primary and co-investigator of several research studies investigating treadmill running performance and VO_{2max} assessment measures, conducting VO_{2max} assessments consistently over the past five years. Dr. Jeanette Garcia is an expert in behavioral medicine and utilizing mixed-method designs. All other personnel involved in this study are Senior Doctoral and Masters Research Assistants at the University of Central Florida's Human Performance Laboratory. All personnel are First Aid and CPR certified and have the required research training through the Collaborative Institutional Training Initiative. Additionally, all research personnel involved in data collection are experienced in the administration of the proposed assessments. All Doctoral students involved in this study are Certified Strength and Conditioning Specialists through the National Strength and Conditioning Association. Our lab has the necessary equipment and personnel to complete the proposed methods.

20.2 We intend to recruit 30 participants enrolled at the University of Central Florida. Research is planned to be completed within three months of the starting date. The facility in which the study will be conducted is the University of Central Florida Institute of Exercise Physiology and Wellness. In the event that participants need medical resources, all graduate research assistants are CPR and First Aid certified. Additionally, participants have access to UCF's Health Center, where emergency medical services can be provided.

21.0 Prior Approvals

21.1 N/A

22.0 Recruitment Methods

22.1 All participants will be recruited by flyer or word of mouth throughout the University of Central Florida. Following an explanation of all procedures, risks and benefits, each participant will be asked to give his or her informed consent prior to participation in this study. Participants will not be permitted to use any nutritional supplements or medications while enrolled in the study.

22.2 Participants will be compensated with a $50 in the form of a gift card within two week of completion of the study.

23.0 Local Number of Subjects

23.1 A total of 30 subjects will be accrued locally.

24.0 Provisions to Protect the Privacy Interests of Subjects

24.1 Participant privacy will be protected at all times. All data collection will be solely conducted by its own personnel. No other persons will have access to the previously mentioned facilities during data collection. Participants will be provided locker room access to change into their attire if needed.

24.2 All consent forms will be completed privately in a small office at the University of Central Florida. Only the principal investigators on this study will have access to any personal information which will be stored privately in a locked file cabinet. All assessments will take place in a laboratory that is not accessible to the general public.

24.3 Prior to any assessment, investigators listed on the protocol will describe in detail each assessment measure they will ask participants to complete.

24.4 Only the approved principal investigator and co-investigators will be permitted to access any sources of information, which will be located in locked cabinets and password-protected computers located in the principal investigator's office.

25.0 Compensation for Research-Related Injury

25.1 Participants are instructed to report any discomforts related to the study to the principle investigator. If immediate assistance is needed it will be provided via the emergency medical system. For non-emergency discomforts, participants must seek their own physician for medical attention. Adverse events/side effects will be reported to the IRB immediately upon notification.

26.0 Economic Burden to Subjects

26.1 We do not anticipate any costs associated with participation in this study.

27.0 Consent Process

27.1 A signed consent form will be required for enrollment prior to participation. The signed consent form will be obtained prior to completing the medical history questionnaire and any subsequent testing pertaining to the study. All participants will be provided with the time necessary to read all documents, and an investigator will be available to explain the study protocol and answer any questions that each potential participant may have. The consent process will take place in a private room at the University of Central Florida.

27.2 Investigators will be following "SOP: Informed Consent Process for Research (HRP-090)."

Non-English Speaking Subjects

- N/A

Subjects who are not yet adults (infants, children, teenagers)

- N/A

Cognitively Impaired Adults

- N/A

Adults Unable to Consent

- N/A

Adults Unable to Consent

21.1.1 N/A

28.0 Process to Document Consent in Writing

28.1 Yes, the protocol will follow the "SOP: Written Documentation of Consent (HRP-091)."

28.2 Consent form attached.

29.0 Drugs or Devices

29.1 N/A

APPENDIX E
PHYSICAL ACTIVITY READINESS QUESTIONNAIRE (PAR-Q +)

2017 PAR-Q+

The Physical Activity Readiness Questionnaire for Everyone

The health benefits of regular physical activity are clear; more people should engage in physical activity every day of the week. Participating in physical activity is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

GENERAL HEALTH QUESTIONS

Please read the 7 questions below carefully and answer each one honestly: check YES or NO.	**YES**	**NO**
1) Has your doctor ever said that you have a heart condition ☐ OR high blood pressure ☐?	☐	☐
2) Do you feel pain in your chest at rest, during your daily activities of living, **OR** when you do physical activity?	☐	☐
3) Do you lose balance because of dizziness **OR** have you lost consciousness in the last 12 months? Please answer **NO** if your dizziness was associated with over-breathing (including during vigorous exercise).	☐	☐
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? **PLEASE LIST CONDITION(S) HERE:** ______	☐	☐
5) Are you currently taking prescribed medications for a chronic medical condition? **PLEASE LIST CONDITION(S) AND MEDICATIONS HERE:** ______	☐	☐
6) Do you currently have (or have had within the past 12 months) a bone, joint, or soft tissue (muscle, ligament, or tendon) problem that could be made worse by becoming more physically active? Please answer **NO** if you had a problem in the past, but it ***does not limit your current ability*** to be physically active. **PLEASE LIST CONDITION(S) HERE:** ______	☐	☐
7) Has your doctor ever said that you should only do medically supervised physical activity?	☐	☐

If you answered NO to all of the questions above, you are cleared for physical activity.
Go to Page 4 to sign the PARTICIPANT DECLARATION. You do not need to complete Pages 2 and 3.

- Start becoming much more physically active – start slowly and build up gradually.
- Follow International Physical Activity Guidelines for your age (www.who.int/dietphysicalactivity/en/).
- You may take part in a health and fitness appraisal.
- If you are over the age of 45 yr and **NOT** accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.
- If you have any further questions, contact a qualified exercise professional.

If you answered YES to one or more of the questions above, COMPLETE PAGES 2 AND 3.

Delay becoming more active if:

- You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at **www.eparmedx.com** before becoming more physically active.
- Your health changes - answer the questions on Pages 2 and 3 of this document and/or talk to your doctor or a qualified exercise professional before continuing with any physical activity program.

2017 PAR-Q+

FOLLOW-UP QUESTIONS ABOUT YOUR MEDICAL CONDITION(S)

1. Do you have Arthritis, Osteoporosis, or Back Problems?
If the above condition(s) is/are present, answer questions 1a-1c — If **NO** ☐ go to question 2

1a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
1b.	Do you have joint problems causing pain, a recent fracture or fracture caused by osteoporosis or cancer, displaced vertebra (e.g., spondylolisthesis), and/or spondylolysis/pars defect (a crack in the bony ring on the back of the spinal column)?	YES ☐ NO ☐
1c.	Have you had steroid injections or taken steroid tablets regularly for more than 3 months?	YES ☐ NO ☐

2. Do you currently have Cancer of any kind?
If the above condition(s) is/are present, answer questions 2a-2b — If **NO** ☐ go to question 3

2a.	Does your cancer diagnosis include any of the following types: lung/bronchogenic, multiple myeloma (cancer of plasma cells), head, and/or neck?	YES ☐ NO ☐
2b.	Are you currently receiving cancer therapy (such as chemotheraphy or radiotherapy)?	YES ☐ NO ☐

3. Do you have a Heart or Cardiovascular Condition? *This includes Coronary Artery Disease, Heart Failure, Diagnosed Abnormality of Heart Rhythm*
If the above condition(s) is/are present, answer questions 3a-3d — If **NO** ☐ go to question 4

3a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
3b.	Do you have an irregular heart beat that requires medical management? (e.g., atrial fibrillation, premature ventricular contraction)	YES ☐ NO ☐
3c.	Do you have chronic heart failure?	YES ☐ NO ☐
3d.	Do you have diagnosed coronary artery (cardiovascular) disease and have not participated in regular physical activity in the last 2 months?	YES ☐ NO ☐

4. Do you have High Blood Pressure?
If the above condition(s) is/are present, answer questions 4a-4b — If **NO** ☐ go to question 5

4a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
4b.	Do you have a resting blood pressure equal to or greater than 160/90 mmHg with or without medication? (Answer **YES** if you do not know your resting blood pressure)	YES ☐ NO ☐

5. Do you have any Metabolic Conditions? *This includes Type 1 Diabetes, Type 2 Diabetes, Pre-Diabetes*
If the above condition(s) is/are present, answer questions 5a-5e — If **NO** ☐ go to question 6

5a.	Do you often have difficulty controlling your blood sugar levels with foods, medications, or other physician-prescribed therapies?	YES ☐ NO ☐
5b.	Do you often suffer from signs and symptoms of low blood sugar (hypoglycemia) following exercise and/or during activities of daily living? Signs of hypoglycemia may include shakiness, nervousness, unusual irritability, abnormal sweating, dizziness or light-headedness, mental confusion, difficulty speaking, weakness, or sleepiness.	YES ☐ NO ☐
5c.	Do you have any signs or symptoms of diabetes complications such as heart or vascular disease and/or complications affecting your eyes, kidneys, **OR** the sensation in your toes and feet?	YES ☐ NO ☐
5d.	Do you have other metabolic conditions (such as current pregnancy-related diabetes, chronic kidney disease, or liver problems)?	YES ☐ NO ☐
5e.	Are you planning to engage in what for you is unusually high (or vigorous) intensity exercise in the near future?	YES ☐ NO ☐

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6. Do you have any Mental Health Problems or Learning Difficulties? *This includes Alzheimer's, Dementia, Depression, Anxiety Disorder, Eating Disorder, Psychotic Disorder, Intellectual Disability, Down Syndrome*

If the above condition(s) is/are present, answer questions 6a-6b — If **NO** ☐ go to question 7

6a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
6b.	Do you have Down Syndrome **AND** back problems affecting nerves or muscles?	YES ☐ NO ☐

7. Do you have a Respiratory Disease? *This includes Chronic Obstructive Pulmonary Disease, Asthma, Pulmonary High Blood Pressure*

If the above condition(s) is/are present, answer questions 7a-7d — If **NO** ☐ go to question 8

7a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
7b.	Has your doctor ever said your blood oxygen level is low at rest or during exercise and/or that you require supplemental oxygen therapy?	YES ☐ NO ☐
7c.	If asthmatic, do you currently have symptoms of chest tightness, wheezing, laboured breathing, consistent cough (more than 2 days/week), or have you used your rescue medication more than twice in the last week?	YES ☐ NO ☐
7d.	Has your doctor ever said you have high blood pressure in the blood vessels of your lungs?	YES ☐ NO ☐

8. Do you have a Spinal Cord Injury? *This includes Tetraplegia and Paraplegia*

If the above condition(s) is/are present, answer questions 8a-8c — If **NO** ☐ go to question 9

8a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
8b.	Do you commonly exhibit low resting blood pressure significant enough to cause dizziness, light-headedness, and/or fainting?	YES ☐ NO ☐
8c.	Has your physician indicated that you exhibit sudden bouts of high blood pressure (known as Autonomic Dysreflexia)?	YES ☐ NO ☐

9. Have you had a Stroke? *This includes Transient Ischemic Attack (TIA) or Cerebrovascular Event*

If the above condition(s) is/are present, answer questions 9a-9c — If **NO** ☐ go to question 10

9a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
9b.	Do you have any impairment in walking or mobility?	YES ☐ NO ☐
9c.	Have you experienced a stroke or impairment in nerves or muscles in the past 6 months?	YES ☐ NO ☐

10. Do you have any other medical condition not listed above or do you have two or more medical conditions?

If you have other medical conditions, answer questions 10a-10c — If **NO** ☐ read the Page 4 recommendations

10a.	Have you experienced a blackout, fainted, or lost consciousness as a result of a head injury within the last 12 months **OR** have you had a diagnosed concussion within the last 12 months?	YES ☐ NO ☐
10b.	Do you have a medical condition that is not listed (such as epilepsy, neurological conditions, kidney problems)?	YES ☐ NO ☐
10c.	Do you currently live with two or more medical conditions?	YES ☐ NO ☐

PLEASE LIST YOUR MEDICAL CONDITION(S) AND ANY RELATED MEDICATIONS HERE: ______________________

GO to Page 4 for recommendations about your current medical condition(s) and sign the PARTICIPANT DECLARATION.

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If you answered NO to all of the follow-up questions about your medical condition, you are ready to become more physically active - sign the PARTICIPANT DECLARATION below:

- It is advised that you consult a qualified exercise professional to help you develop a safe and effective physical activity plan to meet your health needs.
- You are encouraged to start slowly and build up gradually - 20 to 60 minutes of low to moderate intensity exercise, 3-5 days per week including aerobic and muscle strengthening exercises.
- As you progress, you should aim to accumulate 150 minutes or more of moderate intensity physical activity per week.
- If you are over the age of 45 yr and **NOT** accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.

If you answered **YES** to **one or more of the follow-up questions** about your medical condition:

You should seek further information before becoming more physically active or engaging in a fitness appraisal. You should complete the specially designed online screening and exercise recommendations program - the **ePARmed-X+ at www.eparmedx.com** and/or visit a qualified exercise professional to work through the ePARmed-X+ and for further information.

Delay becoming more active if:

- You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ **at www.eparmedx.com** before becoming more physically active.
- Your health changes - talk to your doctor or qualified exercise professional before continuing with any physical activity program.

- You are encouraged to photocopy the PAR-Q+. You must use the entire questionnaire and NO changes are permitted.
- The authors, the PAR-Q+ Collaboration, partner organizations, and their agents assume no liability for persons who undertake physical activity and/or make use of the PAR-Q+ or ePARmed-X+. If in doubt after completing the questionnaire, consult your doctor prior to physical activity.

PARTICIPANT DECLARATION

- All persons who have completed the PAR-Q+ please read and sign the declaration below.
- If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that a Trustee (such as my employer, community/fitness centre, health care provider, or other designate) may retain a copy of this form for their records. In these instances, the Trustee will be required to adhere to local, national, and international guidelines regarding the storage of personal health information ensuring that the Trustee maintains the privacy of the information and does not misuse or wrongfully disclose such information.

NAME ______________________ DATE ______________________

SIGNATURE ______________________ WITNESS ______________________

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER ______________________

For more information, please contact
www.eparmedx.com
Email: eparmedx@gmail.com

Citation for PAR-Q+
Warburton DER, Jamnik VK, Bredin SSD, and Gledhill N on behalf of the PAR-Q+ Collaboration. The Physical Activity Readiness Questionnaire for Everyone (PAR-Q+) and Electronic Physical Activity Readiness Medical Examination (ePARmed-X+). Health & Fitness Journal of Canada 4(2):3-23, 2011.

The PAR-Q+ was created using the evidence-based AGREE process (1) by the PAR-Q+ Collaboration chaired by Dr. Darren E. R. Warburton with Dr. Norman Gledhill, Dr. Veronica Jamnik, and Dr. Donald C. McKenzie (2). Production of this document has been made possible through financial contributions from the Public Health Agency of Canada and the BC Ministry of Health Services. The views expressed herein do not necessarily represent the views of the Public Health Agency of Canada or the BC Ministry of Health Services.

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APPENDIX F
CONFIDENTIAL MEDICAL AND ACTIVITY QUESTIONNAIRE

Confidential Medical and Activity History Questionnaire

Participant #__________

When was your last physical examination? ______________________________

1. **List any medications, herbals or supplements you currently take or have taken the last month**:

Medication	Reason for medication
________________	________________
________________	________________
________________	________________
________________	________________

2. **Are you allergic to any medications? If yes, please list medications and reaction**.

3. **Please list any allergies, including food allergies that you may have?**

4. **Have you ever been hospitalized? If yes, please explain**.

Year of hospitalization	Reason
________________	________________
________________	________________
________________	________________

5. **Illnesses and other Health Issues**

List any chronic (long-term) illnesses that have caused you to seek medical care.

Have you ever had (or do you have now) any of the following. Please circle questions that you do not know the answer to.

Sickle cell anemia	yes	no
Cystic fibrosis	yes	no
Water retention problems	yes	no
Heart pacemaker	yes	no
Epilepsy	yes	no
Convulsions	yes	no
Dizziness/fainting/unconsciousness	yes	no
Asthma	yes	no
Shortness of breath	yes	no
Chronic respiratory disorder	yes	no
Chronic headaches	yes	no
Chronic cough	yes	no
Chronic sinus problem	yes	no
High blood pressure	yes	no
Heart murmur	yes	no
Heart attack	yes	no
High cholesterol	yes	no
Diabetes mellitus or insipidus	yes	no
Rheumatic fever	yes	no
Emphysema	yes	no
Bronchitis	yes	no
Hepatitis	yes	no
Kidney disease	yes	no
Bladder problems	yes	no
Tuberculosis (positive skin test)	yes	no
Yellow jaundice	yes	no
Auto immune deficiency	yes	no
Anemia	yes	no
Endotoxemia	yes	no
Thyroid problems	yes	no
Hyperprolactinemia	yes	no
Anorexia nervosa	yes	no
Bulimia	yes	no
Stomach/intestinal problems	yes	no
Arthritis	yes	no
Back pain	yes	no
Gout	yes	no
Hepatic encephalopathy	yes	no
Mania	yes	no

Hypermania	yes	no
Monosodium glutamate hypersensitivity	yes	no
Seizure disorders	yes	no

Any others (specify):____
____
____

Do you smoke cigarettes or use any other tobacco products?	yes	no
Do you have a history of drug or alcohol dependency?	yes	no
Do you ever have any pain in your chest?	yes	no
Are you ever bothered by racing of your heart?	yes	no
Do you ever notice abnormal or skipped heartbeats?	yes	no
Do you ever have any arm or jaw discomfort, nausea, Or vomiting associated with cardiac symptoms?	yes	no
Do you ever have difficulty breathing?	yes	no
Do you ever experience shortness of breath?	yes	no
Do you ever become dizzy during exercise?	yes	no
Are you pregnant?	yes	no
Is there a chance that you may be pregnant?	yes	no
Have you ever had any tingling or numbness in your arms or legs?	yes	no
Has a member of your family or close relative died of heart problems or sudden death before the age of 50?	yes	no
Has a health care practitioner ever denied or restricted your participation in sports for any problem	yes	no

If yes, please explain: ____
____

Are you presently taking any nutritional supplements or ergogenic aids? (if yes, please detail.
____
____
____
____
____

APPENDIX G
DATA COLLECTION SHEET

VO_{2max} Testing Worksheet

SUBJECT #:____________________ DATE: ___________________

AGE: _______

WEIGHT _____ (kg)

HEIGHT ____ (cm)

Stage	Speed	VO_2	RER	HR	RPE
Warm up					
1 (120 sec)					
2 (120 sec)					
3 (120 sec)					
4 (60 sec)					
5 (60 sec)					
6 (60 sec)					
7 (60 sec)					
8 (60 sec)					
9 (60 sec)					
10 (60 sec)					
11 (60 sec)					
12 (60 sec)					
13 (60 sec)					

Time-To-Exhaustion (TTE) Worksheet

SUBJECT #:______________ DATE: ____________ CIRCLE ONE: SSM / NM

Treadmill speed (mph) ________

TTE		
Time (minutes)	**HR**	**RPE**
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
16		
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24		
25		
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27		
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30		

APPENDIX H
MENTAL TOUGHNESS QUESTIONNAIRE

Mental Toughness Questionnaire (MTQ48)

Please answer these items carefully, thinking about how you are generally. Do not spend too much time on any one item. Answer the questions honestly – no one will see your responses, and there are no correct and incorrect answers.

1 . . . . 2 . . . . 3 . . . . 4 5
Disagree **Agree**

1. I usually find something to motivate me.	1	2	3	4	5
2. I generally feel in control.	1	2	3	4	5
3. I generally feel that I am a worthwhile person.	1	2	3	4	5
4. Challenges usually bring out the best in me.	1	2	3	4	5
5. When working with other people, I am usually quite influential.	1	2	3	4	5
6. Unexpected changes to my schedule generally throw me.	1	2	3	4	5
7. I don't usually give up under pressure.	1	2	3	4	5
8. I am generally confident in my own abilities.	1	2	3	4	5
9. I usually find myself just going through the motions.	1	2	3	4	5
10. At times, I expect things to go wrong.	1	2	3	4	5
11. 'I just don't know where to begin' is a feeling I usually have when presented with several things to do at once.	1	2	3	4	5
12. I generally feel that I am in control of what happens in my life.	1	2	3	4	5
13. However bad things are, I usually feel they will work out positively in the end.	1	2	3	4	5
14. I often wish my life was more predictable.	1	2	3	4	5
15. Whenever I try to plan something, unforeseen factors usually seem to wreck it.	1	2	3	4	5
16. I generally look on the bright side of life.	1	2	3	4	5
17. I usually speak my mind when I have something to say.	1	2	3	4	5
18. At times, I feel completely useless.	1	2	3	4	5
19. I can generally be relied upon to complete the tasks I am given.	1	2	3	4	5
20. I usually take charge of a situation when I feel it is appropriate.	1	2	3	4	5
21. I generally find it hard to relax.	1	2	3	4	5
22. I am easily distracted from tasks that I am involved with.	1	2	3	4	5
23. I generally cope well with any problems that occur.	1	2	3	4	5
24. I do not usually criticize myself even when things go wrong.	1	2	3	4	5
25. I generally try to give 100%.	1	2	3	4	5
26. When I am upset or annoyed, I usually let others know.	1	2	3	4	5

27. I tend to worry about things well before they actually happen.	1	2	3	4	5
28. I often feel intimidated in social gatherings.	1	2	3	4	5
29. When faced with difficulties, I usually give up.	1	2	3	4	5
30. I am generally able to react quickly when something unexpected happens.	1	2	3	4	5
31. Even when under considerable pressure, I usually remain calm	1	2	3	4	5
32. If something can go wrong, it usually will.	1	2	3	4	5
33. Things just usually happen to me.	1	2	3	4	5
34. I generally hide my emotion from others.	1	2	3	4	5
35. I usually find it difficult to make a mental effort when I am tired.	1	2	3	4	5
36. When I make mistakes, I usually let it worry me for days after.	1	2	3	4	5
37. When I am feeling tired, I find it difficult to get going.	1	2	3	4	5
38. I am comfortable telling people what to do.	1	2	3	4	5
39. I can normally sustain high levels of mental effort for long periods.	1	2	3	4	5
40. I usually look forward to changes in my routine.	1	2	3	4	5
41. I feel that what I do tends to make no difference.	1	2	3	4	5
42. I usually find it hard to summon enthusiasm for the tasks I have to do.	1	2	3	4	5
43. If I feel somebody is wrong, I am not afraid to argue with them.	1	2	3	4	5
44. I usually enjoy a challenge.	1	2	3	4	5
45. I can usually control my nervousness.	1	2	3	4	5
46. In discussions, I tend to back-down even when I feel strongly about something.	1	2	3	4	5
47. When I face setbacks, I am often unable to persist with my goal.	1	2	3	4	5
48. I can usually adapt myself to challenges that come my way.	1	2	3	4	5

APPENDIX I
Post-Study Interview Questions

Interview Questions

1. Do you listen to music to enhance or intensify your emotions (e.g., happiness, anger, or sadness)?
2. Do you typically listen to music when you exercise?
3. When you exercise, do you ever rely on certain emotions to get you through the workout?
4. What types of emotions motivate you the most during exercise?
5. Does music have any effect (either positive or negative) on your exercise performance?
6. If you feel that music helps your performance, what aspects of the music do you feel help most?
7. During the TTE without music, what did you think about while you were running?
8. During the TTE with music, do you feel that listening to music helped, hurt, or did nothing to your performance compared to the TTE without music?

APPENDIX J
DIETARY RECALL

1. Use the forms provided to record everything you eat or drink on the days instructed.

2. Indicate the name of the FOOD ITEM, the AMOUNT eaten, how it was PREPARED (fried, boiled, etc.), and the TIME the food was eaten. If the item was a brand name product, please include the name. Try to be accurate about the amounts eaten. Measuring with measuring cups and spoons is best, but if you must make estimates, use the following guidelines:

- A fist is about 1 cup
- Tip of your thumb is about 1 teaspoon
- A thumb represents about 1 ounce of cheese
- A golf ball represents about 2 tablespoons
- The palm is about 3 ounces of meat (roughly the size of a deck of cards)

3. Try to maintain your normal diet, and be honest about what you eat. The information you provide is confidential.

4. Follow the specific instructions below when reporting foods:

- MILK – indicate % fat, source (e.g., cow, almond, coconut), and flavoring (if any).
- FRUITS & VEGETABLES – an average serving size of cooked or canned fruits and vegetables is ½ cup. Fresh, whole fruits and vegetables should be listed as small, medium, or large. Be sure to indicate sugar or syrup is added to fruit and list if any margarine, butter, cheese sauce, or cream sauce is added to vegetables. When recording salad, list items comprising the salad separately and be sure to include salad dressing used.
- EGGS – indicate whole or whites only, method of preparation (e.g., scrambled, fried, poached), and number eaten.
- MEAT/POULTRY/FISH – indicate approximate size or weight, in ounces, of the serving. Be sure to include any gravy, sauce, or breading added and preparation method.
- CHEESE – indicate kind, number of ounces or slices, and whether it is made from whole milk, part skim, or is low calorie.
- CEREAL – specify kind, brand, whether cooked or dry, and measure in terms of cups or ounces. *Consuming 8 oz. of cereal is not the same as consuming 1 cup of cereal. Be sure to include any milk consumed with cereal (see MILK).
- BREADS – specify kind (e.g., whole wheat, enriched wheat, white) and number of slices.
- BEVERAGES – include everything drink, excluding water. Be sure to record cream and sugar used in tea and coffee, whether juices are sweetened or unsweetened, and whether soft drinks are diet or regular.
- FATS - record any butter, margarine, oil, or other fats used in cooking or on food.
- PREPARED DISHES/CASSEROLES – list the main ingredients, approximate amount of each ingredient to the best of your ability, and brand (if applicable).

5. Express approximate measures in cups (c), tablespoons (T), teaspoons (t), grams (g), ounces (oz), pieces, etc.

6. If you are unsure of how to report any food items you consume, please take pictures of the packaging and Nutrition Facts panel, when possible.

Subject #:______________ **Date:______________**

24-Hour Prior to Trial 1

Meal	Time	FOOD/BEVERAGE DESCRIPTION	AMOUNT	Total kcal *(from label)*
Breakfast				
Lunch				
Dinner				
Snacks				

Subject #:______________ **Date:______________**

24-Hour Prior to Trial 2

Meal	**Time**	**FOOD/BEVERAGE DESCRIPTION**	**AMOUNT**	**Total kcal** ***(from label)***
Breakfast				
Lunch				
Dinner				
Snacks				

APPENDIX K
RECRUITMENT FLYER

YOU ARE INVITED TO PARTICIPATE IN A RESEARCH STUDY

"A Mixed-Methods Approach to Understanding the Relationship between Mental Toughness and the Effect of Music on Exercise Performance"

Description of Project/Purpose:

The University of Central Florida's Human Performance Lab is examining the moderating effect of mental toughness on the effect of listening to music during exercise.

Who is eligible?

Recreationally-active males and females between the ages of 18 and 35 years.

What will you be asked to do?

Complete 4 visits to the Human Performance Lab (4 hours total), which includes:

- Informed consent, Medical History Questionnaire, Par-Q+, & Questionnaires
- Maximal exercise test (VO_{2peak} test)
- Two experimental trials consisting of treadmill running while either listening to self-selected music or no music

Compensation: Upon completion of the study, participants will be compensated with a $50 gift card.

To learn more, contact Kayla Baker at 407-823-2367 or kayla.baker@ucf.edu

This research is conducted under the direction of Jeanette M. Garcia, PhD, Department of Educational and Human Sciences and has been reviewed and approved by the UCF Institutional Review Board.

UCF Human Performance Lab 12494 University Blvd. Education Complex Room 172 Orlando, FL 32828

Appendix L

SPSS Output for Order Effect, Moderated Regression, and Linear Regression

```
REGRESSION
  /DESCRIPTIVES MEAN STDDEV CORR SIG N
  /MISSING LISTWISE
  /STATISTICS COEFF OUTS R ANOVA CHANGE
  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT TTElong
  /METHOD=ENTER MTlong MusicLong OrderLong
  /METHOD=ENTER Interaction1 Interaction2 Interaction3
  /METHOD=ENTER Interaction4.
```

Regression

Descriptive Statistics

	Mean	Std. Deviation	N
TTElong	13.2044	5.07871	62
MTlong	156.3871	9.30601	62
MusicLong	1.5000	.50408	62
OrderLong	1.5806	.49748	62
Interaction1	234.5806	80.19332	62
Interaction2	247.4194	79.69235	62
Interaction3	2.3710	1.11963	62
Interaction4	.3334	22.12007	62

Correlations

		TTElong	MTlong	MusicLong	OrderLong	Interaction1	Interaction2	Interaction3	Interaction4
Pearson Correlation	TTElong	1.000	.043	-.194	.277	-.178	.272	.048	.028
	MTlong	.043	1.000	.000	.050	.174	.214	.033	.896
	MusicLong	-.194	.000	1.000	.000	.983	.000	.712	.005
	OrderLong	.277	.050	.000	1.000	.009	.985	.666	.045
	Interaction1	-.178	.174	.983	.009	1.000	.037	.706	.178
	Interaction2	.272	.214	.000	.985	.037	1.000	.656	.210
	Interaction3	.048	.033	.712	.666	.706	.656	1.000	.037
	Interaction4	.028	.896	.005	.045	.178	.210	.037	1.000
Sig. (1-tailed)	TTElong	.	.370	.065	.015	.083	.016	.357	.415
	MTlong	.370	.	.500	.350	.088	.047	.399	.000
	MusicLong	.065	.500	.	.500	.000	.500	.000	.484
	OrderLong	.015	.350	.500	.	.473	.000	.000	.366
	Interaction1	.083	.088	.000	.473	.	.387	.000	.083
	Interaction2	.016	.047	.500	.000	.387	.	.000	.051
	Interaction3	.357	.399	.000	.000	.000	.000	.	.389
	Interaction4	.415	.000	.484	.366	.083	.051	.389	.
N	TTElong	62	62	62	62	62	62	62	62
	MTlong	62	62	62	62	62	62	62	62
	MusicLong	62	62	62	62	62	62	62	62
	OrderLong	62	62	62	62	62	62	62	62
	Interaction1	62	62	62	62	62	62	62	62
	Interaction2	62	62	62	62	62	62	62	62
	Interaction3	62	62	62	62	62	62	62	62
	Interaction4	62	62	62	62	62	62	62	62

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	OrderLong, MusicLong, MTlong[b]	.	Enter
2	Interaction3, Interaction1, Interaction2[b]	.	Enter
3	Interaction4[b]	.	Enter

a. Dependent Variable: TTElong

b. All requested variables entered.

Model Summary

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	F Change	df1	df2	Sig. F Change
1	.340[a]	.115	.070	4.89885	.115	2.520	3	58	.067
2	.365[b]	.133	.039	4.97968	.018	.377	3	55	.770
3	.367[c]	.135	.023	5.02018	.002	.116	1	54	.735

a. Predictors: (Constant), OrderLong, MusicLong, MTlong

b. Predictors: (Constant), OrderLong, MusicLong, MTlong, Interaction3, Interaction1, Interaction2

c. Predictors: (Constant), OrderLong, MusicLong, MTlong, Interaction3, Interaction1, Interaction2, Interaction4

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	181.460	3	60.487	2.520	.067[b]
	Residual	1391.929	58	23.999		
	Total	1573.389	61			
2	Regression	209.542	6	34.924	1.408	.228[c]
	Residual	1363.846	55	24.797		
	Total	1573.389	61			
3	Regression	212.468	7	30.353	1.204	.316[d]
	Residual	1360.920	54	25.202		
	Total	1573.389	61			

a. Dependent Variable: TTElong

b. Predictors: (Constant), OrderLong, MusicLong, MTlong

c. Predictors: (Constant), OrderLong, MusicLong, MTlong, Interaction3, Interaction1, Interaction2

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	9.199	10.823		.850	.399
	MTlong	.016	.067	.029	.236	.814
	MusicLong	-1.956	1.244	-.194	-1.572	.121
	OrderLong	2.814	1.262	.276	2.229	.030
2	(Constant)	6.812	46.099		.148	.883
	MTlong	.032	.293	.058	.108	.915
	MusicLong	-16.900	21.673	-1.677	-.780	.439
	OrderLong	20.279	22.110	1.986	.917	.363
	Interaction1	.095	.137	1.507	.696	.490
	Interaction2	-.112	.139	-1.754	-.804	.425
	Interaction3	.011	2.566	.002	.004	.997
3	(Constant)	38.590	104.197		.370	.713
	MTlong	-.172	.666	-.315	-.258	.797
	MusicLong	-38.086	65.900	-3.780	-.578	.566
	OrderLong	-2.120	69.410	-.208	-.031	.976
	Interaction1	.231	.421	3.648	.548	.586
	Interaction2	.031	.443	.493	.071	.944
	Interaction3	.011	2.587	.002	.004	.997
	Interaction4	-.095	.280	-.416	-.341	.735

a. Dependent Variable: TTElong

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics Tolerance
1	Interaction1	1.508[b]	.705	.484	.093	.003
	Interaction2	-1.754[b]	-.815	.418	-.107	.003
	Interaction3	.022[b]	.039	.969	.005	.049
	Interaction4	-.050[b]	-.177	.860	-.023	.197
2	Interaction4	-.416[c]	-.341	.735	-.046	.011

a. Dependent Variable: TTElong

b. Predictors in the Model: (Constant), OrderLong, MusicLong, MTlong

c. Predictors in the Model: (Constant), OrderLong, MusicLong, MTlong, Interaction3, Interaction1, Interaction2

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  /NOORIGIN
  /DEPENDENT TTElong
  /METHOD=ENTER MTlong MusicLong
  /METHOD=ENTER Interaction1.
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Regression

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Descriptive Statistics

	Mean	Std. Deviation	N
TTElong	13.2044	5.07871	62
MTlong	156.3871	9.30601	62
MusicLong	1.5000	.50408	62
Interaction1	234.5806	80.19332	62

Correlations

		TTElong	MTlong	MusicLong	Interaction1
Pearson Correlation	TTElong	1.000	.043	-.194	-.178
	MTlong	.043	1.000	.000	.174
	MusicLong	-.194	.000	1.000	.983
	Interaction1	-.178	.174	.983	1.000
Sig. (1-tailed)	TTElong	.	.370	.065	.083
	MTlong	.370	.	.500	.088
	MusicLong	.065	.500	.	.000
	Interaction1	.083	.088	.000	.
N	TTElong	62	62	62	62
	MTlong	62	62	62	62
	MusicLong	62	62	62	62
	Interaction1	62	62	62	62

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	MusicLong, MTlong[b]	.	Enter
2	Interaction1[b]	.	Enter

a. Dependent Variable: TTElong

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.199[a]	.040	.007	5.06092	.040	1.215	2	59	.304
2	.217[b]	.047	-.002	5.08399	.008	.466	1	58	.498

a. Predictors: (Constant), MusicLong, MTlong

b. Predictors: (Constant), MusicLong, MTlong, Interaction1

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	62.229	2	31.115	1.215	.304[b]
	Residual	1511.159	59	25.613		
	Total	1573.389	61			
2	Regression	74.268	3	24.756	.958	.419[c]
	Residual	1499.121	58	25.847		
	Total	1573.389	61			

a. Dependent Variable: TTElong

b. Predictors: (Constant), MusicLong, MTlong

c. Predictors: (Constant), MusicLong, MTlong, Interaction1

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	12.475	11.077		1.126	.265
	MTlong	.023	.070	.043	.336	.738
	MusicLong	-1.956	1.285	-.194	-1.522	.133
2	(Constant)	34.871	34.652		1.006	.318
	MTlong	-.120	.221	-.219	-.542	.590
	MusicLong	-16.887	21.916	-1.676	-.771	.444
	Interaction1	.095	.140	1.508	.682	.498

a. Dependent Variable: TTElong

Excluded Variables[a]

Model		Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
						Tolerance
1	Interaction1	1.508[b]	.682	.498	.089	.003

a. Dependent Variable: TTElong

b. Predictors in the Model: (Constant), MusicLong, MTlong

```
REGRESSION
  /DESCRIPTIVES MEAN STDDEV CORR SIG N
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  /CRITERIA=PIN(.05) POUT(.10)
  /NOORIGIN
  /DEPENDENT Performance
  /METHOD=ENTER MT.
```

Regression

Descriptive Statistics

	Mean	Std. Deviation	N
Performance	1.9565	2.46396	31
MT	156.3871	9.38324	31

Correlations

		Performance	MT
Pearson Correlation	Performance	1.000	-.364
	MT	-.364	1.000
Sig. (1-tailed)	Performance	.	.022
	MT	.022	.
N	Performance	31	31
	MT	31	31

Variables Entered/Removed[a]

Model	Variables Entered	Variables Removed	Method
1	MT[b]	.	Enter

a. Dependent Variable: Performance

b. All requested variables entered.

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.364[a]	.132	.102	2.33457	.132	4.417	1	29	.044

a. Predictors: (Constant), MT

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	24.076	1	24.076	4.417	.044[b]
	Residual	158.056	29	5.450		
	Total	182.133	30			

a. Dependent Variable: Performance

b. Predictors: (Constant), MT

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	16.887	7.116		2.373	.024
	MT	-.095	.045	-.364	-2.102	.044

a. Dependent Variable: Performance

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