Effects of Synchronous Music in Sport and Exercise:
A Meta-Analytic Review and Field Studies of Ultra-Distance Athletes

A Dissertation submitted by

Michelle Louise Curran

GCertCrimAnlys BCCJ *Griffith*

GCertTT&L BSc(Psych)(Hons) *USQ*

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Abstract

Effects of music in sport and exercise have been investigated in many forms since the first published study by Ayers (1911). Music has been shown to provide significant benefits to physical and psychological responses but whether such benefits apply to ultra-distance athletes is unknown. The present research quantified effects of music in sport and exercise, specifically in terms of performance, psychological responses, physiological functioning and ratings of perceived exertion (RPE); and also investigated such effects among ultra-distance athletes in training and race environments. Study 1 was a meta-analysis of published research evidence, which quantified effects of music on performance, feelings (Feeling Scale - FS), heart rate (HR), oxygen utilisation (VO_2), and RPE. A total of 86 studies producing 162 effects showed weighted mean effects of $d = .35$ (performance), $d = .47$ (FS), $d = .14$ (HR), $d = .25$ (VO_2), and $d = .29$ (RPE) confirming small to moderate benefits of music. In Study 2, two elite ultra-distance athletes completed a 20 km training session on four occasions listening to synchronous motivational music, synchronous neutral music, an audio book, or no music. Motivational music provided athletes with significant benefits compared to no music and audio book conditions. Neutral music was associated with the slowest completion times for Athlete 1 but the second fastest for Athlete 2, behind motivational music. Using the same interventions in Study 3, nine elite athletes evaluated effects of music during ultra-distance races of 6, 24, or 48 hrs duration. Findings showed the superiority of motivational music over other interventions during the 18-24 hour period. Psychological and perceived exertion benefits of music were reported by some athletes but individual differences were clearly apparent. Overall, lap times were faster during the no-intervention periods and anecdotal reports confirmed that interventions had negative effects for some ultra-athletes. Consistent with previous research included in the meta-analysis, the present findings supported the judicious use of music interventions in sport and exercise.

Certification of Dissertation

I certify that the ideas, experimental work, results, analyses, software, and conclusions reported in this dissertation are entirely my own effort, except where otherwise acknowledged. I also certify that the work is original and has not been previously submitted for any other award, except where otherwise acknowledged.

______________________________ ___________________

Michelle L Curran Date

ENDORSEMENT

______________________________ ___________________

Prof. Peter C. Terry (Supervisor) Date

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First and foremost I need to acknowledge my supervisor Professor Peter Terry. He has been an inspiration to me, keeping the passion alive. He has supported me, even when my ideas were a little crazy and bigger than Ben Hur. Most of all, he has been honest, a characteristic I most respect in a person.

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Statement of Contribution of Others

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Dedication

I dedicate this paper to my three wonderful children Quaid, Pzarn, and Jonte (and by popular request—B2). They have gone without their mum's total attention whilst this has been completed. You guys have shown such strength of character at such young ages that you inspire me to do better.

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Chapter 1 – Introduction

"I like to get in my own world. When I'm getting ready for a meet, I always have headphones on, listening to rap music to get myself fired up."

Michael Phelps

1.1 Structure of the Dissertation

The dissertation has six chapters. This first chapter provides an overview of the subject matter and the theoretical basis upon which the present research is founded. Chapter 2 contains a detailed literature review, with Studies 1, 2, and 3 reported in Chapters 3, 4, and 5, respectively. Chapter 6 presents a general discussion of the findings.

1.2 Statement of the Problem

Music is used frequently in the context of sport and exercise. There are several proposed benefits of music for athletes and exercisers, including improved mood, arousal control, reduced perceived exertion, enhanced work output, improved skill acquisition, flow states, and dissociation from feelings of pain and fatigue (see Terry & Karageorghis, 2006). Since the first published study by Ayers (1911) there have been more than 100 studies measuring the effects of music in sport and exercise. In a narrative review of the findings, Karageorghis and Terry (1997) concluded that music enables athletes to dissociate from feelings of fatigue and perceived exertion, often resulting in a positive mood state. Synchronous music is that which necessitates the conscious performance of movements in time with the rhythmical elements of music, such as beat or tempo (Simpson & Karageorghis, 2006, p. 1095). Conversely, with asynchronous music there is no conscious attempt to align movement with the beat or tempo of music—it is essentially background music.

Most research has been conducted using asynchronous music. The present meta-analysis (see Chapter 2) identified only 14 synchronous music effects reported in the literature compared to 137 asynchronous effects, suggesting a significant gap in the investigation of synchronous music in the sport and exercise domain. Additionally, Karageorghis and colleagues (2009) called for field research to be completed using synchronous music, as all previous outcomes were achieved in laboratory settings.

1.3 Music Outcomes

Music has been shown to have a number of performance, psychological, and physiological benefits in a variety of sport and exercise domains. For example, Ayers (1911) found music to reduce time taken to complete cycling laps during a 6-day race. In Becker, Chambliss, Marsh, and Montemayor (1995) it was found that music significantly influenced the distance walked. Simpson and Karageorghis (2006) found that 400 m runners increased their speed when running in time to music. Music reduced choice reaction time among tennis players in Bishop, Karageorghis, and Kinrade (2009), and was found to produce more positive psychological responses over no music. Psychological benefits have been found to include improved feelings of pleasure or displeasure, enhanced mood and thought processes, and improved pre-task affect and mood (Karageorghis & Terry, 2008, p. 15). The use of music, and in particular synchronous music, appears to improve athletes' ability to extend their potential distance, enhance the acquisition of motor skills, and improve flow states (Terry & Karageorghis, 2006).

Brownley, McMurray, and Hackney (1995) and Hayakawa, Miki, Takada, and Tanaka (2000) found more positive psychological responses for music over no music during aerobics classes. Physiological benefits of lower HR, blood pressure and blood lactate levels when exercising to music were found by Szmedra and Bacharach (1998). Edworthy and Waring (2006) and Jing and Xudong (2008) also found lower HR levels when using music during exercise. Lower oxygen consumption was found by Bacon, Myers, and Karageorghis (2012) as a result of using synchronous music rather than asynchronous music during cycle ergometry. Potteiger, Schroeder, and Goff (2000) found that music acts as a distractor and influences peripheral, central and overall RPE during moderate intensity aerobic exercise. Mohammadzadeh, Tartibiiyan, and Ahmadi (2008) found lower RPE when participants exercised to music compared with completing the same amount of work without music. Overall, there has been a plethora of research showing that the use of music in sport and exercise is associated with improved performance, plus psychological, physiological, and psychophysical benefits.

1.4 Brief Rationale for Using Ultra-Distance Athletes

Engaging in an ultra-distance race is process-oriented rather than a goal-oriented. The *finish line* in an ultra-distance race is quantified by hours spent on a track rather than the traditional distance travelled measurement of other athletic events. The ultra-athlete experiences periods of emotional highs and lows during each event prior to crossing the finish line. It is how the athlete responds to each of these experiences that determine their success or failure in an ultra-distance event. The ultra-athlete draws on a wide range of cognitive, affective, and performance-related strategies to complete an ultra-event.

Ultra-distance athletes make up a very small and unique population of athletes worldwide. It is conceivable for the average person to train themselves to complete a marathon (42.195 km) but an ultra-marathon often involving distances of 100+ km is not only usually perceived to be unattainable but also not necessarily a desired achievement. "Ultra-running is a unique sport that gives the athlete the loneliness of a runner but also provides the camaraderie and companionship that is not seen in many disciplines of other sports. On paper, an ultra-race would be as small as a meter more than a marathon distance. However, “50 km and 100 km races are the most common around the world” (International Association of Athletics Federations; IAAF.org).

In their study Acevedo, Dzewaltowski, Gill, and Noble (1992) found that most ultra-marathoners are middle-aged (M = 40.20 years) and are very different in their cognitive orientations to other athletes. Acevedo and colleagues also found that the ultra-marathoner has a higher commitment to running and greater confidence than other athletes, placing more importance on the time sustained and distance achieved than on winning. Ultra-distance athletes tend to report mood stability. Tharion, Stowman, and Rauch (1988) found there to be no significant differences in pre- and post-run mood states in ultra-marathoners. Fatigue was considered to be the only significant difference between finishers and non-finishers and this was thought to be a direct result of distance travelled.

Morgan and Pollock (1977) hypothesised that elite ultra-athletes used dissociative strategies (attending to distracting thoughts or images) rather than associative strategies (attending to the individual’s physical sensations). Though this hypothesis was initially challenged by Acevedo and colleagues (1992), it was found that 75% of the athlete’s psychological thought patterns were categorised as external, supporting Morgan and Pollock’s original hypothesis. Psychological factors are not the only impacts on an ultra-athlete’s performance. Acevedo and colleagues found that ultra-athletes who were focussed on place achievement reduced their success, and it is thought that this could be the result of attending to their position in the race rather than attending to hydration, fuel consumption, and racing strategies. A number of physiological factors can impact on the athlete's performance, such as hyperthermia, hypothermia, dehydration, accidental injury, over-use injuries, gastric distress as a result of incorrect food and fluid intake, sickness, and extreme fatigue. The most common psychological techniques that were found to be used by ultra-athletes were visualisation, setting goals, and thought control (Acevedo et al., 1992).

1.5 Rationale for Research

There has been no published meta-analytic review of the use of music in sport and exercise. Further, a statistical analysis of the complexities of the effects of music on specific elements of physiology, psychology, and performance is absent from the existing research literature. There are a number of specific gaps in the literature that have been identified within this domain. Such gaps include the imbalance between synchronous and asynchronous music research. Synchronous music research is more complex as it not only accounts for personal music tastes and motivational qualities but requires the matching the tempo of the music to the athlete's personal cadence.

Music in sport and exercise research has shown outcomes achieved predominantly in a training mode in a laboratory. The extension of music research to include ultra-distance athletes allows for the outcomes previously identified in other sport and exercise domains to be tested in an environment where the athlete is not only physically but mentally stretched to their limit. There are a number of potential benefits of using synchronous music in an ultra-distance event. Firstly, due to the regularity of cadence required for optimum performance, it may aid in the efficiency of pacing. Secondly, it has been shown to lower perceived exertion. Thirdly, it can act as a dissociative strategy.

A plethora of research has been conducted, particularly in the last decade, measuring the biochemical effects of ultra-distance athletes but this is yet to be extended to include the use of psychological interventions. Current sport psychology research in the field has been limited to descriptive psychological experience research. The rationale for the current research is underpinned by the repeated call for music research to extend outside the laboratory, the increased popularity of ultra-distance events world-wide, and the lack of psychological intervention research in the ultra-distance field.

1.6 Broad Aims and Overview of Current Studies

The research has two broad aims:

1. To quantify the impact of music on sport and exercise, specifically in terms of performance, psychological effects, physiological variables and perceived exertion.
2. To investigate effects of music among ultra-distance athletes in both training and race environments.

These aims will be achieved by the completion of three studies, including a meta-analysis, two case studies, and a field experiment. An overview of these studies is provided in Figure 1.1. In Study 1, quantification of the effects of music in sport and exercise will be summarised by completion of a meta-analysis. Study 2 has two purposes: (a) to conduct case studies of two elite athletes to assess the effect of four interventions (i.e., synchronous motivational music, synchronous neutral music, audio book, no music) on outcomes measures (i.e., performance, psychological, physiological, RPE) in training; and (b) to test the experimental protocol for Study 3. The aim of Study 3 is to extend the interventions and outcomes used in Study 2 to the competitive race environment.

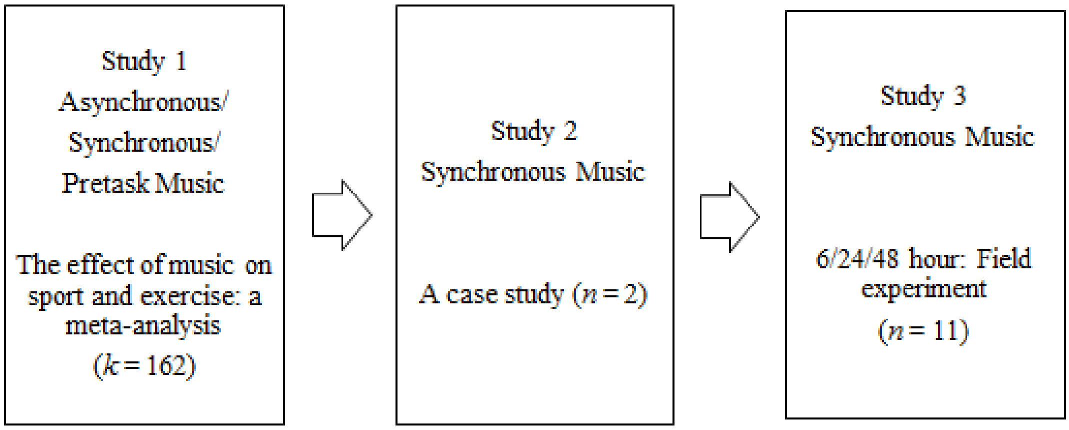

Figure 1.1. Research design.

1.7 Researcher Expertise in Ultra-Distance Athletics

The researcher was engaged as an elite ultra-distance athlete from 1993 to 1998. In this time the following records were gained:

- First woman in Australia to walk 100 km in a 24 hour race
- Former No 1 in Australia ultra-distance female walker
- Australian 50 km road best
- Australian 50 mile road best
- Australian 100 km road best
- Australian 50 km track record (female)
- Australian 50 mile track record (female)
- Member of World Record Team for most distance walked by a relay team in a 24 hour race.

Interest in ultra-distance athletics commenced when the researcher observed, in her teenage years, two young men who walked from Beenleigh to Tugun (approximately 65 km). She was intrigued by the narrative they provided relating to the balance of rush and pain that they experienced on their journey. At the age of 23, Michelle decided to embark on her own journey as an ultra-athlete, organising her own event and crew—walking from the Sunshine Coast to Brisbane—113 km in 18 hours.

Chapter 2 – Review of Literature

Sport represents one of the largest industries in the United States with domestic sports consumption and investment amounting to $213 billion in 2006. The Sports Business Journal notes that this multi-billion dollar industry is more than twice the size of the auto repair services and parking industries and seven times the size of the movie industry. Hence, research into sport has a very wide potential impact in the business world. Research into physical activity also has broad implications for public health.

Salmon, Owen, Crawford, Bauman, and Sallis (2003) highlighted a lack of physical activity as one of the main risk factors for non-communicable diseases, resulting in approximately 60% of deaths worldwide. Haskell and colleagues (2007) examined the recommendations on the types and amounts of physical activity recommended by the American College of Sports Medicine and the Centres for Disease Control and Prevention. An update of these guidelines presented by Salmon and colleagues (2003) found that “healthy adults aged 18 to 65 need moderate intensity aerobic physical activity (e.g., walking briskly) for a minimum of 30 minutes if completed five days a week, or 20 minutes of vigorous exercise (e.g., jogging) if completed three days a week” (p. 1). Engaging in these physical activities was found to reduce the individual’s risk for chronic diseases and disabilities.

On the other hand, “sedentary behaviour (e.g., watching television; reading; listening to music or the radio; relaxing, thinking, resting; and talking on the telephone)” was described by Salmon and colleagues as a growing national concern (p. 178). It was suggested that the identification of factors associated with a lack of physical activity needs to be approached from both individual (e.g., preferences, knowledge, beliefs, and attitudes) and environmental approaches (Salmon et al., 2003). Barriers, enjoyment, and preferences were each found to have predictive power in explaining choice of either physical activity or sedentary behaviour (Salmon et al., 2003). The need to study exercise from a bio-psychosocial interaction perspective was highlighted in Biddle and Mutrie (2001) with further explanation from Rejeski (1994):

> [w]hen people exercise they are doing far more than simply moving physically. As numerous studies suggest, the social environment provided with exercise training (e.g., enjoyment, peer support, or interactions with exercise leaders) may be as important to psychosocial outcomes as the activity itself. (p. 1053)

Music has been shown to improve exercise adherence in both clinical and athletic populations (Annesi, 2001; Elliot, Carr, & Savage, 2004), with Karageorghis and Priest (2008) positing that their findings of the benefits of music in sport and exercise may yield long-term benefits of exercise adherence.

Music has become a ubiquitous feature of exercise and sport environments. Exercise leaders encourage synchronization of movement with music tempo to enhance enjoyment, reduce perceptions of fatigue, and encourage more effort from exercisers (Crust, 2008; Karageorghis & Terry, 2008). Athletes use music to relax, to feel stimulated, or to generate a particular pre-competition mindset (Bishop, Karageorghis, & Loizou, 2007; Terry, Dinsdale, Karageorghis, & Lane, 2006). Sport organisers use music to create an atmosphere of excitement, patriotism, or tension among crowds of spectators (Steinbach, 2008; Tubino, de Souza, & Valladão, 2009). Drawing on these examples, it is apparent that many people intuitively believe that music has potential benefits in the domain of sport and exercise, although compelling evidence of such benefits has yet to be summarised objectively.

Investigations into the benefits of music during physical activity have a long history, dating back at least to Ayres (1911) who observed that competitors in a 6-day cycle race travelled faster when a band was playing. Benefits of music demonstrated in the research literature have included enhanced affective responses (e.g., Brownley et al., 1995; Edworthy & Waring, 2006; Elliott et al., 2004), the promotion of flow states (e.g., Karageorghis, Jones, & Stuart, 2007; Pates, Karageorghis, Fryer, & Maynard, 2003), and the alleviation of “choking” under pressure (e.g., Mesagno, Marchant, & Morris, 2009).

Music has been associated with improved performance in short-duration physical activities, such as 60-yard sprinting (e.g., Hall & Erikson, 1995), 400-metre running (e.g., Simpson & Karageorghis, 2006), grip strength (e.g., Karageorghis, Drew, & Terry, 1996), and the Wingate anaerobic test (e.g., M. Eliakim, Meckel, Nemet, & A. Eliakim, 2007). Performance improvements in long duration activities have also been shown in activities such as cycling (e.g., Atkinson, Wilson, & Eubank, 2004; Elliott, Carr, & Orme, 2005; Lim, Atkinson, Karageorghis, & Eubank, 2009; Schwartz, Fernhall, & Plowman, 1990), rowing ergometry (e.g., Rendi, A. Szabo, & T. Szabo, 2008), treadmill running (e.g., Bharani, Sahu, & Mathew, 2004; Ciccomascolo, Finn, Barbarich, & Rinehardt, 1995), and treadmill walking (e.g., Karageorghis et al., 2009).

The mechanisms by which such performance benefits accrue are not well understood, although the available evidence indicates that it is more than just a psychological phenomenon. Karageorghis and Priest (2012a) highlighted that although music in sport and exercise has been investigated extensively, research is currently lacking a focus on the underlying mechanisms; especially physiological mechanisms (p. 48). Music has been shown to reduce perceived exertion during exercise (e.g., Nethery, 2002; Potteiger et al., 2000), which is suggestive of a dissociation or distraction effect. Moreover, music has been shown to significantly improve physiological functioning during exercise (e.g., Bacon et al., 2012; Szmedra & Bacharach, 1998). However, not all investigations have provided support for music use with several studies finding no benefits (e.g., Nelson, 1963; Pujol & Langenfeld, 1999; L. Scott, D. Scott, Bedic, & Dowd, 1999).

Karageorghis and his colleagues have published several conceptual models to represent how various effects of music occur in sport and exercise contexts (e.g., Bishop & Karageorghis, 2009; Karageorghis & Terry, 1997; Karageorghis, Terry, & Lane, 1999; Terry & Karageorghis, 2006). The researcher adopted the 2006 conceptual framework, as shown in Figure 2.3, to inform the present objective summary of the extant literature. This conceptual framework, when compared to its predecessors, highlights an expanding list of potential benefits of music (Terry & Karageorghis, 2006). The essence of the model is that a range of personal and situational variables interact to determine how four mediating variables serve to influence a range of important outcome variables. Notably, in the model, the potential benefits of music are separated into the four categories of psychological responses, psychophysical responses, physiological responses, and improved performance. These categories provide a scaffold for the present meta-analysis and subsequent field experiments.

It is apparent that the specific effects of music in sport and exercise contexts are dependent upon a wide range of personal and situational variables. Such variables include but are not limited to, age and gender (Priest, Karageorghis, &

Sharp, 2004), musical idiom (Gfeller, 1988; Priest et al., 2004), music familiarity and preference (Crust, 2004b; Dyrlund & Wininger, 2008), music tempo (Elliott, 2007; Karageorghis & Terry, 2008; Szabo, Small, & Leigh, 1999), exercise intensity (Dyrlund & Wininger, 2008; Tenebaum et al., 2004) and, in particular, the nature of the physical activity (Karageorghis et al., 2009; Matesic & Comartie, 2002; Simpson & Karageorghis, 2006).

2.1 Definitions

For the purposes of the meta-analysis, it was necessary to distinguish between various categories of physical activity, including sport, exercise and motor tasks. Hence, these are defined for the reader below.

2.1.1 Sport. SportAccord Council (2012)—International Sports Federations—provided a definition based on a pragmatic description of physical activities considered as sport. "It is determined that sport should:

- have an element of competition.
- not be harmful to any living creatures.
- not rely on equipment that is provided by a single supplier.
- not rely on any "luck" element specifically designed into the sport".

Categories of sport include physical sports (e.g., rugby, athletics, hockey, skiing); mind sports (e.g., chess); motorised sports (e.g., Formula 1, motorcycling, powerboating); co-ordination sports (e.g., billard sports, aikido, karate); and animal supported sports (e.g., equestrian sport, sports fishing).

2.1.2 Exercise. Exercise in the context of the current research can be defined as any activity involving the human body that assists in the maintenance of physical fitness, to improve general health and wellbeing (Biddle & Mutrie, 2008). Exercise can be grouped into three main types: flexibility (e.g., stretching), aerobic exercises (e.g., cycling, swimming, walking, rowing, running, hiking), and anaerobic exercises (e.g., weight training, eccentric training or sprinting; Biddle & Mutrie, 2008). Research in a particular sport domain can be categorised as being exercise, rather than sport, if an individual's engagement is more recreational in nature (i.e., health and wellbeing attainment) as opposed to being related to the attainment of a competitive outcome (e.g., a cycling time trial [sport]; cycle ergometry [exercise]).

2.1.3 Motor task. A motor task is achieved through the combination of cognitive and physical processes to complete a desired task (Stallings, 1973). Once a particular skill level is achieved, the individual is able to execute the task in a more efficient manner, thereby resulting in its consistent completion. A choice reaction time task (e.g., Bishop et al., 2009), ball bouncing (e.g., Karper, 1979), and grip strength (e.g., Karageorghis et al., 1996; Razon, Basevitch, Land, Thompson, & Tenenbaum, 2009) are examples of motor tasks rather than sports or exercise *per se*. However, each of these skills also exist in various sport and exercise activities (e.g., choice reactions in team sports, ball bouncing in basketball, grip strength in weightlifting), and may be associated with performance benefits.

2.2 Theoretical Issues

Measurement of the effects of music in sport and exercise has been underpinned by a number of conceptual frameworks. Initially, researchers focused on the "action properties" that have the potential for "the listener to feel sedated or elated, happy or sad" (Terry & Karageorghis, 2011, p. 362). Terry and Karageorghis (2011) outlined the key limitations of previous research to be: "failure to consider the socio-cultural background of participants; low quality music selection procedures; inconsistency in music exposure and details of role in an experimental task; lack of reporting of music intensity and volume, and non-standardisation across music conditions; inaccurate interpretation and reporting of music terminology by sports researchers; and the inappropriate use of performance measures" (p. 16). Zhu (2012) highlighted similar issues across the field of sport psychology, identifying measurement training and interdisciplinary research as two of the areas in need of improvement.

Karageorghis and Terry's (1997) initial literature review outlined the need for the music selection process to take into account "the participants' age profile, musical preferences, and socio-cultural background, paving the way for a more definitive focus augmenting existing methodological and theoretical developments, particularly related to the selection of music" (see Terry & Karageorghis, 2011, p. 362).

2.2.1 Conceptual models. Several conceptual frameworks have been developed to address the above limitations. The literature to date has highlighted the need to select music in accordance with specific criteria to ensure the motivational effect on exercise (Karageorghis et al., 1999). An interaction between music variables (e.g., tempo, lyrics, melody, and harmony) and personal variables (e.g., socio-cultural background, associations, and preferences) occurs to determine the motivational qualities of music for the individual (Karageorghis et al., 1999; see Figure 2.1).

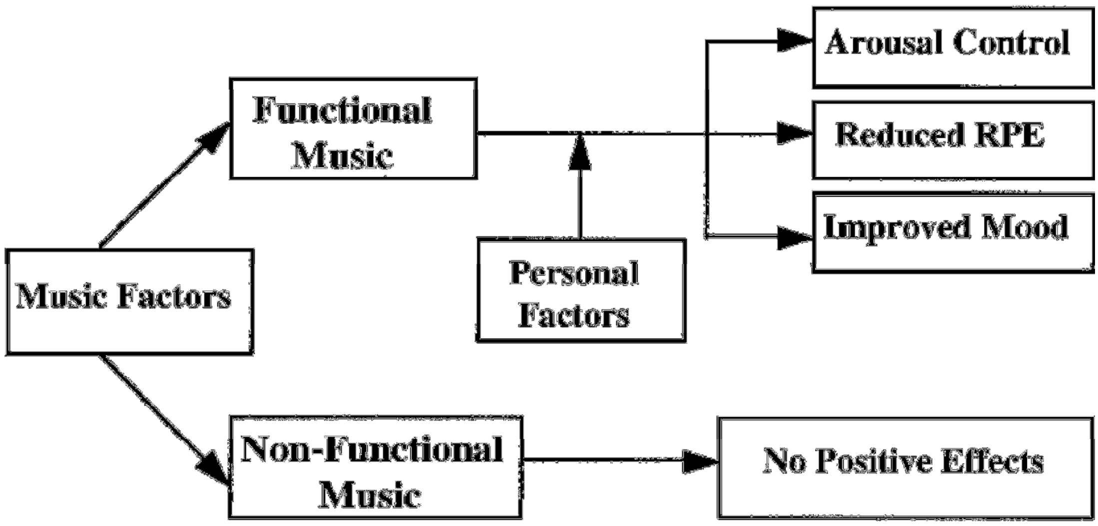

Figure 2.1. A conceptual framework for the prediction of psychophysical responses to music during submaximal exercise. (Adapted with permission from Taylor and Francis; *Journal of Sports Sciences, 17,* 713-724.)

The original conceptual framework developed by Karageorghis et al. (1999) was designed to predict the psychophysical effects of asynchronous music in sport and exercise. Potential benefits of music were also identified in the model to be the reliable influence of music on arousal or activation levels and the capacity to lower perceived exertion. Appropriately selected music has been shown to enhance the positive aspects of mood (e.g., vigour, excitement, happiness), whilst reducing the negative aspects of boredom, tension, and depression. Karageorghis et al. (1999) highlighted the role of music use in exercise adherence and pre-event routine as positioning the athlete or exerciser with the optimal mindset (see Figure 2.2).

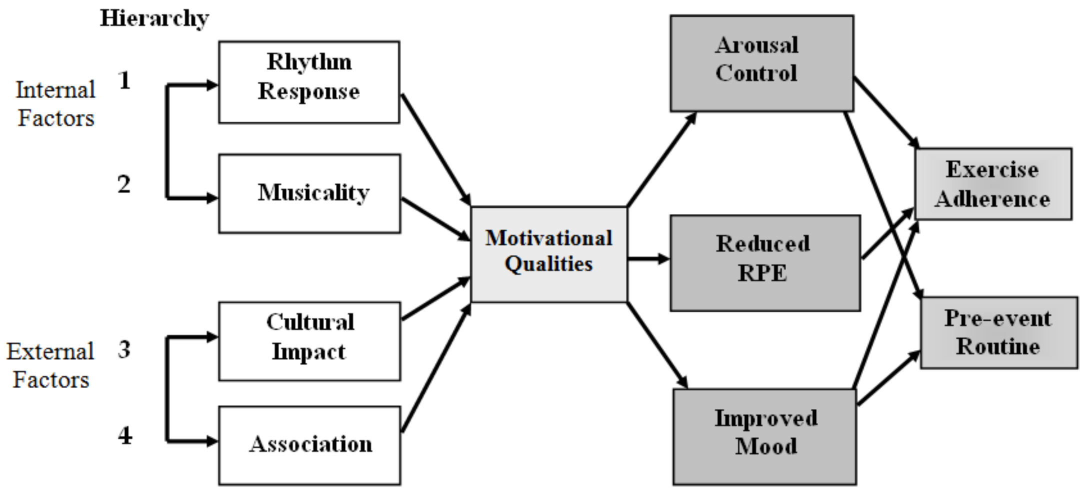

Figure 2.2. Conceptual framework for the prediction of responses to motivational asynchronous music in exercise and sport. (Adapted with permission from Taylor and Francis; *Journal of Sports Sciences, 17,* 713-724.)

The more simplified 2006 conceptual framework (see Figure 2.3), was designed primarily for use in the sport context. Terry and Karageorghis (2006) highlighted the expanding list of potential benefits of music shown in the research base. Karageorghis et al. (1999) had previously proposed that personal and situational variables interact to influence the effects of music via four mediating variables – rhythm response, musicality, cultural impact, associations. Rhythm response relates to natural responses to musical rhythm, especially tempo (i.e., speed of music as measured in beats per minute). Musicality refers to pitch-related elements such as harmony (i.e., how the notes are combined) and melody (i.e., the tune). Cultural impact is the pervasiveness of the music within society or a sub-cultural group. Association pertains to the extra-musical associations that music may evoke, such as the composition *Chariots of Fire* by Vangelis, with Olympic glory (Karageorghis et al., 1999). Bishop and colleagues (2009) evaluated the impact of both intrinsic (e.g., acoustic properties) and extrinsic (e.g., classically conditioned associations) sources that influence emotional responses to music (p. 61). It was found that the manipulation of intrinsic sources (e.g., faster tempi) was not as influential as the emotional induction power of a "tried and true favourite" (e.g., The Proclaimers' song *I Would Walk 500 Miles* in the ultra-athletes' playlist), which resulted in more positive valence. In turn, the effects of these four variables combine to promote one or more of the potential benefits of music for the listener. Such benefits include improved mood, arousal control, dissociation, reduced perceptions of exertion, greater work output, improved skill acquisition, flow states, and ultimately improved performance.

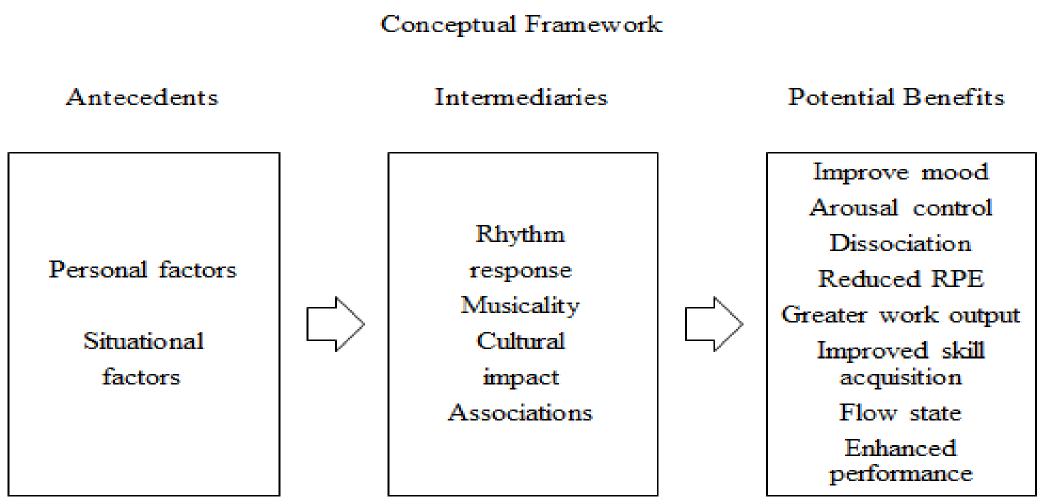

Figure 2.3. Conceptual framework for benefits of music in sport and exercise contexts. (Terry & Karageorghis, 2006, Proceedings of the Joint Conference of the Australian Psychological Society and the New Zealand Psychological Society, 415-419).

2.3 Advances in Music Research

The use of music in sport and exercise has progressed in recent decades partly as a result of the portability of listening devices. Research into the effects of music in the sport and exercise domain up until the end of the 1980s accounted for only 4% of the research available to date. Empirical research was found to increase in the next decade to 30%, with the new millennium already yielding 65% of the available research.

Terry and Karageorghis (2011) reported the development of music applications in the 1970s and 1980s to most commonly be used in exercise-to-music classes. In this era the individual exerciser either listened to group music or was saddled with a bum bag to hold their radio/cassette player. The Sony Walkman was developed first in 1978 to allow the Sony co-chairman to listen to operas whilst on overseas trips (Hornby, 2006). The Walkman was designed as a tool that allowed individuals to take their music with them whilst listening through headphones. In the same era, pre-game theme music typically played before North American ice hockey games was depicted in movies as synonymous with crowds reaching levels of elation and the athletes coming out *charged* onto the ice.

Today, researchers and business enterprises devote much time and money to the development of new devices to allow both the novice exerciser and elite athlete to use wearable solutions for the delivery of music whilst gaining the benefits of open-air environments (Buttussi & Chittaro, 2008; Oliver & Flores-Mangas, 2006). The advent of MP3 players such as the iPod™ has provided the athlete with the ability to not only lose themselves in their music but also to develop individually-designed playlists. Oliver and Flores-Mangas (2006) highlighted the pervasive nature of MP3 players and HR monitors, including the increased popularity of running playlists to assist runners with their training. In addition to the availability and lightweight nature of modern technology for the delivery of music, we have recently seen the advent of web-assisted playlist developers, allowing athletes to fine tune their work out according to the characteristics of the music (e.g., JogTunes: Music at your speed; Interval running iTunes™ playlist).

2.4 Music Elements

A number of different elements of music combine to provide the listener with an aesthetic experience. Terry and Karageorghis (2011) identified the five elements of music to be *melody*, *harmony*, *rhythm*, *tempo* and *dynamics.* The melody of music is the succession of notes or a line of tones using steps, skips and repeated tones—the part that you might sing along with (Owen, 2000; Terry & Karageorghis, 2011). Harmony in music refers to the relationship between two or more simultaneous pitches (Owen, 2000). Terry and Karageorghis noted that it is this combination of notes that can evoke changes in the listener's mood, making them feel happy, sad, relaxed or energised. Owen highlighted a composer's use of harmony and tonal ambiguity to evoke mood or impression. The composer of a musical score for a film creates music to elicit emotions in the audience that are synonymous with the theme of the scene. Music has been found to be just as integral to a movie as the dialogue.

The rhythm of music is the variation in the accentuation of sounds over time (Owen, 2000). Owen highlighted that the mood of music is drawn from either a stable or unstable harmonic rhythm. Musical styles impact on the listener's movement—as in dance—from the slow and jolting movements found in reggae, to the fast and pulsating ones seen in salsa. Tempo is the speed of a particular piece of music (i.e., how fast or slow it is played) and is usually measured in beats per minute (bpm; Owen, 2000). The character of a musical piece can be compromised when its tempo is changed outside of a certain bandwidth (Terry & Karageorghis, 2011). Edworthy and Waring (2006) measured the effect of changing music tempo and loudness, finding an increase in performance with loud fast music but not with loud slow music. The dynamics of music emanate from the complexity of sound achieved through the individual input of the musician. It is their touch (gentle versus forceful) that sets the stage for the structure of the musical composition (Terry & Karageorghis, 2011).

2.5 Effects of Music

Research into the effects of music in sport and exercise psychology has historically investigated its psychological, psychophysical, psychophysiological, and ergogenic effects (Terry & Karageorghis, 2011). The ergogenic effect exerted by music is found when there is an improvement in physical performance through either a delay in fatigue or increased work capacity. “Psychological effects refer to the influence that music has on mood, emotion, affect, cognition and behaviour” (Terry & Karageorghis, 2011, p. 360). Psychophysical effects in music-related research are typically assessed using RPE to measure physical effort. “The influence that music has on physiological parameters (e.g., blood lactate, HR, respiration rate) is related to the psychophysiological effects of music on the athlete” (Terry & Karageorghis, 2011, p. 361). Karageorghis et al. (1999) found rhythm and tempo to generally be the elements of music that prompt a physical reaction in the athlete.

2.5.1 Models of music used in sport and exercise. In the context of using music as an intervention in sport and exercise there are four predominant methods. However, only three will be examined as relevant to the current research. These methods are synchronous, asynchronous and pre-task. Firstly, synchronous music is the use of the rhythmic and temporal aspects of music to regulate movements (Hayakawa et al., 2000; Kiel et al., 2008; Karageorghis & Jones, 2000; Karageorghis et al., 2009; Mikol & Denny, 1955; Simpson & Karageorghis, 2006). Terry and Karageorghis (2011) noted the synchronisation of the athlete’s cadence with synchronous music as contingent upon the rhythmic proficiency of the individual athlete, and their ability to align stride rate to the tempo of the music. The ability to strictly standardise experimental tasks was found by Terry and Karageorghis to be the predominant limitation of previous research using synchronous music. The level of standardisation required to ensure internal validity not only requires the conscious process of stride-rate alignment outlined above but also measurement of the accuracy of this alignment by the researcher.

Use of a constant stride rate to optimise performance may potentially have detrimental effects. Firstly, the synchronous application of music to sport and exercise may lead to entrainment that is either faster or slower than the athlete's preferred or desired work rate. Secondly, the rhythmical qualities of music (e.g., syncopation) can make the process of synchronisation difficult to achieve for the athlete, leading to performance detriments and a more negative psychological state.

Jantzen, Oullier, and Scott Kelso (2008) differentiated between the concepts of synchronisation and syncopation in sport and exercise domains. Synchronisation, as described earlier, is the temporal coincidence between the motor movement and auditory signal. In syncopation, the action/motor movement is required to occur between consecutive beats. Jantzen and colleagues identified, using metronome and finger flexion/extension, that at low tempi synchronisation and syncopation produced a consistent bistable regime. When the tempo was increased, the regime shifted to that of a monostable one where synchronisation predominated.

It was also found that further increases resulted in a loss of synchronisation between the finger and the metronome (Jantzen et al., 2008). Recent research involving the use of synchronous music has shown greater benefits than previously found, in the areas of performance, psychological responses, and physiological functioning (Bacon et al., 2012; Karageorghis et al., 2009; Karageorghis et al., 2010). Consistent with Jantzen and colleagues, researchers using music in sport and exercise have evaluated effects of slow compared to fast music, though this research has typically used asynchronous music (Bacon & Hookway, 2003; Becker et al., 1994, 1995; Bishop et al., 2009; Boutcher & Trensche, 1990; Brownley et al., 1995; Copeland & Franks, 1991; Edworthy & Waring, 2006; Elliot, 2007; Gallagher, 1996; Hayakawa et al., 2000; Karageorghis et al., 2007; McMordie, 2009; Potteiger et al., 2000; Szabo & Hoban, 2004; Szabo et al., 1999).

Secondly, asynchronous music is often described as background music that improves the overall experience of exercising. The majority of research into music effects (the current meta-analysis showed 85%) has used asynchronous music. Additionally, as this type of music requires no synchronisation between the athlete's movement and tempo, it is often used as a planned distraction (Terry & Karageorghis, 2011).

The application of music pre-task accounts for less than 10% of studies in sport and exercise (Becker et al., 1994; Becker et al., 1995; Dorney, Goh, & Lee, 1992; Eliakim et al., 2007; Jansen van Rensburg, Kroff, & Terblanche, 2004; Karageorghis et al., 1996; Urakawa & Yokoyama, 2005; Yamashita Iwai, Akimoto, Sugawara, & Kono, 2006). Terry and Karageorghis (2011) outlined the use of music in pre-competition routines. One only has to sit in the stands at an Olympic opening ceremony or to simply watch the television broadcast to feel the elevation of mood in the arena and self to comprehend the effect of music. Michael Phelps, the greatest Olympian of all time, uses music as a standard part of his pre-race routine. Terry and Karageorghis reiterated the potency of music on human emotions but warned to be mindful that personal preferences should be met and to have an awareness of the emotions elicited by pieces of music and their converse effects dependent on the intermediaries outlined in Figure 2.3. The successful connection with music when engaging in sport and exercise and its role in improving the enjoyment, adherence, and efficiency for the individual has been extended to public health settings (Karageorghis, Priest, Terry, Chatzisarantis, & Lane, 2006).

2.5.2 Music selection. Karageorghis and Terry (1997) outlined the typically haphazard nature of music selection in sport and exercise research as an important limitation. The previously random selection of music has been replaced by a methodical process. The Brunel Music Rating Inventory (BMRI) was developed by a panel of experts in music selection rather than by exercise participants. Karageorghis et al. (2006) highlighted the importance of the interpretation of music specific to the individual rather than the perceived choice of music by researchers in determining psychophysical responses.

2.5.2.1 Brunel music rating inventory (BMRI-2). Karageorghis and colleagues (2006) developed a revised instrument to rate the motivational qualities of music selections in exercise settings, resulting in the BMRI-2. The revised process requires the athlete to rate if the style of music would motivate them during exercise in relation to rhythm, style, melody (tune), tempo (speed), sound of the instruments, and beat of the music (see Appendix F). The BMRI-2 is a single-factor, six-item instrument and is considered to have psychometric properties superior to its predecessor, the original BMRI, with a mean Cronbach alpha coefficient of .89 (Karageorghis et al., 2009). The scale is scored by participants on a 7-point Likert scale from 1 (*strongly disagree*) to 7 (*strongly agree*).

2.5.3 Limitations of music use. "Use of music during skill acquisition can be detrimental, as in the initial stages of skill learning a higher level of information processing is required to maintain accuracy in movements" (Terry & Karageorghis, 2011, p. 375). The distraction effect of music can impede learning.

Additionally, governing bodies (i.e., The International Amateur Athletics Federation) have banned the use of music in competition (Terry & Karageorghis, 2011). The expected rationale for this decision would lie in the prevention of communication with coaches during races. However, the intoxicating nature of music has been named by insurance underwriters as too great a risk in mass-participation events. Though the New York Marathon has subsequently banned the use of personal music players since 2007, this act has only stimulated the debate as to the strength of the effects of music in sport (Terry & Karageorghis, 2011).

2.6 Demonstrated Benefits of Music

The ergogenic effects of music can be seen via higher work outputs, increased endurance, power efficiency or strength. Terry and Karageorghis (2006) "identified repetitive and laborious activities as lending themselves especially well to musical accompaniment" (p. 4). Atkinson et al. (2004) found that subjects were more motivated by the tempo and rhythm of music than the harmony and melody.

The assessment of outcome variables independent of each other often clouds the full picture of the benefits of music in sport and exercise. An athlete who works to exhaustion traversing longer distances, increasing their HR, with higher RPE, and positive measures of affect, provides a picture of positive performance gains, negative physiological response, negative RPE, and positive affect. Such a picture warrants further analysis. The effects in the preceding example are actually superior to an athlete working at a sub-maximal level with reduced time taken (positive effect), lowered HR (positive effect), lowered RPE (positive effect), and positive measure of affect (positive effect), although at first glance may not appear to be so.

Edworthy and Waring (2006) attributed an increase in HRs to the greater treadmill speeds achieved with faster tempo music. Higher RPE were found in the fast loud music condition, which was found to be consistent with the participant's greater work output, compared to the higher perception of exertion experienced by those in the no music condition who were not actually working harder (Edworthy & Waring, 2006). Additionally, Crust and Clough (2006) marked the characteristics of music (i.e., rhythm and musicality) and the rationale for the use of music as an intervention (i.e., increase arousal, dissociation, or synchronisation of music) as important considerations when reviewing the ergogenic potential of music in sport and exercise.

It has been proposed that the use of music as a distractor, or external source of information, impacts on the internal processing of information such that it has an influence on performance and perceived exertion (Boutcher & Trenske, 1990; Copeland & Franks, 1991; P. Nakamura, Pereira, Papini, & F. Nakamura, 2010; Pennedbaker & Lightner, 1980; Potteiger et al., 2000). Gfeller (1988) found that listening to preferred music assisted with attentional focus being directed towards external sources rather than on the discomfort and fatigue being experienced. The use of non-preferred music has been found to have the inverse effect, thus shifting focus to internal sources increasing RPE (Tenenbaum et al., 2004).

2.6.1 Mechanisms by which benefits of music accrue. In theorising about the mechanisms that underpin emotional responses to music, Juslin and Västfjäll (2008) postulated six psychological mechanisms by which emotional responses are generated. First, the *brain stem reflex* is a mechanism whereby fundamental acoustic properties of music stimulate the listener by activating the central nervous system regardless of appraisal. Second, the pairing of a particular piece of music with other positively or negatively valenced stimuli, where the listener inextricably links a specific song with a particularly pleasurable exercise or sporting experience, is termed *evaluative conditioning*. The third mechanism is referred to as *emotional contagion*, whereby the listener "catches" the inherent emotion in the music inducing the same emotion in them (Gabrielsson & Juslin, 2003). Fourth, the stimulatory effect of *visual imagery* is known to be an effective emotion regulation strategy (Plutchik, 1984; Terry et al., 2006) and a large proportion of athletes engage in the use of imagery to induce relaxation or generate aggression prior to competition.

Fifth, use of music to ignite *episodic memory* of previous personal experiences can stimulate memories, for example, of first love. Using the same mechanism the athlete can develop memories of a particular performance via a specific piece of music. Both episodic memory and evaluative conditioning are associative mechanisms, very similar in nature to the mediating variable referred to as *associations* in the Terry and Karageorghis (2006) model. The final mechanism hypothesised by Juslin and Västfjäll (2008) to link music and emotions is known as *musical expectancy.* An athlete can use a simple beat from a favourite musical genre to feel happier than listening to unfamiliar music.

2.6.2 Performance benefits. Anshel and Marisi (1978) found enhancement in physical endurance when movement was coordinated with the musical stimulus. However, it was found that when music synchronisation was not combined with pedalling speed the same endurance outcomes were not achieved when compared to the no music condition. Researchers have also found that music conditions result in an increase in self-selected intensity (Abraham & Thomas, 1999; Bacon & Hookway, 2003). Annesi (2001) found no changes in length of exercise session with music, whereas other researchers have found participants to have a longer period of exercise before exhaustion when listening to music (Bharani et al., 2004; Karageorghis and Jones, 2000).

Atkinson, Wilson, and Eubank (2001) found a 2% increase in cycling time with fast tempo music, with an increase in cycling speed mostly achieved in the first few minutes of a 10 km trial. Participants were found to walk further when using music (Becker et al., 1995, Beckett, 1990). Music played at fast tempo and higher intensity resulted in shorter reaction times than moderate intensity music, with no difference found when compared to no music or white noise conditions (Bishop et al., 2009). Brohmer and Becker (2006) found an increase in peak power achieved during music tests when compared to no music tests. Performance gains were also achieved in both an increase in cycling rate and time with music (Cohen, Paradis, & LeMura, 2007). Crust (2004a) found the removal of music to significantly decrease the performance benefits of music, while Crust (2004b) found music to produce significantly longer treadmill performance. Swimming form and speed were found to increase in swimmers taught with music (Dillon, 1952). Edworthy and Waring (2006) found a positive relationship between the speed of the music and the running speed of the athlete. An increase in anaerobic power was also found in volleyball players with the use of pre-task music (Eliakim et al., 2007).

2.6.3 Psychological benefits. "The psychological effects of music relate to the influence of music on affect (feelings of pleasure or displeasure), mood, emotion, cognition and behaviour" (Karageorghis & Terry, 2008, p. 15).

2.6.3.1 Affect. The changing behavioural responses to environmental stressors are at the core of emotional regulation (Beedie, Terry, & Lane, 2005). Bishop and Karageorghis (2009) discussed the effect of music on emotions and the diversity and intensity often eliciting utilitarian emotions—with Scherer and Zenter

(2001) reporting changes in motivational direction, proprioceptive feedback and physiological reactions. "Music played loudly resulted in higher arousal with results revealing descriptors such as: astonished, delighted, excited, glad, and satisfied" (Bishop & Karageorghis, 2009, p. 72). Synchronous and asynchronous music were shown to improve how one feels in high intensity exercise (e.g., Boutcher & Trenske, 1990; Edworthy & Waring, 2006; Karageorghis et al., 2009) whereas Rejeski (1985) posited that music would not achieve the same benefits at higher exercise intensities.

2.6.3.2 Mood. Dissociative techniques used by athletes can promote a positive mood state—heightened vigour and happiness—while the negative aspects of mood (e.g., tension, depression, and anger) are allayed (Bishop et al., 2007). Mood can be found to change cognitions and the focus of mood-regulation strategies may centre on encouraging positive rather than negative self-talk (Beedie et al., 2005). Hayakawa et al. (2000) examined the effects of synchronous and asynchronous music in a step-aerobics class and found that participants reported more positive moods with music. In Hewston, Lane, Karageorghis, and Nevill's (2005) investigation of the use of music in pre-competition format it was found that music enhanced mood, providing evidence that the use of pre-competition music may increase calmness, happiness, and vigour combined with a reduction in tension and depression; a pattern consistent with performance optimisation previously identified by Totterdell and Leach (2001).

2.6.4 Psychophysical benefits. Karageorghis and Priest (2012a) described the psychophysical benefits of music to be an ascertainment of the "subjective perceptions of physical effort and fatigue" by an athlete or exerciser (p. 47).

2.6.4.1 Perceived exertion benefits. A fairly consistent theme related to RPE is that music has shown benefits during exercise (Nethery, 2002; Potteiger et al., 2000; Szmedra & Bacharach, 1998) and consistent with findings in Karageorghis et al. (2009), a steady decline in benefit is found when athletes near maximal intensities (Boutcher & Trenske, 1990; Schwartz et al., 1990; Tenenbaum et al., 2004; Tenenbaum, Eklund, & Kamata, 2012). Atkinson et al. (2001) found lowered RPE with fast tempo music and increased work rate, which was in direct contrast to their 2004 study that found an increase in RPE at higher work rates with music. Bharani et al. (2004) and Fatouros et al. (2005) found participants reported lower RPE at a sub-maximal level of exercise with music; conversely Brownley et al. (1995) did not find support for a difference in RPE with music. Boutcher and Trenske (1990) found outcomes in perceived exertion react according to workload, with reduced RPE reported in lighter workloads and higher RPE reported in the no music condition when the workload was increased.

2.6.5 Psychophysiological benefits. The psychophysiological benefits of music are reflected in the physiological connection of the psychological effects of music (Karageorghis & Priest, 2012). Fatouros et al. (2005) found music to be beneficial when exercising by suppressing cardiovascular and metabolic responses (i.e., HR, systolic pressure, rate pressure product, VO_2, norepinephrine, and lactate). Conversely, Gallagher (1996) did not find physiological gains with the use of music in exercise. Annesi (2001) found no changes in VO_2 max with the use of music; whereas Beckett (1990) found greater recovery HRs with music when compared to no music. Bharani et al. (2004) found higher peak HRs were achieved with music when exercising to exhaustion. Birnbaum, Boone, and Huschle (2009) measured cardiovascular responses to music tempo during steady-state exercise including measures of oxygen consumption, cardiac output, stroke volume, minute ventilation, and frequency of breaths; with an overall decrease in cardiovascular efficiency. The unchanged HR found in Birnbaum et al. is consistent with results found in Brownley et al. (1995) and Bishop et al. (2009); but inconsistent with the positive HR outcomes achieved by Edworthy and Waring (2006).

Physiological responses in the form of respiratory frequency and cortisol responses were found to have mixed outcomes in music conditions (Brownley et al., 1995). Dorney et al. (1992) found that listening to music whilst engaged in physical performance resulted in both positive and negative changes in HR. Yamamoto et al. (2003) found listening to fast music increased plasma epinephrine prior to exercise. Relaxational music used during exercise was found to reduce physiological effects after exercise (e.g., decreased cortisol concentrations; Ghaderi, Rahimi, & Azarbayjani, 2009; HRs and urinary protein; Jing & Xudong, 2008).

2.6.6 Neural mediators. Over the previous decade, the neural basis of music effects has been studied extensively (see, for example, Menon & Levitin, 2005). This is an important area to consider within the current research framework, to examine the possible neural mediators of music effects on behaviour, particularly performance outcomes.

Menon and Levitin (2005) summarise their findings across three areas of interest. Firstly, in terms of functional neuro-anatomy, listening to music was found to be associated with pleasurable responses to music, as indicated by activity in the nucleus accumbens (NAc), ventral striatum, ventral tegmental system (VTA) and hypothalamus. Use of functional magnetic resonance imaging (fMRI) technology over positron emission tomography (PET) enabled Menon and Levitin to more clearly view activation in the NAc when listening to music. Additional activation was also shown in the hypothalamus, which is responsible for modulating autonomic responses including heart rate and respiration.

Secondly, Menon and Levitin (2005) extended examination of music listening effects by exploring connections *between* neural regions. The role of major dopaminergic pathways was examined, including the mesolimbic pathway that transmits dopamine (responsible for reward-driven learning) from the VTA to the NAc and the limbic system that supports functions such as emotion, behaviour and motivation. A key finding was evidence of the interaction between the reward and affective systems and the autonomic systems, when listening to music.

Finally, Menon and Levitin (2005) speculated about possible neurochemical markers that arise as a result of listening to music, which are mediated by increased dopamine levels in the NAc and VTA. Interactions between NAc and VTA and the frontal regions of the orbitofrontal cortex (OFC; the region responsible for cognitive processing and decision making) and the inferior frontal cortex (IFC; inhibitory control), suggested a close link between affective and cognitive processing of music.

Overall, Menon and Levitin (2005) have provided a plausible explanation of the neural mediators that underlie music-induced emotional responses, which goes some way to explaining how music affects physiological performance.

2.7 Measurement Issues

Zhu (2012) reported on an in-depth examination of the measurement processes and tools in sport psychology. It was concluded that little headway has been made since Tenenbaum and Bar-Eli (1995) highlighted that sport psychology was behind in the use of new measurement methodology when compared to other fields of psychology. The advent of new statistical validation methods is granted, but this still leaves the field of sport psychology behind. Subsequent to the lack of advances in measurement methodology, a number of within-measurement issues exist and are outlined below.

2.7.1 Measurement of performance benefits. The measurement of performance is ultimately measured by how far you run, how long you last or what speed you achieved, although it can be extended to include, for instance, improvement in form. The accuracy of the measurement device plays a key role in the discernment of the performance benefits of music. Additionally, the training and role of the user in using measurement equipment opens the results to possible bias. Guidelines are cemented in sporting domains requiring certification of tracks, pools, and downward slopes, for example. Specific user instructions accompany measurement items from stop watches to measuring wheels but the precision of measurement is directly aligned to the accurate use of equipment and recording of data, whether this be computerised or manually scored. Lap time was chosen as the measure of performance in the current research, with all data provided by race officials. All events were required to meet IAAF standards in relation to track measurement and record keeping.

2.7.2 Measurement of psychological benefits. Ekkekakis (2012) identified three steps for choosing a psychological measure. Initially, the outcome construct being measured needs to be actively defined to inform the next step of choosing a theoretical model in which to conceptualise the outcome construct. Lastly, the assessment of the validity and reliability of the measure needs to be assessed to ensure it meets or surpasses acceptable Cronbach alpha levels. Ekkekakis (2012) highlighted that in the early 1990s little attempt was made to differentiate between affect, mood, and emotion (see Batson, Shaw, & Oleson, 1992) but more recently, Beedie et al. (2005) have produced a demarcation and a workable system has started to emerge.

2.7.2.1 Affect. Ekkekakis (2012) cited Russell and Barrett (2009) in defining core affect as a "neurophysiological state consciously accessible as a simple primitive non-reflective feeling most evident in mood and emotion but always available to consciousness" (p. 104). An individual constantly experiences core affect but the type and intensity can vary, occurring independently or as a component of emotions and mood (Ekkekais, 2012). Hardy and Rejeski's (1989) bipolar FS (see Appendix I) has been chosen for use in the current studies as a measure of in-task affect for its ease of use and the close alignment of its proposed outcomes with the desired measurement of affect. The FS is an 11-point, single-item scale ranging from +5 (*very good*) to -5 (*very bad*) with a mid-point of 0 (*neutral*).

2.7.2.2 Emotion. Emotion occurs where there is a complicated set of connected events that interact with a person, event, or thing. The event does not need to be in the present; past, future, real or imagined to still have the ability to elicit emotions, with the defining element being the cognitive appraisal of the interaction between person and object (Ekkekakis, 2012). Emotion is normally elicited as an emotional episode that is generally a reaction to something, about something, and elicited by something including—anger, fear, jealousy, pride, and love (Ekkekakis, 2012).

2.7.2.3 Mood. A mood is often typified for its duration when compared to affect and emotion (Ekkekakis, 2012). Frijda (2009) defines mood to be "the appropriate designation for affective states that are about nothing specific or about everything—about the world in general" (p. 258). Morris (1992) marks the defining difference between mood and emotions as the common absence of eliciting stimuli and the lack of identifiable causation. The accurate choice of the appropriate measure of mood is outlined by Ekkekakis (2012) as fundamental to the measurement of derived benefits, however the process is lacking in most published reports. Ekkekakis outlined that in the act of choosing the appropriate measure the researcher should ascertain whether the goal is to assess a specific, narrowly defined state (or set of distinct states) or broad dimensions that are theorised to underlie a global domain of content (such as mood or core affect).

The Brunel Mood Scale (BRUMS; Terry, A. Lane, H. Lane, Keohane, 1999; Terry, A. M. Lane, & Fogarty, 2003) was chosen for use in the current research. This 24-item measure is less convenient then a single-item measure and somewhat more susceptible to an increase in respondent fatigue and reactivity. However, the reduction in random measurement error outweighed the preceding issues (Ekkekakis, 2012). Ekkekakis (2012) outlined the use of these measures as more common when there are longer periods between testing, as can be seen in the current research. The BRUMS was used to ascertain distinct mood states rather than to gain a global measure of mood and consists of six subscales (anger, confusion, depression, tension and vigour). The BRUMS (see Appendix H) takes 1-2 minutes to complete and uses a 5-point response scale (0 = *not at all*, 1 = *a little*, 2 = *moderately*, 3 = *quite a bit*, 4 = *extremely*). The standard timeframe used when responding is "*How you feel right now*" (Terry, A. Lane, H. Lane, et al., 1999; Terry, A. M. Lane, et al., 2003).

2.7.3 Measurement of psychophysical benefits. Nigg, Jordan, and Atkins (2012) outlined psychophysical benefits as measures requiring the participants to engage cognitive or perceptual processing to produce the data. More specifically, they are the sensory responses of the participant to physiological processes experienced when listening to music. Borg's RPE scale was found by Karageorghis and Priest (2012a) to be the sole measure in the music and exercise literature of psychological assessment by the athlete/exerciser of the physiological process.

2.7.3.1 Measurement of perceived exertion benefits. The RPE scale (Borg, 1998) is a measure used to quantify the individual's subjective perception of their exertion levels between 0 (*rest*) and 10 (*maximum effort*). Additional tools for measuring RPE include (CR10 scale, Borg, 1982; and the CR100 scale, Borg, 1998, as cited in Tenenbaum et al., 2012). The measurement of perceived effort is seen by some as inherently flawed (see Tenenbaum et al., 2012), resulting from the assumption that an individual is able to accurately articulate their perceptions. An additional issue in the measurement of exertion is the particularly challenging prospect of recording the information, particularly in a field setting. Further issues arise from the risk of the participant providing a socially desirable rather than accurate response.

Tests of reliability and validity reveal that both Borg's 15 point RPE scale and CR10 scale are reliable measures of perceived exertion with rest-retest reliability coefficients ranging from .71 to .91 (Noble & Robertson, 1996). Borg's (1982) CR10 scale has been chosen for use in the current studies to measure the athlete's RPE for its ease of use, superior psychometric properties, and to allow easy comparison to other research in the use of music in sport and exercise. The Borg CR10 (1982) is a general intensity category scale with ratio properties from 0 (*nothing at all*) to 10 (*extremely strong*).

2.7.4 Measurement of psychophysiological benefits. The influence of music on physiological functioning (e.g., blood lactate, HR, oxygen uptake) is commonly termed psychophysiological effects, referring to those that are psychologically mediated (e.g., emotional, motivational; Terry & Karageorghis, 2011).

2.7.4.1 Heart Rate. HR has typically been monitored in athletes to gain maximum efficiency from their training and in a race setting as a means of measuring objective rather than perceived exertion levels. The HR can be seen to increase as a direct result of work output levels. A depth of research has identified key limitations in the use of HR monitors: temperature differences (Stannard & Thompson, 1998); the influence of caffeine (Flinn, Gregory, McNaugton, Tristam, & Davies, 1990); sympathetic neural stimulus (Urakawa & Yokoyama, 2005; Yamashita et al., 2006); and hormonal changes in female athletes (Fox, 1984). Additional to these findings, O'Toole, Douglas, and Hiller (1998) highlighted issues in variability that prevents accurate use in guiding training pace in running. O'Toole and colleagues proposed that an athlete should expect their HR to decrease over the course of a long race. The use of HR as a tool in both training and race environments to improve efficiency needs to pay caution to the standard error of measurement of submaximal HR of 1.1-1.4% that was found by Lamberts, Lemmink, Durandt, and Lambert (2004). There is a plethora of research pertaining to the benefits of lowered or increased HR dependent on intended outcomes, though little research has been completed on the measurement tools used in the sport and exercise field.

2.7.4.1.1 Heart Rate monitor. A HR monitor is a portable device that can be used as a means for measuring the estimated energy expenditure of the individual (Montoye, Kemper, Saris, & Washburn, 1996). The device operates whereby when a heartbeat is detected, a radio transmitted signal is sent to the watch. Each device has its own unique coded signal reducing the risk of one athlete's HR being sent to another athlete's device. A less invasive device—with only a watch—is now available; however they require the user to place their fingers on two sensors on the watch for a few seconds. This alternative option required another task for the athlete to complete and given the nature of the current research the chest strap and wrist receiver monitoring device was chosen. Polar HR Monitor, Suunoto Monitor, or the Timex Monitors were used to measure HR.

2.8 Meta-analysis

2.8.1 Overview of meta-analysis. Meta-analysis has come to underpin evidence-based practice, affording the practitioner the ability to access a summation of the pooled evidence related to the effectiveness of interventions (Baker & Jackson, 2008). This trend has extended to psychology and specifically sport psychology with prominent researchers investing in the summation of literature to solidify the base on which future directions of research can form their foundations (Terry, 2011).

A meta-analysis is the method of statistically combining data from multiple individual studies collated for their shared research hypotheses (Glass, 1976). Field (2001) outlined the superior nature of meta-analytic work when compared to discursive reviews that are subject to the flaws of human nature providing biased, selective reviews of literature. A quantifiable overall effect size measurement can be gained, allowing comparison of the findings of disparate studies in one interpretable metric. Further, this grouping of results of individual studies, where each study becomes a data-point, answers a specific research question.

Meta-analysis provides the reader with the answers to three general questions. Firstly, it measures the statistical relationship between two variables, quantifying the effect of X on Y. This measure of central tendency is the summation of this effect in a statistically meaningful manner that allows the significance and strength of the effect to be assessed. Secondly, variability between study outcomes is assessed to ascertain if the significant difference is greater than that expected by chance alone. Karimi and colleagues (2010) "outlined the laborious process involved in any systematic review—meta-analysis—of reading perhaps a thousand abstracts, locating and reading hundreds of full documents, concluding with the collating and summation of findings suitable for researchers and clinicians" (p. 1).

The fundamental objective of the current research was to develop a search strategy that could be replicated by other researchers, in the future, to improve the quality of meta-analytic work and ultimately provide a greater breadth and detail in information for use in practical settings. Quintessential to this process is the methodical nature of meta-analytic work. It is the stringent stepped approach that ensures that the most accurate summation of a research question is presented.

At the outset it is essential that methodology be established and recorded to ensure no step or decision is omitted but additionally to enable meta-analytic work to grow in quality consistent with other methods of research. Finally, where heterogeneity (variability) exists, the moderator variables are assessed to help decipher the true influence of X on Y.

2.8.1.1 Review protocol. The overarching decision making process shown in Figure 2.5 identifies five basic steps to completing a meta-analysis. Defining the hypothesis is fundamental to any research project but forms a crucial step in the meta-analytic process. This well-defined statement identifies the relationship between the variables to be investigated, allowing for the preparation of inclusion and exclusion criteria. Torgerson (2003) highlights the importance of not being biased by prominent articles when developing protocols. The explicit nature of this initial stage of methodology reduces the retrieval of irrelevant papers.

The choice of conceptual framework is crucial to the review process as this focuses the research questions based on the type of intervention, what population characteristics are to be included, and the outcomes being reviewed (Torgerson, 2003). Torgerson stresses the importance of inclusion and exclusion criteria being detailed *a priori* allowing for clear guidelines to be set reducing the risk of a biased inclusion process. The *a priori* decision to include or exclude unpublished studies also assists in the reduction of bias, including the decision related to methodological quality (Field, 2001; Rosenthal & Rubin, 1979; Torgerson, 2003). The provision of all retrieved included studies and excluded studies—with justification—in the review strengthen the quality of the process.

Lipsey and Wilson (2001) identify the coding of data in a systematic review as the most technically demanding aspect. Overall, the coder must firstly consolidate an in-depth understanding of the coding protocol; have the knowledge and skills to facilitate accurate interpretation of a research report; and have an understanding of the current research domain. The following process for the training of coders must ensue to ensure accuracy of results:

- Coding protocol training
- Practice coding – comparison of coding until a high rate of agreement is achieved
- Identification and discussion of difficult decisions related to coding
- Assessing coder reliability
    - consistency of single coder, recoding of studies after a passing of time to ensure no memory exists of original coding

- consistency between coders—draw sample of studies to be coded independently and compared between two coders (Lipsey & Wilson, 2001).

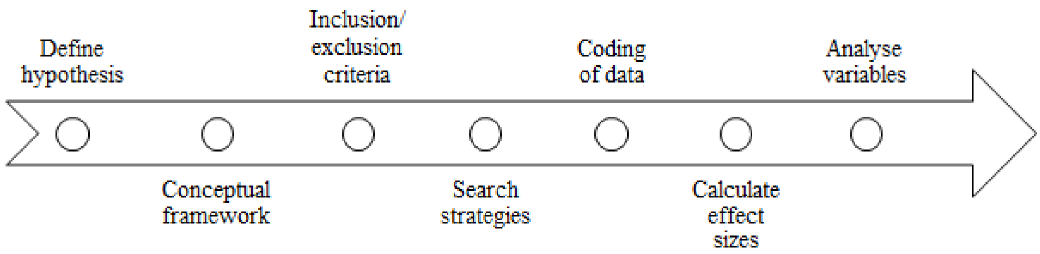

Figure 2.4. Steps to conducting a meta-analysis.

2.8.1.2 Search strategies. Karimi, Pohl, Scholer, Cavedon, and Zobel (2010) identify that the key problem with the search process when completing a systematic review is the failure to identify all relevant articles. This issue is linked to the differing systems of parsing, indexing and searching documents. Karimi and colleagues highlight that even when detailed search strategies have been outlined in the past the ability to replicate these searches is limited partly by spelling errors, missed spelling variants, truncation errors, and operator errors.

The two predominant paradigms for completing searches of literature are the Boolean search and ranked retrieval. Traditional search strategies use the Boolean retrieval system where a query is composed of a string of keywords. The ranking retrieval search engine is now the predominant system used for Web searches. "When drawing collections for review this method uses information such as term frequency in the document, term frequency across the collection, and local density" (Karimi et al., 2010, p. 5). Karimi and colleagues highlight that an important strength of using a ranked retrieval system is the prioritisation of the most likely relevant items. The major limitation of using this method in a systematic review is the reduced ability to replicate due to regular updating of the collection being drawn on.

The current systematic review used both Boolean and ranked retrieval strategies commensurate with the optimum search method for the specific engine. Search engines typically rank results from those considered most relevant through to those considered least relevant. It was consistently noted that the order presented by the search engines was not indicative of the actual relevance of articles, and that the entire returned range of documents had to be considered equally. To have ceased any search when documents consistently failed to be returned would have missed items for inclusion.

2.8.1.3 Random versus fixed-effects models. The fixed-effect model assumes that the only reason for variation of effect sizes between studies is a result of an error in the estimation of the effect size (Borenstein, Hedges, Higgins, & Rothstein, 2009). The weights of the smaller studies are largely ignored as the effects sizes in the larger studies are deemed to provide better information. Conversely, the random effects model aims to provide an estimate of the mean of the distribution of effects (Borenstein et al., 2009). Prominent researchers in the field concur that the fixed-effect model provides biased estimates of the true effect size (Field, 2001; Hagger, 2006; Hedges, 1992; Hunter & Schmidt, 2000); with Hunter and Schmidt (2000) performing fixed-effect model assessment and finding Type I errors for up to 28% of the studies with sample sizes up to 100. A similar study performed by Hagger (2006) in the sport and exercise field reported similar findings to that of Hunter and Schmidt, with the conclusion that random-effects models would be most suited when wishing to apply the results to real world applications. The summary statistic obtained in the random effects model does not give greater weight to larger studies or lesser to a smaller study but considers all effects so as to not be overly influenced by one particular study (Borenstein et al., 2009). The assumption of a common effect size in the fixed-effect model deviates from the process of accumulating data from a number of studies completed independently of each other, with individual differences present in each study. The additional benefit of the random effects model over that of the fixed effects is the generalizability of the outcomes to other populations compared to the limited utility of analysis completed under the assumption that all the studies are from an identical and narrowly defined population (Borenstein et al., 2009). The current meta-analysis is drawn from populations that are quite disparate from each other and thus the random effects model is best suited.

2.8.1.4 Limitations of meta-analysis. The repetitive theme when reviewing meta-analytic processes is the inherent requirement for protocols to be transparent and objective (Hagger, 2006; Lipsey & Wilson, 2001; Torgerson, 2003). The painstaking nature of meta-analytic work from searches through to coding and analysis further supports the attempt of researchers to provide a semblance of transparency when reviewing their study pool (Hagger, 2006). The seemingly simplistic process of measuring the effect of X on Y brings with it the daunting task of further classifying studies according the wealth of moderating influences on the core outcome. The breadth of these variables requires not only categorisation but a sub-categorisation process to ensure an accurate analysis of the outcome variables and their influencing factors can ensue.

The use of coders in meta-analytic work carries both strengths and weaknesses in its process. From the outset in the decision making process, regarding inclusion and exclusion criteria, the differing perspective provided by individuals with knowledge of the field of research, can provide an alternate angle and reduce bias by lowering the chance of researcher influence. Coder reliability is the process of checking the internal and inter-coder reliability of coder's decisions using intra-class reliability coefficients (Hagger, 2006). These processes leave the calculation of the corrected average effect size, through classification of variables and measures, to be a subjective one open to bias (Hagger, 2006). In addition, this limitation of meta-analysis is the most prominent issue of 'the file draw problem'.

A key consideration when exploring the limitation of potential bias lies in the omission of studies that are either unavailable to the researcher, through an ineffective search strategy, or through lack of publication resulting from a finding of no effect (Hagger, 2006; Rosenthal & DiMatteo, 2000). The lack of inclusion of studies finding a null hypothesis or a negative effect introduces an element of subjectivity and the quality of the meta-analysis is brought into question. Countering this issue is the engagement of meta-analytic researchers in rigorous search strategies and a commitment to the location of, so-called, fugitive literature. Borenstein (2005) advocated trim and fill as the best method for adjusting for publication bias, particular as it is a way of formalising the presentation of funnel plots.

Schmidt, Le, and Oh (2009) outlined the limitation of not being able to correct for sampling error in single studies. Meta-analysis processes allow for the effects of sampling error to be reduced, providing the sample (*k*) is large enough. The random sampling errors are averaged out across studies. Smaller sample sizes can still be managed, although a small amount of sampling error will remain in the final results. Consideration and management of the primary data errors is essential, including original article data errors. Effective management of these errors occurs through detection and possible removal using outlier analysis. Schmidt et al.

highlighted the problematic nature of outlier removal as it is often difficult to distinguish between data errors and large sampling errors, resulting in biased corrections for sampling error.

2.8.2 Computerised technology. Comprehensive Meta-Analysis (version 2.0; CMA) is a stand-alone program for meta-analysis allowing the use of close to 100 formats to find a common effect size index (Borenstein, Hedges, Higgins, & Rothstein, 2007). The user friendly interface, which is similar to MS Excel, allows the researcher to perform a wide range of tasks, including the extensive range of computational options, moderator analysis, homogeneity, and outlier assessment (Borenstein, 2005). CMA has undergone a number of reviews, finding it to be one of the superior meta-analysis packages available (Bax, Yu, Ikeda, & Moons, 2007; Pierce, 2008). CMA easily manages publication bias issues (McDaniel, Rothotein, & Whetz, 2006). The provision of both fixed- and random-effects provides the researcher with a choice of methodology. Field (2005) outlined that both psychometric and non-psychometric methodologies produce similarly accurate correlation coefficients, reducing the issue of the Hedges and Olkin (1985; Hedges, 1992) non-psychometric methodology of meta-analysis used in CMA.

2.8.3 Current meta-analysis methodological strengths and rationale. The current meta-analysis set out to follow methodological design found in previous high quality works (Armitage & Conner, 2001; Chatzisarantis, Hagger, Biddle, Smith, & Wang, 2003; Craft, Magyar, Becker, & Feltz, 2003; Hagger, Chatzisarantis, & Biddle, 2002). The complex design of the current meta-analysis can be found to exceed previous standards of analysis. The rationale for the detailed nature of this review was to extend the detail derived from a meta-analysis to a standard that is not only highly accurate but increases the derived outcomes to allow detailed practical applications. This has been achieved through a number of methodological considerations:

- The extension of search of publications beyond standard database searches to include a manual trawl of reference lists of every article and all subsequently identified individual journals, resulting in a minimisation of possible unidentified articles considered for inclusion.
- The location and recoding of articles presented in previous meta-analyses on the subject matter rather than the standard practice of using previously calculated effect sizes, thus increasing the possibility of errors by the original researchers being duplicated.
- The coding of all articles included in the meta-analysis on ten separate occasions to ensure accuracy and consistency.
- The sub-categorisation of moderators to a level where further sub-categorisation was not possible.
- The specific analysis of effect direction dependent on sub-categorisation processes.
- Delineation between standard deviations and standard error of mean when calculating effect sizes.
- Use of Comprehensive Meta-Analysis (CMA) allowing for the inclusion of more articles than allowable by a manual process or other less sophisticated meta-analytic programs.
- An extensive analysis of outcome constructs commensurate with their influence on the research question of interest and subsequent analysis to ascertain the most appropriate measures of outcome constructs.

As highlighted by Hagger (2006) and Spence (1999) the quality of meta-analytic works is often limited by the researcher's detailed attention to extant literature, accuracy in coding, and extensive analysis of data.

2.9 Ultra Distance Research

There has been much research in the field of ultra-distance athletes over the last couple of decades. With the exception of a few studies, however, the research is in the area of biomedical science including cardiovascular effects (e.g., Burr et al., 2012; Wilson et al., 2011), multiple physiological outcomes (e.g., oxygen uptake and HR; Lazzer et al., 2011), and effects of fluid intake (e.g., Bürge et al., 2011; B. Knechtle, P. Knechtle, & Rosemann, 2011); with a growing area of research assessing muscle fatigue using tensiomyography (TMG; e.g., Garcia-Manso et al., 2011).

Research related to psychological outcomes in ultra-distance athletes is limited and, where present, is largely anecdotal. Krouse, Ransdell, Lucas, and Pritchard (2011) completed a descriptive study detailing the motivation, goal orientation, demographic details, and coach utilisation of female ultra-runners (N = 344). Overall, female ultra-runners were found to be task oriented, internally motivated, health and financially conscious individuals (Krouse et al., 2011). Lane and Wilson (2011) studied the relationship between trait emotional intelligence and emotional state changes in an ultra-distance event. An association was found between trait emotional intelligence and adaptive psychological states, proposing this to be the key difference between athletes who respond well to repeated bouts of hard exercise compared to others.

Parry, Chinnasamy, Papdopoulou, Noakes, and Micklewright (2011) examined the changes in mood prior to and after an Ironman triathlon, also assessing the relationship between expected performance outcomes, perception of effort, and pacing. A positive relationship was found between time completed in race and RPE. Subscales of the mood states of tension and fatigue showed differences between pre- and post-race trials. Somatic anxiety was found to be higher prior to the race when compared to baseline measures.

M. Doppelmayr, Finkernagel, and H. Doppelmayer (2005) assessed the changes in cognitive performance during the renowned Badwater Ultramarathon, where athletes run in 50^{o} C heat from 80 m below sea level to the finish line at approximately 2500 m above sea level. It is considered to be amongst the world's toughest footraces and tests the athletes' resolve to the limit. The formidable challenge sees athletes battling extreme heat, dehydration, total physical exhaustion, and sleep deprivation to complete the infamous race. Two athletes were tested three times during the two days preceding the race to form a baseline, then at approximately 30, 95, 130, 160, 195, and 215 kms using the KLT Konzentrations-Leistungs-Test (Düker & Lienert, 1965) to evaluate their cognitive performance; the *D2* Aufmerksamkeits-Belastungstest (Brickenkamp, 1994) to measure the athlete's attention and concentration; and the *EKV Dimensionen der erlebten korperlzchen Verfassang* (Kleinert & Liesenfeld, 2001) test to measure four dimensions of subjective bodily experience—training, flexibility, health, energy.

Contrary to the hypothesis that there would be a steady decrease in cognitive performance, it was found that "at 195 km—during the early morning of Day 3—the worst cognitive results were achieved, thought to be a cumulative effect of total exhaustion and sleep deprivation" (Doppelmayr et al., 2005, p. 484). Both athletes showed a slight increase in performance data during the last test sessions which was attributed to the motivational aspect of reaching the finish. The results are consistent with other reports that a combination of stress from heat and prolonged exercise results in a considerable decrease in cognitive performance.

Crust, Keegan, Piggott, and Swann (2011) completed a phenomenological study of long distance walking. The individual experiences of the athletes were reported relating to pre-walk (i.e., mixed emotions), during walk (i.e., positive feelings, disconnect and reflect, task-oriented focus, flow, shared experience, challenges, and disruptions), and end of walk (i.e., bittersweet feelings, sense of well-being, and personal growth). Participants reported that it was a ‘journey of self-discovery’ that occurred within a ‘bubble’ (p. 258). The detachment from everyday life experienced whilst in the ‘bubble’ was sustained throughout the walk as the seldom-gained time and space afforded them the ability to self-reflect and relax. Participants reported evidence of improved cognitive functioning, reduced levels of stress opening their mind to a broader analysis of work-related problems.

2.10 Aims

Participation in ultra-distance events regardless of sport has been shown to have both positive and negative psychological and physiological outcomes. The research body, with the exception of Ayers (1911), is devoid of investigations of music intervention in ultra-distance events. Research into the effects of music on sport and exercise has found positive effects on both psychological and physiological outcomes predominantly in laboratory settings. The extension of music interventions in field experiments and elite populations was recommended by Simpson and Karageorghis (2006). The present research examined the effects of music on elite athletes from a population that has been shown, in previous research, to push their minds and bodies to extreme limits. The addition of music in ultra-events (where its use is legal) opens the athlete to the potential of greater distance achieved, with reduced perception of exertion, improved affect, and lowered HRs. Coupling this with the potential for a pacing effect achieved through synchronous music (Simpson & Karageorghis, 2006) to provide a rhythmically-centred automated stride has the potential to further extend the potential of individual athletes.

Chapter 3 – Study 1

3.1 Introduction

Study 1 was a meta-analysis of the effects of music on five specific sport and exercise outcomes (performance, FS, HR, VO_2, RPE), providing the most comprehensive and up to date quantification of the benefits of music, both synchronous and asynchronous. Although several narrative reviews (e.g., Hohler, 1989; Karageorghis & Terry, 1997, 2008; Lucaccini & Kreit, 1972; Terry & Karageorghis, 2011) and two unpublished meta-analyses (Karageorghis, 1992; Lim, 2007) have been produced, no quantitative summary of the effects of music in physical activity domains (sport, exercise, and motor tasks) has yet been published. Therefore, the purpose of the present study was (a) to conduct a meta-analysis of the evidence pertaining to the proposed benefits of music for five sport and exercise outcomes (performance, FS, HR, VO_2, RPE), and (b) to identify variables that may moderate such benefits.

3.2 Hypotheses

The hypotheses for the Study 1 were:

1. That music will have a significant positive effect on performance outcomes in sport and exercise domains.
2. That music will have a significant positive effect on affective responses, as measured by the FS.
3. That there will be significant positive effects on HR outcomes when using music.
4. That music will be associated with significant improvements in oxygen consumption, as measured by VO_2.

5. That participant's RPE would significantly improve with the use of music.

6. That music characteristic (synchronous, asynchronous, pre-task) will moderate the reported benefits of music for sport and exercise outcomes.

7. That personal and situational characteristics (gender, age group, journal ranking) will moderate the reported benefits of music for sport and exercise outcomes.

3.3 Method

3.3.1 Literature search. A systematic literature search was completed to ensure that the current meta-analysis provided a comprehensive and accurate statistical representation of the benefits of music on sport and exercise. The extensive nature of the search served to reduce bias and increased the probability of locating rogue and unpublished articles in addition to those from major journals up to a cut-off date of December 31, 2010.

An electronic search was completed and located studies between 1911 and 2010, using combinations of the following keywords: *Music, sport, exercise, distraction, psychophysical, performance, effects, physiology*, and *meta-analysis*. Initially, advanced searches of databases were completed including: *SPORT Discus*, *Psychology and Behavioural Sciences Collection*, *PsycCRITIQUES*, *PsycEXTRA*, *PsycINFO*, *Psych*LIT, *PyscARTICLES*, *ERIC*, *PubMed*, *SAGE Journals*, *ScienceDirect, Psychology and Behavioural Sciences Collection*, and *Wiley InterScience* to locate published articles.

Secondly, reference lists of obtained research studies were manually screened to obtain additional relevant research studies. A manual trawl was then completed of all relevant psychology, physiology and sports journals including: *Journal of Sports Sciences, Journal of Sport & Exercise Psychology, Journal of Applied Sport Psychology, International Journal of Sport Psychology, The Sport Psychologist, Perceptual and Motor Skills, Research Quarterly for Exercise and Sport, Journal of Sport Behaviour, Canadian Journal of Applied Sport Science, Sports Medicine, Journal of Sports Medicine, Medicine & Science in Sports & Exercise, International Journal of Fitness, Journal of Sports Medicine and Physical Fitness, Physical Educator, Women's Sport Fitness, The Tohoku Journal of Experimental Medicine, Journal of Physical Education and Sports Sciences, Chest, Psychology of Sport and Exercise, International Journal of Sports Medicine, International Journal of Applied Sports Sciences, Psychomusicology, Sociology of Sport Journal, Journal of Human Movement Studies, The Journal of Strength and Conditioning Research, Adapted Physical Activity Quarterly, Physiotherapy, Journal of Cardiopulmonary Rehabilitation, Journal of Music Therapy, South African Journal of Sports Medicine, Psychophysiology, European Physical Education Review, International Journal of Sport Psychology Online, The Psychologist, Psychological Review, Physical Education and Sport, The Sports Journal, Music Therapy Perspectives, Missouri Journal of Health, Physical Education, Recreation & Dance, International Sports Journal, Performance and Mood, Applied Psychophysiology and Biofeedback, Journal of Experimental Psychology: Human Perception and Performance, Human Brain Mapping, Soviet Sports Review, Canadian Journal of Sports Sciences, The Sorts Journal, Missouri Journal of Health, Physical Education, Recreation & Dance, Journal of Applied Behavior Analysis, The American Journal of Psychology, IAHPERD Journal, Journal of Sport & Exercise Psychology, The Applied Research in Coaching and Athletics Annual, Emotion, Contemporary Thought, Kansas*

Welfare Digest, Recreation Canada, British Journal of Sports Medicine, Heart & Lung – The Journal of Critical Care, European Journal of Sport Science, Philica, *Ergonomics, Health Values, Clinical Rehabilitation, International Journal of Obesity*, *Computers in Human Behavior, Monetary Reinforcement, Media Psychology*, *International Journal of Psychophysiology, Psychology of Music, Journal of Undergraduate Kinesiology Research, Scandinavian Journal of Rehabilitation Medicine, Journal of Cardiology, American Physical Education Review, Physical Education & Sport/Science, Movement & Health, and Canadian Journal of Behavioral Science*; and where an electronic copy was not available a physical copy was obtained by attendance at relevant university libraries.

Where an article was identified as potentially suitable for inclusion in the meta-analysis but unavailable through the methods described above, the interlibrary loan facility of state universities (Doc-ex) was used to source additional journal articles. In addition, Google Scholar was used to locate studies that had not been identified through other search engines and prominent author's web pages were scrutinised to identify further studies for inclusion. Previous summaries of literature relevant to music in sport (e.g., Karageorghis, 1992; Lim, 2007) were also examined to identify additional studies suitable for inclusion. Finally, prominent researchers in the field were contacted to request any unpublished or recently submitted studies, and a notice was placed on the Sport Psychology ListServ seeking additional studies. In the instance where insufficient data was provided in an article, attempts were made to contact the author concerned to request provision of the data. In all, a thorough search was completed ensuring the comprehensiveness of the review of the effect of music on sport and exercise.

3.3.2 Inclusion criteria. To be eligible for inclusion in the meta-analysis, studies must have: (1) used a music intervention and assessed any of the following outcome variables: physical performance, psychological responses, perceived exertion, or physiological functioning; (2) reported pre- and post-scores and/or had used a control group; (3) included sufficient statistics to facilitate the calculation of effect sizes using CMA (Borenstein et al., 2007); and (4) must be published in a peer-reviewed journal. If the study did not meet the inclusion criteria it was excluded. The analysis was limited to studies written in the English language prior to December 2010.

3.3.3 Exclusion of unpublished studies. There has been rigorous debate in relation to the inclusion of unpublished studies in meta-analytic works (Sterling, Rosenbaum, & Weinkam, 1995). The basis for this concern lies in the belief that only studies producing significant results will be published, finding those with non-significant results being placed in the 'file-drawer' (Rosenthal & DiMatteo, 2000). Rosenthal and DiMatteo proposed that the omission of unpublished studies can result in an inflated effect size, if indeed there was publication bias present in the literature. However, support for the exclusion of unpublished studies points to the lack of peer review and scrutiny by established researchers that occur with unpublished studies (Sterling et al., 1995). The current meta-analysis excluded analysis of unpublished data but delineated quality of published articles using journal ranking.

3.3.4 Search results. The literature search concluded in December, 2010. The search strategies yielded more than 500 citations using music in sport and exercise, from which 164 studies were targeted for detailed review. Where the abstract of a study was the only item published all authors were sourced and emailed in an attempt to gain sufficient data for inclusion in the meta-analysis. At least two researchers completed a thorough analysis of each study to assess eligibility according to the inclusion criteria. The study was excluded if it did not meet the inclusion criteria.

Seventy-eight studies were excluded because they did not meet the inclusion criteria. Of these, 14 (18%) studies had insufficient data to enable calculation of effect sizes, where the authors had been contacted to obtain data to no avail; 5 (6%) did not measure physical performance, psychological responses, perceived exertion, or physiological functioning; 2 (3%) did not use pre- and post-scores and/or did not use a comparison/control group; 35 (45%) were outside domain guidelines (i.e., sport, exercise, motor task); 7 (9%) used music in exercise related to pain management/rehabilitation; 10 (13%) studies did not meet the defined music characteristics; and 5 (6%) were removed in the post hoc process outlined below. The net result of the meticulous search procedures was that a total of 86 studies met all of the inclusion criteria. Overall, a total of 162 effect sizes with 2,492 participants were entered into the meta-analysis.

3.3.5 Post hoc analysis. Lipsey (2009) outlined an important issue in meta-analyses regarding studies that report results for multiple measures of an outcome construct. The inclusion of all available effect sizes for the same outcome construct results in increased weighting of one study over others and the potential for statistical dependencies among effect sizes (Lipsey, 2009). The current meta-analysis reported intervention effects on four different outcome constructs (physical performance, psychological responses, perceived exertion, and physiological functioning). A range of measurement methods were used within each outcome construct. The decision was made to select the most appropriate measure of individual outcome constructs. Where multiple effects were available for one chosen measure of outcome construct in a study, it was decided to average the obtained effect sizes to yield a single median effect size for that measure of the outcome construct. All excess effect sizes were removed. Finally, analysis of the influence of advances in technology and research methodology was conducted to ensure there was no uneven weighting or change of measure dominance per decade. Further to Figure 2.5, the post hoc measure of outcome construct decision process is shown in Figure 3.1.

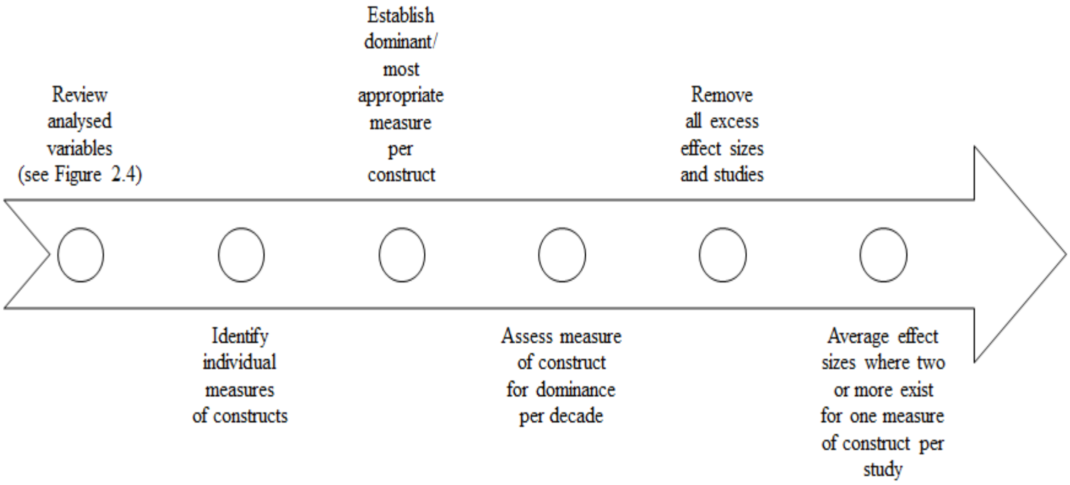

Figure 3.1. Post hoc measure of outcome constructs decision flow chart.

3.3.5.1 Measure of outcome construct decision. An overall pool of results for the outcomes of physical performance, psychological responses, perceived exertion, and physiological functioning was assessed (k = 483) to ascertain the most appropriate measure within each outcome. Measurement variability was evident in the physical performance outcome but individual methods were deemed sufficiently consistent to proceed without sub-categorisation. Psychological outcome constructs were measured in the research by 12 separate constructs (see Figure 3.2). The FS was found to be the dominant measure of psychological response.

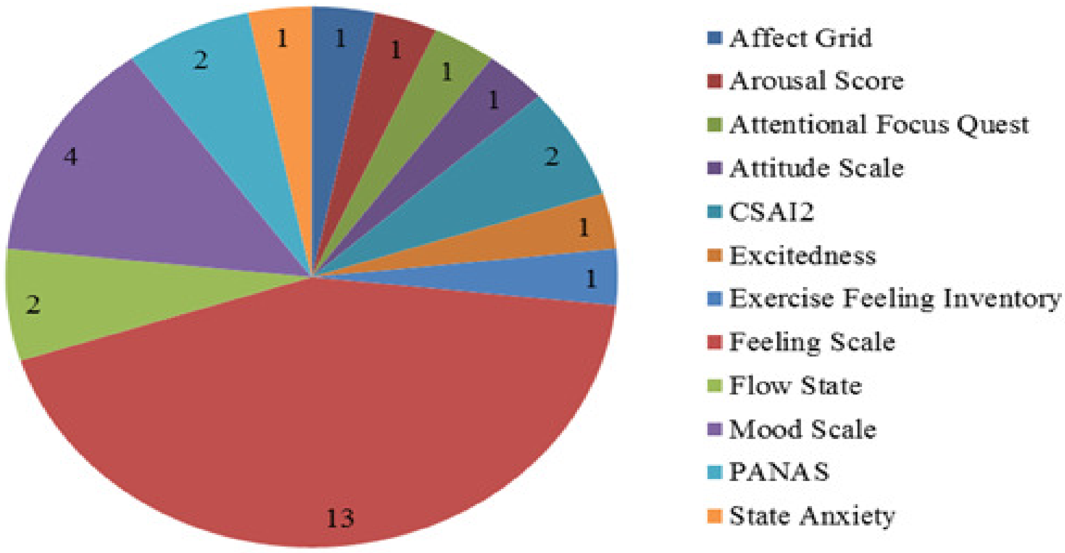

Figure 3.2. No. of iterations of measures of psychological outcome constructs.

A review of the measures used to provide outcomes for perceived exertion showed consistency, with all studies using a version of Borg's RPE scale, which necessitates no further sub-categorisation. Physiological functioning was measured in the research by 12 constructs (see Figure 3.3). Although HR was found to be the dominant measure of physiological functioning, VO_2 also yielded sufficient results (n = 10) to warrant the inclusion of both HR and VO_2 as outcome constructs in the meta-analysis.

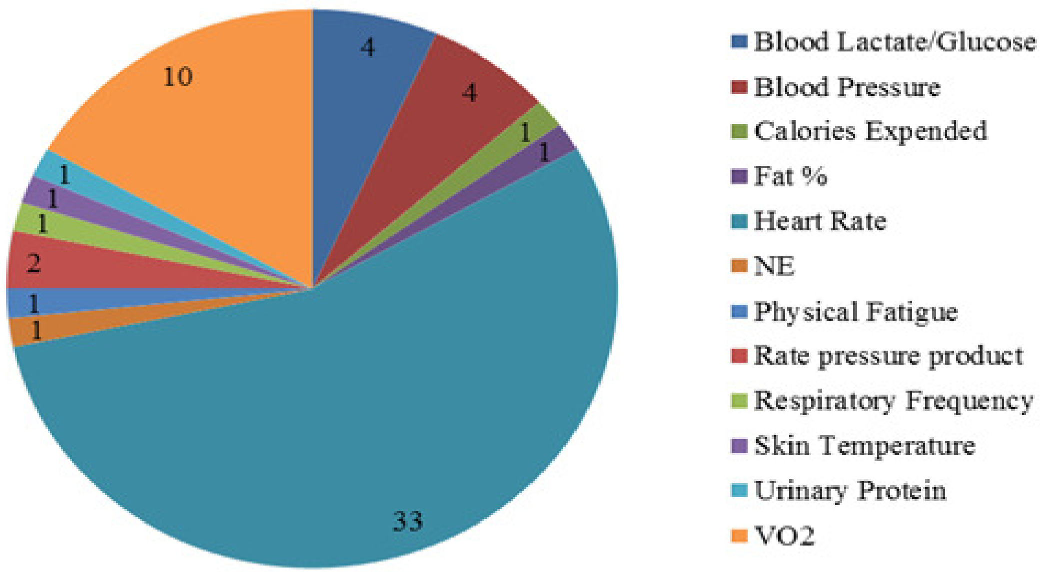

Figure 3.3. No. of iterations of measures of physiological outcome constructs.

Analysis by decade showed that, despite the limitations of HR as a measure outlined in the literature review, there has been an increase of 13% in its use in the last decade, while the use of VO_2 has shown a 7% increase over the same period (see Figure 3.4).

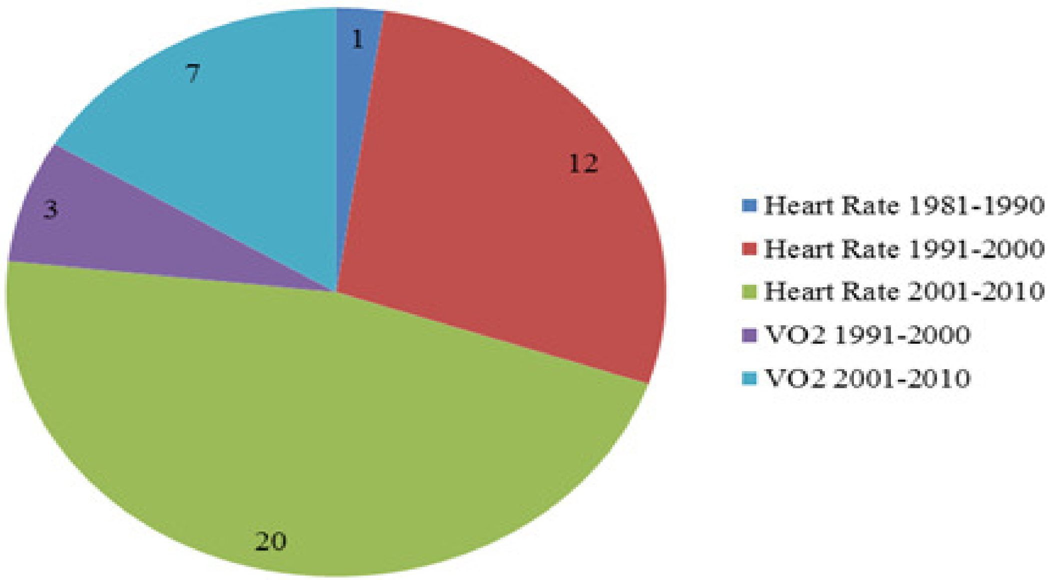

Figure 3.4. No. of iterations of HR and VO2 measures per decade.

3.3.5.2 Loss of studies. An initial pool of 91 studies was identified for inclusion in the current meta-analysis. As highlighted in Lipsey (2009), the choice to adopt the most appropriate measure within an outcome construct may result in a loss of data. Five studies were excluded (Atkinson et al., 2001; Hayakawa et al., 2008; Hewston et al., 2005; Karageorghis et al., 2007; Lanzillo, Burke, Joyner, & Hardy, 2001) at this stage, resulting in the final sample of 86 studies.

3.3.6 Moderator variable coding. Studies that met the inclusion criteria were coded for (a) domain characteristics (i.e., sport, exercise, motor task); (b) participant gender (i.e., male, female, mixed); (c) age group (i.e., child/youth, adult/college, senior); (d) study characteristics (i.e., publication status, year, journal ranking), (e) outcome constructs (i.e., physical performance, psychological responses, RPE, physiological responses); (f) measure of outcome construct (i.e., performance, FS, RPE, HR, VO_2); and (g) music characteristics (i.e., synchronous, asynchronous, pre-task; motivational, neutral; self-selected, researcher-selected).

3.3.6.1 Domain characteristics. Studies were coded as to whether their examination of music was used whilst engaging in sport, exercise or a motor task. Table 3.1 is a summary of activity type and corresponding allocation to domain. Further, the activities were coded into subcategories, where available (e.g., treadmill, walking, aerobics, cycling, running, and weight lifting).

3.3.6.2 Participants characteristics. The total number of participants that contributed to the data set for the current meta-analysis was 2,492. Both males (19%) and females (12%) were well represented across the studies, including a combination of the two (59%), and not specified (9%). Ages ranged from 9 to 101 years, with these groups categorised into: (1) child/youth; for participants under the age of 18 years, (2) adult/college; for participants between the ages of 18 and 59 years; and (3) college; for participants identified as attending college or university, (4) senior; for participants who were 60 years and over, and (5) not specified. Where the age range spanned two or more levels, the mean age was used to determine the category. Gender was coded: (1) male, (2) female, (3) mixed where both genders were included in the study's participant group, and (4) not specified.

Table 3.1

Categories of Domain Characteristics Coded in the Meta-analysis

Activity type	Sport/Exercise/Motor Task
Cycling	
Time Trial	Sport
Recreational	Exercise
Cycle ergometry	Exercise
Running	
400-m sprint/60-m dash	Sport
Recreational	Exercise
Treadmill running	Exercise
Walking	
Recreational	Exercise
Treadmill	Exercise
Rowing	
Time Trial	Sport
Recreational	Exercise
Rowing ergometry	Exercise
Competitive Rowers	Sport
Swimming	
Time Trial	Sport
Recreational	Exercise
Water Aerobics	Exercise
Dart Throwing	Sport
Dumb Bell Lifting	Exercise
Karate Drill	
Kata	Sport
Basketball	
Ball Dribbling/Foul Shooting	Sport
Ball Bouncing	Motor Task
Aerobic/Cardiovascular exercise	
Fitness testing/Circuit training	Exercise
Bench Stepping	Exercise
Strength task	Motor Task
Pursuit rotor	Motor Task
Reactive Measures	
Wingate Anaerobic test	Motor Task
Choice reaction time	Motor Task
Pre-game Routine	Sport
Ballet Sequence	Sport

3.3.6.3 Study characteristics. The study characteristics coded were publication status (i.e., published or abstract), decade of publication, and the quality of journals where the study was published. Where the full text of a study was published in a peer review journal it was coded as *published*. The publication of an abstract in a peer reviewed journal, including where additional information was provided through contact with the author was coded as an *abstract*.

Research outlets are ranked on three tiers (A*/A, B, and C), according to overall journal quality (Australian Research Council, 2010). A journal ranked as A* or A is subject to very high standards of research quality resulting in low acceptance rates. A tier B journal would consist of a small number of papers of very high quality. Tier C journals consist of quality peer reviewed journals that do not meet the criteria of the higher tiers (Australian Research Council, 2010).

3.3.6.4 Outcome constructs. The outcome constructs were coded as (1) physical performance; (2) psychological responses; (3) RPE; and (4) indices of physiological responses.

3.3.6.5 Measure of outcome construct. The measures of outcome construct were coded as performance, FS, RPE, HR, and VO_2.

3.3.6.6 Music characteristics. The music characteristics coded were delivery of music (i.e., synchronous, asynchronous, or pre-task) and the properties of music (i.e., motivational, neutral; self-selected, researcher-selected).

3.3.6.7 BMRI use. The use of the BMRI/BMRI-2 was coded for its use in the music selection and assessment of motivational qualities.

3.3.7 Coder reliability. Each study was independently coded by the researcher. In total, each article was coded on 10 different occasions over an 18-month period to make sure adequate time lapse had occurred to safeguard that coder drift did not impact the results. Coder drift, also known as coder fatigue, results in changes in coder output over time, either from boredom and long hours, or from improved meta-analytic skills gained through practice (Raffle, 2006). Intra-coder reliability calculations found the per-case agreement rate to be .99 in the last two coding events. To establish inter-coder reliability and allow for coder drift, a random sample of 22 (26%) studies were coded by two other members of the research team (Orwin, 1994). The per-case agreement rate was .94. According to Shaughnessy, Zechmeister, and Zechmeister (2006) this statistical representation of the number of variables coded the same divided by the total number of variables was within acceptable range.

3.3.8 Effect size calculation and data entry. The effect of music on sport and exercise was judged against an alpha level of .05. Eight-six studies were included, yielding 162 effect sizes that were evaluated according to their measure of outcome construct categories (performance, FS, RPE, HR, and VO_2). Thomas and French (1986) provided a concise summary of the methodology relating to meta-analysis in the field of sport and exercise. It is expressed that an effect size is a common assessment in standard deviation units of the effectiveness of an experimental treatment. Further explaining that given an effect size of + .50, would be a representation of the experimental group having a benefit over that of the control group by half a standard deviation on the dependent measure. Data extraction from each study occurred to enable calculation of effect sizes. Results of independent studies produced either a positive effect, showing a benefit of music on the outcome construct, or a negative effect, where music was found to have a detrimental effect.

Cohen's *d* was chosen as the measure of effect size. Hagger (2006) outlined Cohen's *d* to be the difference in means between two groups divided by the pooled within-group standard deviation. Cohen's conventions for effect size interpretation are outlined as follows: a small effect, $d = .20$; a medium effect, $d = .50$; and a large effect, $d = .80$ or above (Aaron, Aaron, & Coups, 2010).

Effect sizes were calculated using the *Comprehensive Meta-Analysis (Version 2)* software package (CMA: Borenstein et al., 2007). CMA facilitates effect size calculation from a wide array of reported information, allowing the retention of some studies that would previously have been excluded because they did not report the traditional statistics (M, SD, N, F, t, etc.). The data formats used included, but was not limited to:

1. Independent groups (means, SD's)
2. Independent groups (std. difference)
3. Means, SD in each group
4. Paired groups (*N*, *t*-value)
5. F for difference in change
6. Paired groups (difference, *p*)

In addition, CMA manages complex issues associated with meta-analysis, including the impact of study weights on the combined effect and heterogeneity, whilst providing both fixed and random effects models. In studies reporting multiple effects from a single dependent variable (e.g., effects of music-based exercise on mood responses at 3 weeks and at 6 weeks) a single composite effect was calculated, as recommended by Lipsey (2009).

3.3.8.1 Accuracy of effect size calculation. The instance of error in calculating effect sizes in previous meta-analyses in the subject area was addressed. This was covered both by the 10 recodes to ensure accuracy, and the visual scrutiny of effect sizes to highlight unusually high numbers that may be erroneous. Additionally, clarification of the differentiation between standard deviation and standard error was established in each study. The consequence of not ensuring accuracy in this area often results in inflated overall effect sizes (Gumedze &

Jackson, 2011). In addition, when updating meta-analytic work, the effect sizes calculated by previous works in the same subject area are often used in lieu of sourcing articles and recalculating effect sizes. The current meta-analysis sourced all original articles and recalculated effect sizes to prevent the possibility of duplicating errors in the original study.

3.3.8.2 Choice of random effects. A random-effects model was used to facilitate generalization of the results, as recommended by Hagger (2006). Effect sizes were corrected for sample size and dispersion. The issue of "fugitive literature" (see Hagger, 2006, p. 107) was addressed using Duval and Tweedie's trim and fill procedures and further exploration of funnel plots.

3.3.8.3 Outliers. Viechtbauer and Cheung (2010) highlighted that it is not uncommon to find outliers in a meta-analysis that have the potential to distort the conclusions. The robustness of the results of a meta-analysis that hinge on one or two influential studies can result in the overall effect being called into question (Viechtbauer & Cheung, 2010). Typically, it would be expected that the influential studies are small in nature, when the reality is that they are in fact more often the larger ones (Baker & Jackson, 2008; Gumedze & Jackson, 2011). Thus it is not considered to be as simple a task as removing unusual results. Previous management of these issues has been handled by random effects models and extensions of these including: BUGS code (Smith, Spiegelhalter, & Thomas, 1995), analogous multivariate, and nonparametric procedures (Baker & Jackson, 2008). Baker and Jackson (2008) proposed a model whereby the weight of the outlier was reduced rather than the complete removal of the outlier. Further work by Jackson (Gumedze & Jackson, 2011), where they produced an extension of the model outlined in Baker and Jackson, highlights that where there are many apparent outliers, the removal or downweighting of the study may not be helpful or meaningful.

Review of the current dataset, the nature of the included studies, and subsequent outcome effects presented many apparent outliers. Consideration of the diversity of anticipated effects (e.g., physiological effects, $d = < .10$; psychological effects, $d = > .40$) in individual studies it would be remiss to expect a dataset devoid of outliers. Visual analysis of forest plots and consideration of the abovementioned limitations of downweighting of outliers where numerous are present, has resulted in the decision to maintain the datasets as is, without the removal of outliers. The stringent methodology outlined below and the publication bias measurement outcomes further support this decision.

3.3.8.4 Publication bias. Funnel plots were completed for each of the measures of outcome constructs. Publication bias was addressed by utilising the trim and fill method in CMA. The trimming process employs an iterative procedure involving the re-computing of the effect size by removing the most extreme small positive effect sizes, resulting in the effect sizes being symmetrical around the new effect size. This process is effective in that it reduces the variance but is limited by resulting in a narrow confidence interval. This is corrected by the fill process, which involves adding back in the removed studies, correcting the variance, and hence the confidence interval of the estimate (Borenstein, 2005; Duval & Tweedie, 1998, 2000a, 2000b).

3.3.8.5 Homogeneity. Q and I^2 statistics were used to assess homogeneity of effect sizes and the significance of moderators. I^2 is a transformation of Q that estimates the percentage of variation in effect sizes that can be accounted for by heterogeneity (Higgins & Thompson, 2002). A large and significant Q_T statistic suggests there is heterogeneity of effect sizes. In relation to moderators, a non-significant Q_B suggests the variable is not a moderator. Conversely, when there is a significant Q_B, the variable is a moderator and accounts for differences in effect size.

In relation to random effects analysis, the tau-squared (study-to-study variance) is computed within and not pooled across subgroups and is not assumed to be the same for all subgroups. As described by Borenstein (2005), subgroups of studies were combined using the fixed effect model, as a result of not assuming a common among-study variance component across subgroups.

3.4 Results

A literature search identified 164 relevant studies. Of those studies meeting all the inclusion criteria, 86 studies providing 162 effect sizes were coded for domain, participant, study, music characteristics, outcome constructs and BMRI use. Included studies covered a 100 year period, from 1911 to 2010. CMA (Borenstein et al., 2007) was used for all analyses. All effect sizes reported are from a random-effects model (Hedges, 1992); all statistics were based on an alpha level of .05; and all confidence intervals (CI) were at 95%. A table of all included studies and their individual effect sizes is presented in Appendix A.

3.4.1 Parametric data screening. The use of CMA for calculation of effect sizes did not necessitate testing for outliers, as previously outlined. Prior to completing analyses, the distribution of computed effect sizes was screened for missing values and skewness. The mean effect size only has meaning when the assumptions underlying parametric statistical tests are met. There were no missing values present. There was, as expected, some skewness and kurtosis present due to the diverse range of dependent measures in the different studies. The non-normality was deemed to be within acceptable limits requiring no further action. Assessment of coder drift using per case agreement rate (Yeaton & Wortman, 1993) determined that intra-rater reliability was acceptable. The mean agreement rate was calculated to be 0.99. Agreement rates on the 22 studies assessed for inter-coder reliability were deemed to be acceptable (0.94).

3.4.2 Homogeneity. The test of homogeneity was significant (Q_T [*df*, 161] = 11.51, $I^2 = 37.47$, $p < .05$) indicating that the effect sizes were heterogeneous and appropriate for use in a random effects model. The percentage of the total variance that was not attributed to random error was approximately 37% ($I^2 = 37.47$), which is deemed to be consistent with the relative variance accounted for in the meta-analysis.

3.4.3 Trim and fill. The true effect sizes, suggested by the trim and fill method using the random-effects model, were $d = .19$ (performance), $d = .48$ (FS), $d = .14$ (HR), $d = .24$ (VO_2), and $d = .30$ (RPE), calculated by factoring for studies that were unable to be located and unpublished studies, with 18 (performance), and 0 (FS, HR, VO_2, RPE) studies required to be trimmed (Duval & Tweedie, 2000b). Funnel plots of the standard error by standard difference in means are presented for performance (Figure 3.5), FS (Figure 3.6), HR (Figure 3.7), VO_2 (Figure 3.8), and RPE (Figure 3.9).

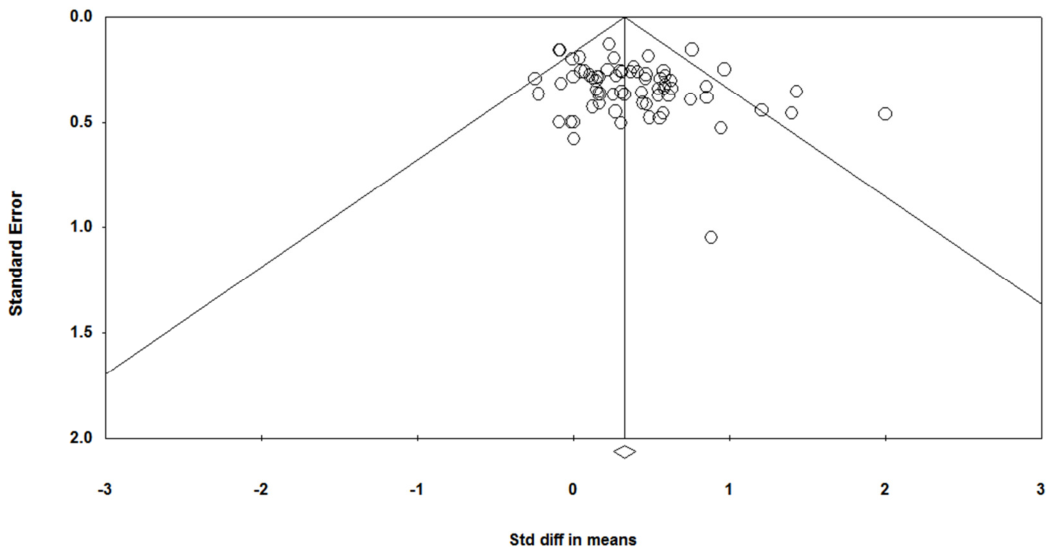

Figure 3.5. Funnel plot of standard error by standard difference in means (Performance).

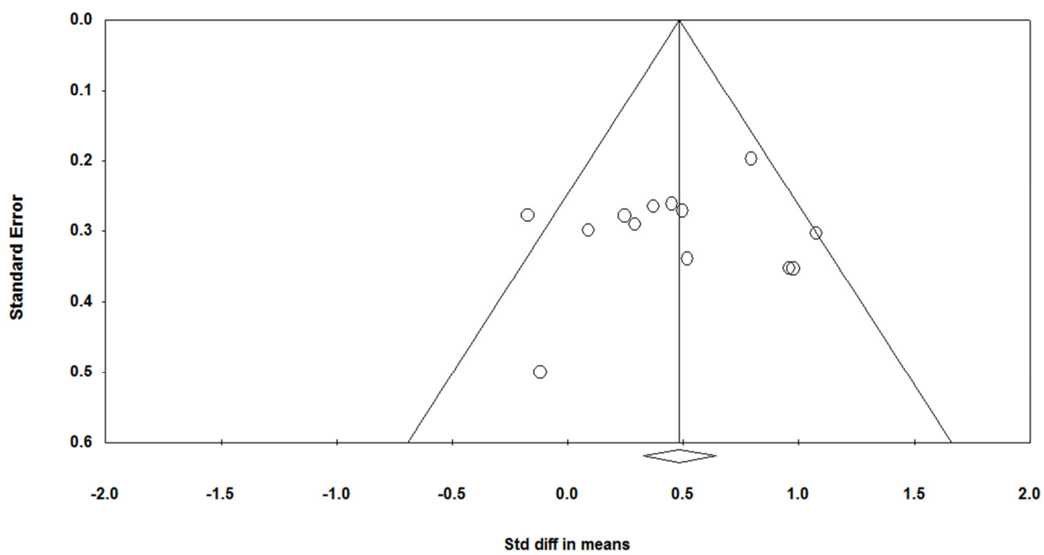

Figure 3.6. Funnel plot of standard error by standard difference in means (FS).

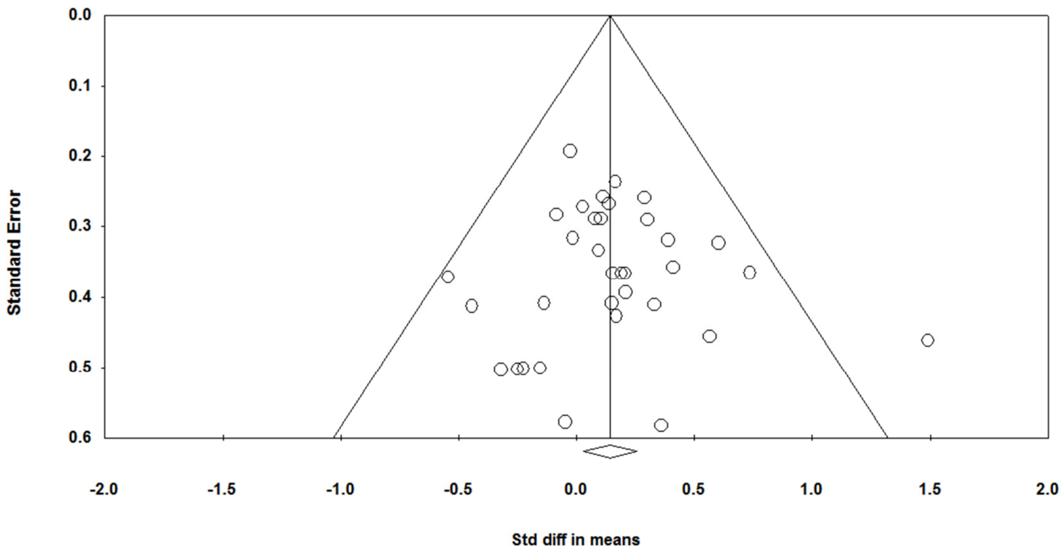

Figure 3.7. Funnel plot of standard error by standard difference in means (HR).

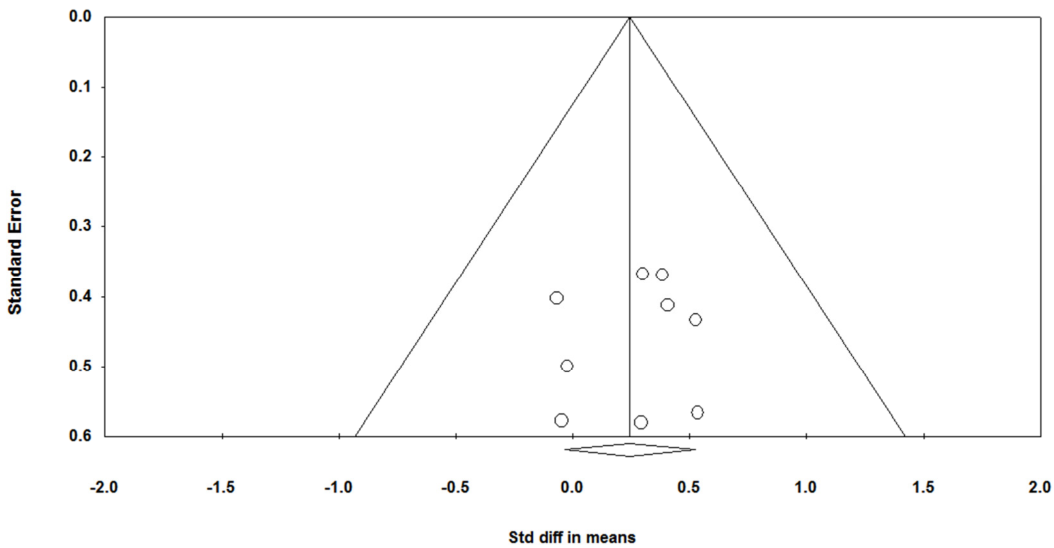

Figure 3.8. Funnel plot of standard error by standard difference in means (VO_2).

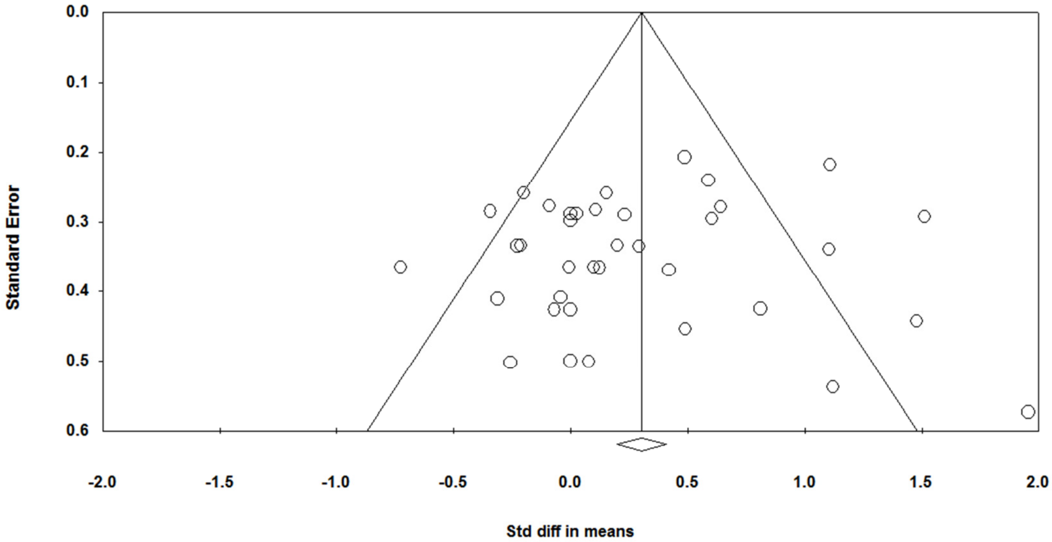

Figure 3.9. Funnel plot of standard error by standard difference in means (RPE).

3.4.4 Overall analysis. Table 3.2 presents the mean weighted effect sizes, standard errors, 95% confidence intervals, and *Q* value for the measures of outcome constructs (performance, FS, HR, VO_2, and RPE) of the effect of music in sport and exercise. Overall a significant difference was found between measures of outcome constructs Q_B (4) = 11.51, *p* = .02. Music showed a moderate significant beneficial effect for FS, a small but significant effect for performance, HR and RPE, and a small effect for VO_2 that was not statistically significant.

Table 3.2

Effects of Music in Sport and Exercise – Measures of Outcome Constructs (k = 162)

Effect	*k*	*M*	*SE*	95% CI	*Q-value*
Performance	68	.35†	.05	.27 - .44	11.51ŧ
FS	13	.47†	.11	.27 - .68	
HR	34	.14ŧ	.06	.03 - .26	
VO_2	10	.25	.14	-.04 - .52	
RPE	37	.29†	.09	.11 - .46	

Note. k = number of effects; *M* = mean point estimate effect size (Cohen's *d*); 95% CI = 95% confidence intervals; † $p \leq .001$, * $p < .01$, ŧ $p < .05$.

3.4.4.1 Moderator analysis. To determine moderator effects, analyses were conducted for each potential moderator variable: domain, gender, age group, publication status, journal ranking, outcome construct, music characteristics, and BMRI use. The number and distribution of effects for the individual outcome constructs yielded insufficient data to complete moderator analyses for all outcome variable constructs with the exception of performance. Moderator analysis was carried out on the performance outcome construct, the results of which are presented in Table 3.3.

3.4.4.1.1 Domain characteristics. The Q statistic (testing effect size heterogeneity) was not significant and therefore the differences observed between effect sizes based on domain characteristics can be attributed to chance.

3.4.4.1.2 Participant gender. Results for participant gender found no significant difference in effect sizes. Any difference in effects of gender can be attributed to chance.

3.4.4.1.3 Age group. The Q statistic was not significant and therefore the differences observed between effect sizes based on age group can be attributed to chance.

3.4.4.1.4 Journal ranking. The Q statistic was not significant for journal ranking, finding no significant difference in effect size.

3.4.4.1.5 Music characteristics. There was no significant difference in the Q statistic for music characteristics, with any difference attributed to chance alone.

Table 3.3

Moderator Effects of Music in Sport and Exercise – Performance Construct (k = 68)

Effect	*k*	*M*	*SE*	95% CI	*Q-value*
Domain					N.S.
Exercise	50	.33†	.05	.24 – .43	
Sport	14	.52†	.12	.28 – .75	
Motor task	4	.11	.15	-.19 - .40	
Participant gender					N.S.
Male	14	.39†	.09	.21 - .56	
Female	6	.37‡	.17	.05 – .70	
Mixed	42	.37†	.06	.25 - .49	
Age group					N.S.
Child/Youth	7	.50‡	.21	.08 - .91	
Adult/College	52	.36†	.04	.28 - .45	
Senior	2	.46	.52	-.56 - 1.49	
Journal ranking					N.S.
Tier A*/A	4	.52*	.21	.11 – .92	
Tier B	19	.35†	.06	.24 – .46	
Tier C	27	.29†	.07	.15 – .43	
Other	18	.48†	.11	.25 – .70	
Music characteristics					N.S.
Synchronous	7	.35‡	.18	.01 – .70	
Asynchronous	54	.35†	.04	.26 – .44	
Pre-task	7	.44‡	.20	.05 - .84	

Note. *k* = number of effects; *M* = mean point estimate effect size (Cohen's *d*); 95% CI = 95% confidence intervals; † $p \leq .001$, * $p < .01$, ‡ $p < .05$.

3.5 Discussion

Music has been shown to have performance, psychological and perceived exertion benefits in a variety of sport and exercise domains. The purpose of the current study was to provide quantification of the benefits of music on performance, FS, HR, VO_2, and RPE in sport and exercise domains. Additionally, the study set out to identify potential moderating variables in this relationship; namely, domain, gender, age group, journal ranking, and music characteristics.

The review protocol extended previous standards of meta-analytic work to ensure that the most comprehensive and accurate summary of the area of interest occurred. This improved accuracy and specificity provides researchers and practitioners with a stronger evidence base from which to initiate music applications. The detailed nature of the search strategies combined with the more thorough review protocol, including outlier management, ensured a rigour consistent with calls from previous researchers (Hagger, 2006; Spence, 1999).

Previous, unpublished meta-analyses of effects of music in sport and exercise were carried out using different methodology to the current research, treating results from disparate outcome variables as though they were the same measure. Although direct comparison of results is therefore not possible, the range of effects for the measures of outcome constructs in the current meta-analysis (d = .14 to d = .47) with a median of d = .29 and a mean of d = .30, shows the present findings to be generally consistent with previous summaries, confirming a small-to-moderate benefit of music overall (d = .32, Karageorghis, 1992; and d = .25, Lim, 2007).

The results of the meta-analysis provided unequivocal evidence of the beneficial effects of music in sport and exercise domains. One hundred years of research, with a rapid increase in investigations during the last two decades, demonstrates the growing popularity of researching use of music in sport and exercise. Use of a random effects model allows for the extrapolation of findings beyond the sample, generalising the findings to be a representation of effects in the real world.

Evidence was sought to assess performance, psychological, physiological, and perceived exertion outcomes of music. Outcome constructs were measured by performance, FS, HR, VO_2, and RPE. All measures were associated with significant positive results, with the exception of VO_2 which showed a positive result that did not reach significance. Results showed clear support for the efficacy of music in improving these outcomes. These findings are of importance to athletes and exercisers alike.

It was anticipated that assessment of the moderating influences on individual constructs would show significant results. However, this was limited by the number of effects available for the moderation categories within each construct, restricting moderator analysis to the performance outcome only. It was anticipated that there would be a significant difference for performance outcomes between sport, exercise, and motor task. There was a significant positive effect for the use of music in both exercise and sport domains ($p < .001$), with music for motor tasks producing a positive though not significant effect.

Participant characteristics (gender and age group) were hypothesised to moderate the benefits of music. Overall, there were no significant differences in music effects for gender and age group. There were significant beneficial effects of music for males ($p < .001$), females ($p < .05$), and mixed groups ($p < .001$). The adult/college age group, among whom the majority of the research has been conducted, showed significant positive effects of music ($p < .001$), with a significant positive effect also being shown in the child/youth ($p < .05$) with the senior age group finding a positive though not significant result.

The study characteristics, including publication status and journal ranking, did not moderate the reported benefits of music. The results for publication status did not yield any meaningful results. The independent ranking of the journals found significant positive results for all three of the tiers: A*/A ($p < .05$), B & C ($p < .001$).

A significant difference was found when examining the effects of music across the different outcomes ($p < .05$). Music was shown to provide the greatest benefits for FS, followed by performance, RPE, then VO_2, with the lowest positive effect being seen in the HR measure of physiological outcomes. The small significant effect shown for HR ($p < .05$) should not be diminished by its size or significance level. Even a very small improvement in a measure of physiological functioning associated with music use can be considered important, given the secondary benefits gained through improved performance outcomes.

It was anticipated that differences would be found between music characteristics. Overall no significant difference was found in the scale of benefits between synchronous, asynchronous, and pre-task music. There was a significant positive effect for all music characteristics: synchronous ($p < .05$), asynchronous ($p < .001$), and pre-task music ($p < .05$). The results of the meta-analysis have shown that the benefits of music remain fairly consistent across a wide range of personal, situational and musical variables, with limited delineation of results between moderating variables.

Interest in music for sport and exercise has led to a plethora of research, particularly in the last two decades. The examination of results provided in this meta-analysis, not only provide a quantitative summary of the research results to date but identify key areas for research focus in the future. Firstly, with the majority of research being completed in the laboratory, the use of field research will allow an examination of music gains in a real world environment. Outside of the primary benefits of music in sport, the ability for music to contribute to exercise adherence and subsequent health benefits is yet to be determined unequivocally and would form an additional focus for future research.

In the sport arena, the margin between gold and silver is tiny, with the pursuit of a sporting edge chased relentlessly by coach and athlete alike. The findings of the present research show benefits of music across activity modality, gender, age group, and outcome construct. There is now little doubt about the potential performance gains that can be derived from music whether it is used pre-task or in-task; in sport, exercise, or motor task; for performance, psychological, perceived exertion, or physiological gains; and regardless of mode of reporting (i.e., publication status, journal ranking). The challenge is now to fine tune the use of music to maximise the benefits specific to an athlete/exerciser. The popularity of music use, combined with the advent of technological advances for its delivery, provide a setting for the inclusion of music in the daily lives of individuals for the betterment of health and wellbeing, and the elevation of athletes to previously inconceivable levels.

Chapter 4 – Study 2

"A journey of a thousand miles begins with a single step"
Lao Tzu

4.1 Introduction

Study 2 is a case study of two elite ultra-distance athletes using music in a training environment. The athletes completed four conditions (synchronous motivational music, synchronous neutral music, audio book, and no music) independently on four different occasions covering 20km per condition. Physiological functioning was measured using HR, with psychological outcomes measured using RPE, BRUMS and FS. Performance times were measured in half and full lap time to complete (seconds), with one lap equalling 5 km.

4.2 Overview of Study Aims and Hypotheses

This study had three aims:

1. To assess if the ergogenic effects of music can be extended to populations that stretch their physiological and psychological capabilities to their limits, in the context of athletes competing in ultra-distance events.
2. To assess if the ergogenic effects of music on physiological functioning (HR), psychological functioning (RPE, BRUMS, FS), and performance, previously found in laboratory settings, can be extended to field settings.
3. To test protocols (intervention selection processes, technical materials, outcome measure retrieval processes) to be used in Study 3.

The hypotheses tested were:

1. That both synchronous music conditions will be associated with benefits to in-task physiological functioning, psychological responses, and performance outcomes, compared to audio book and no-music conditions.
2. That motivational synchronous music will show benefits over neutral synchronous music as measured by physiological functioning, psychological responses, and performance outcomes.

4.3 Method

4.3.1 Participants. Two elite ultra-distance athletes were selected for participation in the case study. One of the athletes was an ultra-distance race walker (male, aged 55; Athlete 1); the second athlete was an ultra-distance runner (female, aged 37; Athlete 2). When selecting participants, the primary selection criterion, to ensure their status as elite performers, required their ranking as number one in Australia at some point in their athletic career. Furthermore, the researcher selected participants who had different prior experiences with the use of music (i.e., Athlete 2 had previous experience using music in training, but Athlete 1 had no prior experience using music in training). The researcher used previous contacts in the ultra-athletic field to obtain the personal details of suitable athletes. The runner was contacted through a race director known to both researcher and athlete; and the walker was a previous co-racer with the researcher and was contacted through Australian Centurion Walkers.

The selected participants were first contacted by email and telephone to inform them of the nature of the research and to request their participation. The potential participants were then informed that the purpose of the project was to assess the effect of music on ultra-distance athletes. They were advised that this would require them to complete four sessions of 20 km in length with each of four different interventions (synchronous motivational music, synchronous neutral music, audio book, and no music). The different interventions were delivered in counterbalanced order at the same time of day, with the athletes completing a designated 5 km loop four times, totalling 20 km. Both athletes were asked to consume the same meal the evening preceding each session and the same breakfast on the day of the session. Additionally, the athletes completed the same individual warm-up session by travelling to the testing venue at the University of Queensland by running/walking, prior to each training event. The training sessions were planned for a 2-month period during autumn in an attempt to control for temperature.

4.3.2 Apparatus and measures.

4.3.2.1 Music selection. The motivational qualities of music selections were rated using the BMRI-2 (Karageorghis et al., 2006). The athlete was requested to rate if the style of music would motivate them during exercise with each BMRI-2 item (see Appendix F) in relation to rhythm, style, melody (tune), tempo (speed), sound of the instruments, and beat of the music. This single-factor, six-item instrument is considered to have psychometric properties that are superior to its predecessor, the original BMRI, with a mean Cronbach alpha coefficient for the single factor of .89 (Karageorghis et al., 2009). The scale is scored by participants on a 7-point Likert scale from 1 (*strongly disagree*) to 7 (*strongly agree*).

4.3.2.2 No music control condition. For this condition, participants completed the task without listening to any music or distractor, with the omission of headphones.

4.3.2.3 Non-music distraction. The audio book *HRH* by Danielle Steel was used as the distractor intervention.

4.3.2.4 Music delivery apparatus. The music was delivered through iPod Nano™ or iPhone™ devices carried using Belkin easy fit armbands. Headphones were attached to the relevant apparatus with over the ear attachments to provide maximum comfort. Athlete 2 provided her own earphones to reduce risk of distraction through discomfort.

4.3.2.5 Performance measurement. Laptimes were calculated using the stopwatch function on the iPhone™.

4.3.2.6 Heart rate measurement. HR was measured using a chest strap to wrist receiver system. Polar HR Monitor, Suunto Monitor, or Timex Monitors were used to measure HR.

4.3.2.7 Perceived exertion measurement. The RPE scale (RPE; see Appendix J; Borg, 1998) is an incremental assessment of the athletes perception of their exertion levels between 0 (*rest*) and 10 (*maximum effort*).

4.3.2.8 Feelings measurement. Hardy and Rejeski's (1989) bipolar Feeling Scale (FS, see Appendix I) was used to measure in-task affect. The FS is an 11-point, single-item scale ranging from +5 (*very good*) to -5 (*very bad*) with a mid-point of 0 (*neutral*).

4.3.2.9 Mood measurement. The Brunel Mood Scale (BRUMS; Terry, A. Lane, H. Lane, et al., 1999; Terry, A. M. Lane, et al., 2003) was used to assess mood state. The 24-item BRUMS (see Appendix H) takes 1-2 minutes to complete and uses a 5-point response scale (0 = *not at all*, 1 = *a little*, 2 = *moderately*, 3 = *quite a bit*, 4 = *extremely*). The standard timeframe used when responding is "*How you feel right no*w" (Terry, A. Lane, H. Lane, et al., 1999; Terry, A. M. Lane, et al., 2003).

There are six subscales (anger, confusion, depression, tension and vigour) with four items in each subscale.

4.3.2.10 Cadence measurement. The individual athletes measured their cadence by completing three trials of running or walking and counting the steps within a 1-minute period.

4.3.2.11 Location. The training sessions were completed on a 5 km route at University of St Lucia, Queensland (see Appendix C).

4.3.3 Procedure. Ethics approval was gained from University of Southern Queensland Ethics Committee for Human Research Approval No. H09REA148. Participants first signed the Participant information and consent form—Case Study (see Appendix E).

4.3.3.1 Performance measurement procedure. Lap times were recorded at the 2.3 km and 5 km points where the split time was viewed on the iPhone™ stopwatch function and recorded on the Record Keeping Sheet (see Appendix D). The design and accessibility of the course impacted where measurements could be taken. Consequently, the approximate halfway mark of each lap was taken as 2.3 km.

4.3.3.2 Music selection procedure. Initially, the athletes were requested to provide the researcher with a list of music preferences either by song or artist to enable a compilation of suitable playlists for review by the athlete. After being provided with this list, and the cadence of athlete, the researcher downloaded all songs. To ensure sufficient music was available to work with, an initial pool was required on average of approximately 200 songs per athlete.

Where insufficient songs with the correct tempo were identified from these initial lists, participants were asked to provide specific musical genres (e.g., pop, rock, classical) that were considered when identifying appropriate music tracks for the motivational and neutral music conditions. The researcher used Google searches (e.g., motivational music, Top 100), and input from regular music listeners to gauge music titles suitable for download and consideration. As synchronous music was essential, tracks approximating each athlete's preferred cadence range were filtered via Virtual DJ (Atomix Productions, Los Angeles, USA) to identify those within ±4 bpm of the reported cadence. This ensured that there would be no noticeable attenuation in fidelity of the sound when the tempo of the tracks was modified slightly to the standardised tempo of 145 bpm (the reported cadence for both athletes).

Athletes were provided with an Excel spread sheet with songs and each of the six items of the BMRI-2 listed to aid in ease of coding. To maintain reliability the athletes were provided with a copy of the BMRI-2 scoring sheet (Appendix G) and scored the first 10 songs on individual recording sheets. Athletes then transferred scores onto the Excel spread sheet and continued rating the music tracks using this document only. Individual results were collated and sorted into motivational (rated ≥ 36 on the BMRI-2 out of a possible range 6-42) and neutral (rated 18-30) music playlists of 40 songs each for the respective conditions. Detailed analysis of individual athlete's selected music according to genre, lyrical content, and rhythmic characteristics was not undertaken as it was considered to be outside the scope of the current research.

Virtual DJ (Atomix Productions, Los Angeles, USA) provides the user with a function to combine and record multiple songs into one playlist. Songs were individually entered into the program, adjusted to the individual athlete's designated stride rate and then recorded in real-time. While one song was being recorded another was loaded into the program (two virtual turntables are provided; see Appendix B) and adjusted to the required bpm. At the conclusion of each song the next song was faded in. This task was repeated until a period of 2 hours and 15 minutes was recorded for each intervention condition. This process was replicated for both music conditions (motivational and neutral) for each athlete. The music file was then loaded into iTunes^{TM} and synchronised with the relevant iPod^{TM} technology. The volume of the music was adjusted to a comfortable level for each athlete.

The four intervention conditions were motivational music, neutral music, audio book, and no music. The music requirements were 38 songs at approximately 3.5 minutes per song. A total of 152 songs were processed through Virtual DJ totalling approximately 10 hours of real-time recording of music by the researcher for Study 2. Overall the search procedure, downloading of music, checking each song individually through Virtual DJ for assessment of tempo, preparation of spread sheets, loading into sharing folders, scoring responses, and allocation of songs exceeded 100 hours of work by the researcher. With each athlete requiring approximately 3 hours to rate music (another 6 hours) and taking into account the recording time, use of self-selected synchronous music requires a time commitment in excess of 110 hours. This extensive time requirement becomes germane when balanced against the potential benefits to be gained from music use during ultra-distance training.

4.3.3.3 No music and distractor procedure. The no music condition was delivered simply by asking the athletes to remove headphones and have no active intervention. The audio book was chosen by the researcher for the consistency of the voice reading the story, and the regular pace of the reading. The audio book was downloaded from disc into iTunes™ and then synchronised with the relevant iPod™ technology for delivery to the athletes.

4.3.3.4 Heart rate measurement procedure. HR monitors were attached to the athletes prior to commencement of each training session. At the 2.3 km and 5 km points the athletes were asked to verbally report their HR as viewed on the wrist monitor and this was recorded on the Record Keeping Sheet (see Appendix D).

4.3.3.5 Perceived exertion measurement procedure. Prior to each testing session, participants were provided with identical instructions regarding the use of Borg's RPE scale (Borg, 1998). Participants were asked to verbally report their RPE to the researcher at the 2.3 km and 5 km points of each lap and this was recorded on the Record Keeping Sheet (see Appendix D).

4.3.3.6 Feelings measurement procedure. Prior to each testing session, participants were provided with instructions regarding the use of Hardy and Rejeski's Feeling Scale (FS; 1989). Participants were asked to report how they were feeling according to the FS at the 2.3 km and 5 km points and this was recorded on the Record Keeping Sheet (see Appendix D). The athletes found it difficult to use the FS, which ranges from +5 (*very good*) to -5 (*very bad*) with a mid-point of 0 (*neutral*). Instead, both athletes adapted the model for the FS to 0 (*very bad*) to 10 (*very good*) with a mid-point of 5 (*neutral*). This adaptation was used through all sessions for consistency. Adjustments were made at the analysis stage to align athlete's ratings to the original scale ranges to enable comparison to other research in the area.

4.3.3.7 Mood measurement procedure. Participants completed the BRUMS (Terry, A. Lane, H. Lane, et al., 1999; Terry, A. M. Lane, et al., 2003) prior to and after each training session, using the standard response timeframe of "*How do you feel right now*".

4.4 Data analysis

Data were analysed using raw figures for individual outcome measures (e.g., performance as measured by lap time). Descriptive statistics were used to provide the reader with a summary of the results, combined with the use of Cohen's *d* to infer the effects of intervention (motivational music, neutral music, no music, and audio book) on the outcome measures.

4.5 Results

Overall the results of the case study showed synchronous music to have quantitative and anecdotal benefits on all outcome variables (see Table 4.1).

4.5.1 Completion time. Athlete 1 found motivational music to be superior to other conditions, completing the course 280 seconds (4.6 minutes) faster compared to the no music condition (d = .77), with all other conditions associated with approximately equal times (see Figure 4.1).

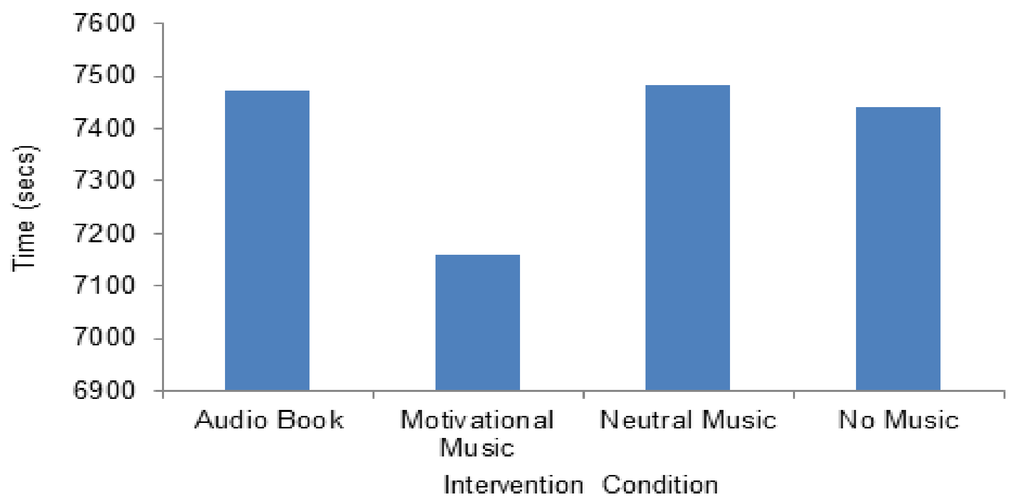

Figure 4.1. Athlete 1: Time to complete 20 km course per condition.

Athlete 2 reduced her time to completion by 295 seconds (4.9 minutes) and 133 seconds (2.2 minutes) respectively with motivational (*d* = .92) and neutral music (*d* = .41) when compared to no music (see Figure 4.2). The audio book condition showed an increase of 1040 seconds (17.3 minutes, *d* = -3.27) to complete the course when compared to motivational music.

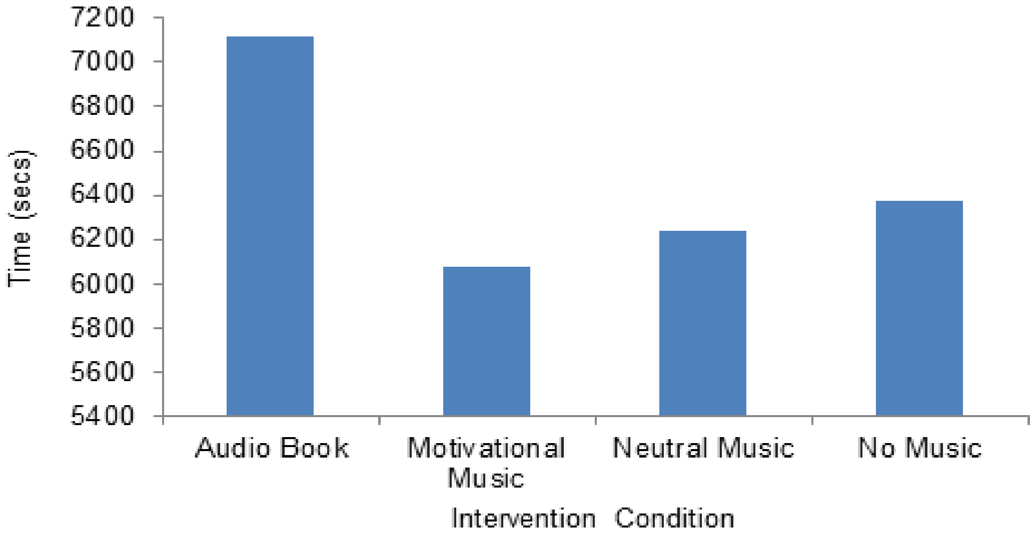

Figure 4.2. Athlete 2: Time to complete 20 km course per condition.

4.5.2 Feelings. Fluctuations in how Athlete 1 felt during the training sessions were consistent with verbal reports (see Figure 4.3). Athlete 1 reported feeling better with motivational (*d* = 1.27) and neutral music (*d* = .27), when compared to no music. The audio book was associated with the least positive feelings. The athlete's feelings became progressively less positive during the training session for all conditions but his feelings did not fall below 2 or into the negative range at any point regardless of condition.

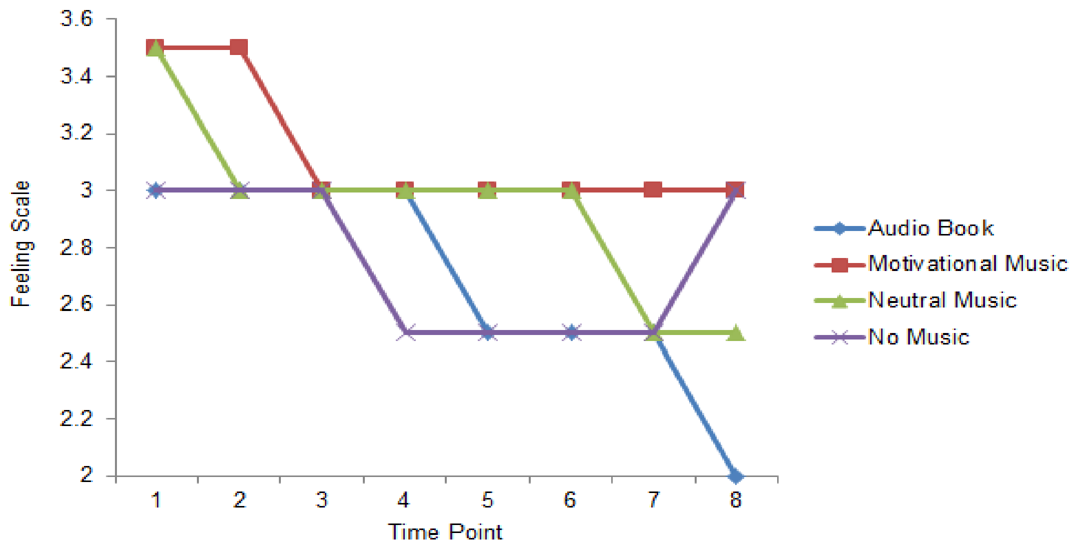

Figure 4.3. Athlete 1: Change in feelings over 20 km course per condition.

Athlete 2's feelings profile was quite distinct per intervention condition (Figure 4.4). Consistent with verbal reports, she felt progressively better with motivational music, followed by audio book, then neutral music; with no music providing the least positive FS ratings overall. At no point did her feelings become negative (i.e., rated below 0). The motivational music condition ($d = 2.12$) was associated with more positive feelings than no music, and the other two conditions.

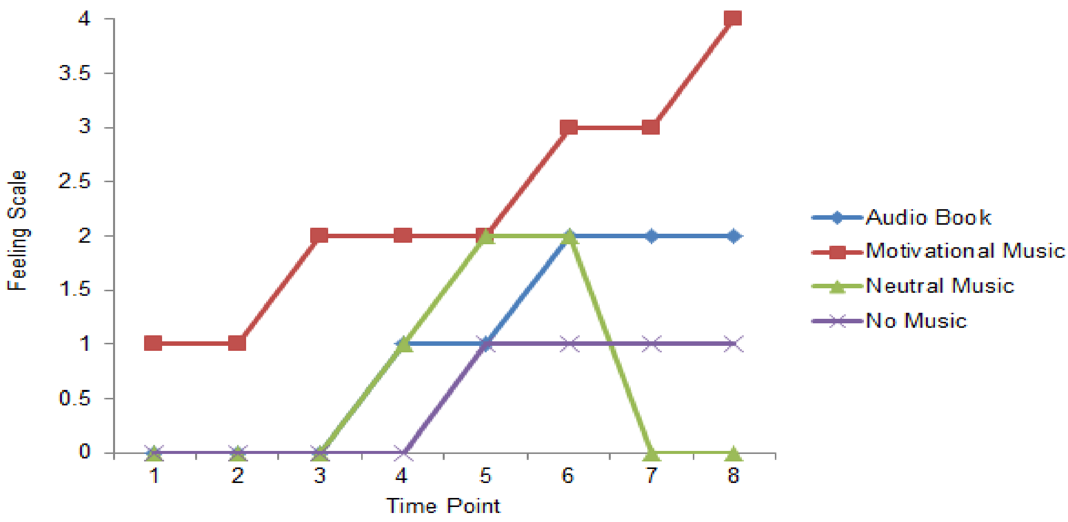

Figure 4.4. Athlete 2: Change in feelings over 20 km course per condition.

4.5.3 Perceived exertion. Athlete 1 reported working harder at a progressively increased rate with motivational and neutral music, with no music and audio book showing more inconsistent RPE scores (i.e., with peaks and troughs; see Figure 4.5). In the motivational music condition the athlete performed faster for the same RPE as the neutral music condition.

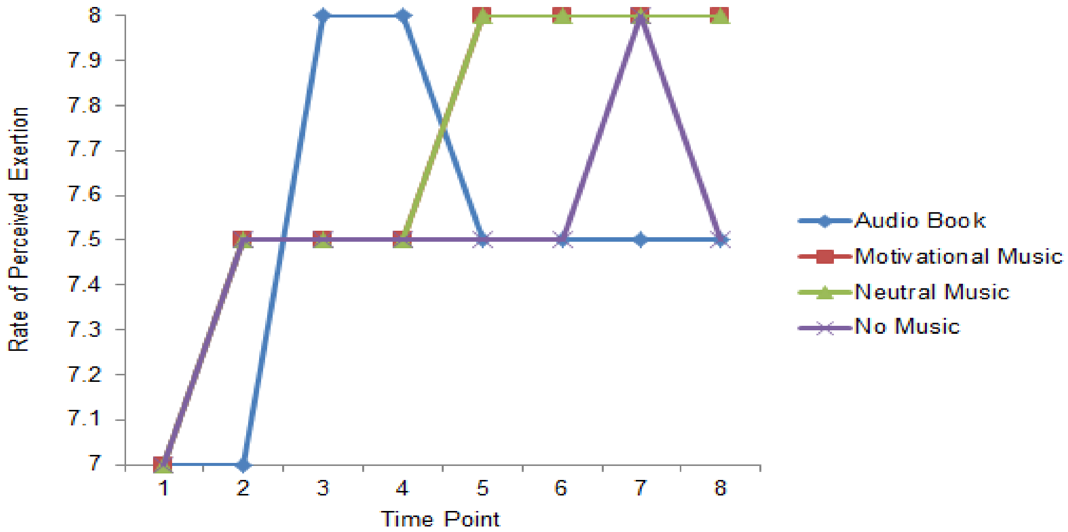

Figure 4.5. Athlete 1: Changes in perceived exertion over 20 km course by condition.

Athlete 2's perceived exertion was greater in the no music condition (see Figure 4.6). Overall, progressively higher RPE was reported over the 20 km course. The motivational music condition found Athlete 2 performing faster for a similar RPE.

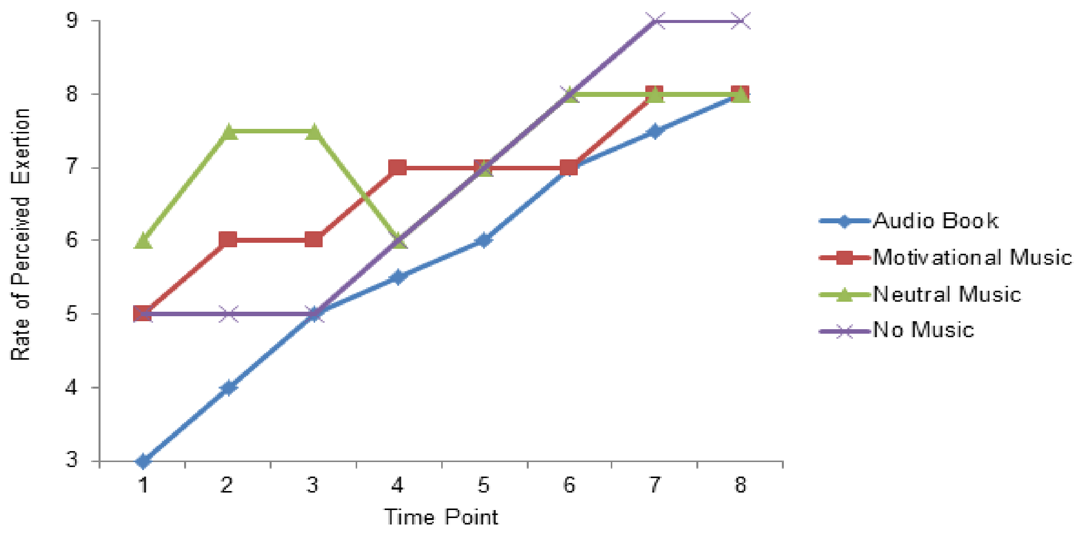

Figure 4.6. Athlete 2: Changes in perceived exertion over 20 km course per condition.

4.5.4 Heart rate. Athlete 1 showed a steady increase in HR across the conditions with the highest HRs reported in the audio book condition (Figure 4.7). Motivational (d = .58) and neutral music (d = .93) were associated with lower HRs compared to no music, despite quicker completion times. The athlete's HR range was between 115 and 140 bpm even at the end of 20 km.

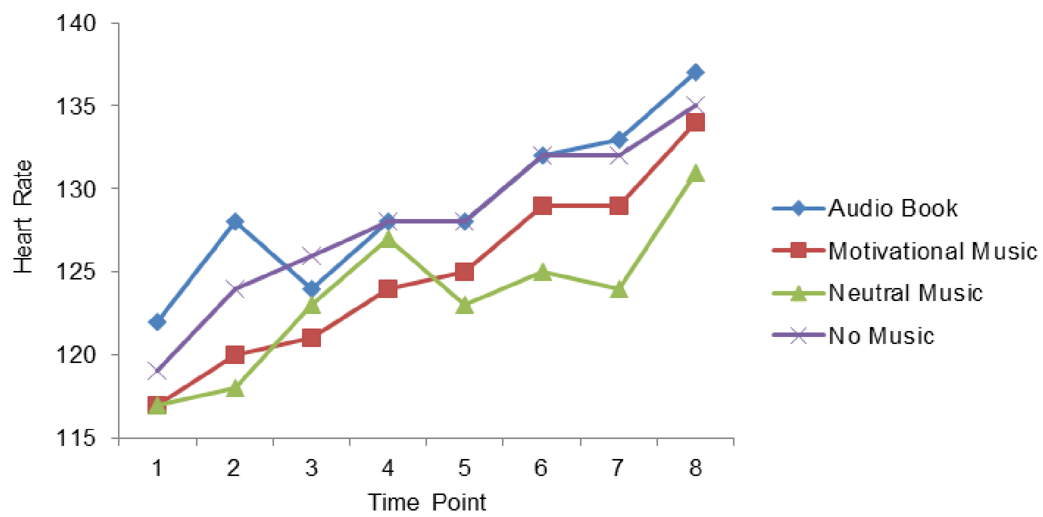

Figure 4.7. Athlete 1: Changes in heart rate over 20 km course per condition.

Athlete 2 showed a steady increase in HR for the motivational and neutral music conditions (see Figure 4.8). Her HR was highest in the no music condition. Although her HR was higher overall in the motivational (d = .62) and neutral music (d = .28) conditions compared to no music, these conditions yielded faster course completion times.

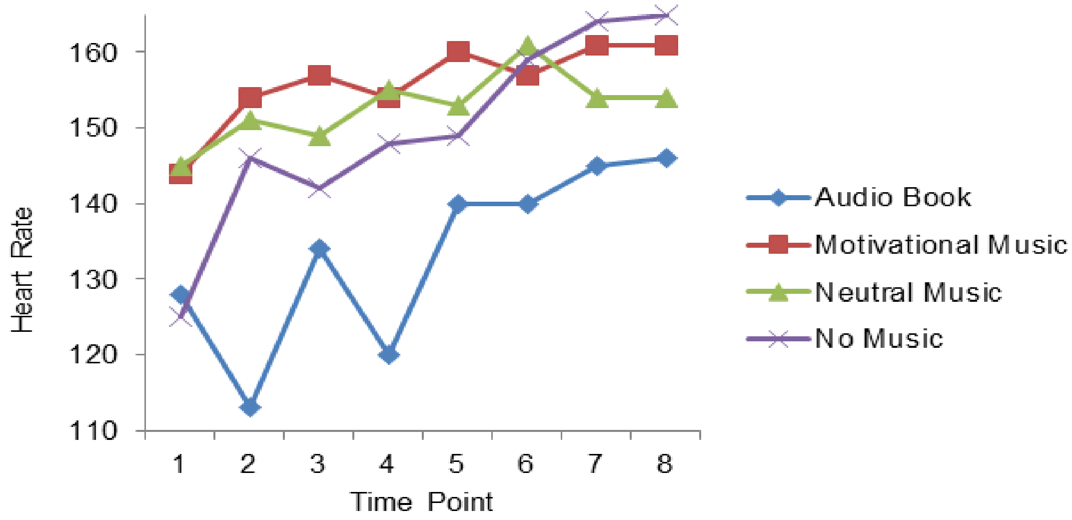

Figure 4.8. Athlete 2: Changes in heart rate over 20 km course per condition.

4.5.5 Mood. Overall, both athletes reported very stable positive moods throughout the study. Athlete mood changes are reported for vigour and fatigue only as all other scores were zero at both time points. The temperament of an ultra-athlete lends itself to limited mood changes overall. Consistent with this is the zero scores at both time points for tension, depression, anger, and confusion. Anticipated individual differences in mood responses to the four conditions were demonstrated.

Athlete 1 reported post training vigour to be greater in the music conditions compared to the no music and audio book conditions (see Figure 4.9). Fatigue was greater for the no music and audio book conditions, with lower levels reported for motivational and neutral music.

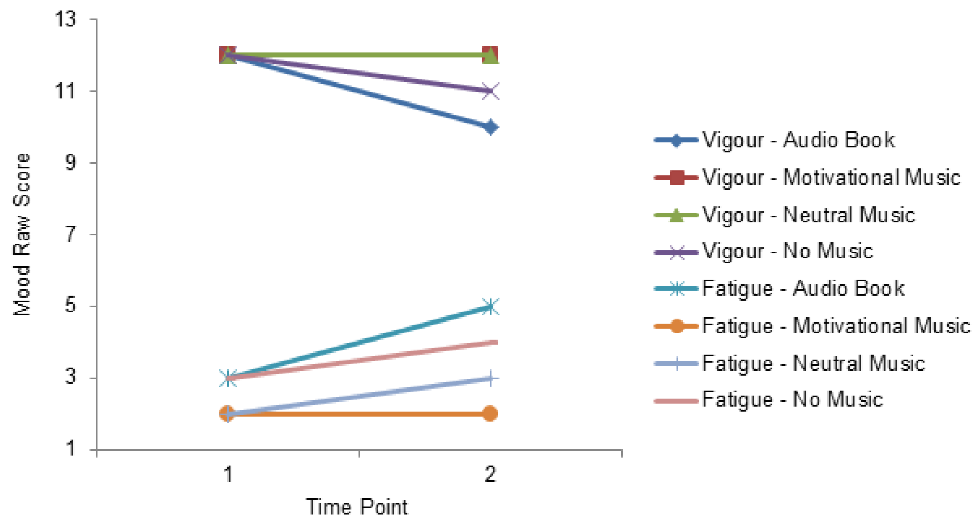

Figure 4.9. Athlete 1: Mood responses pre- and post-training per condition. *Note.* Time point 1 = pre-training, 2 = post training.

Athlete 2 presented at training with a larger range of pre-training scores for vigour and fatigue (see Figure 4.10). Motivational music showed increases in both fatigue and vigour from pre- to post-training. All other conditions found a decrease from pre- to post-training in fatigue combined with an increase in vigour. Overall, for Athlete 2, mood responses were more positive for the two music conditions when compared to audio book and no music.

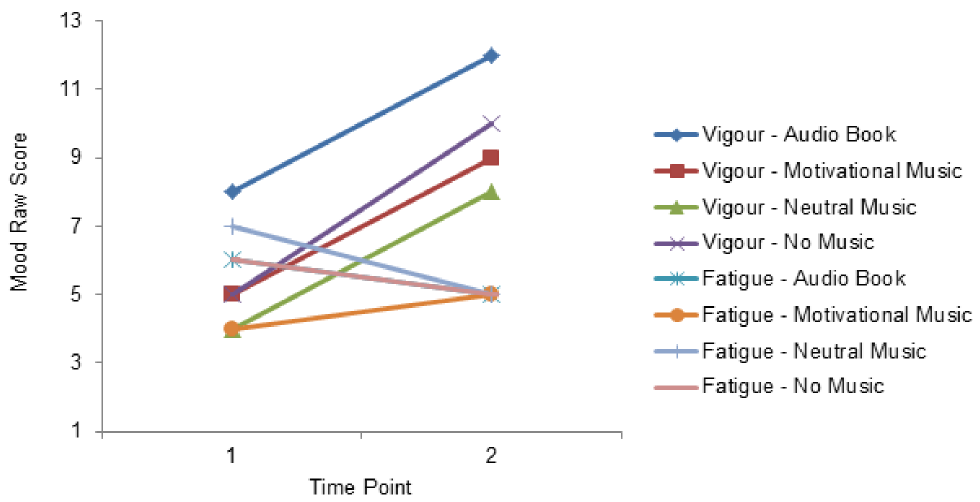

Figure 4.10. Athlete 2: Mood responses pre- and post-training per condition. *Note.* Time Point 1 = pre-training, 2 = post training.

4.5.6 Anecdotal reports. Both athletes reported overall improvements with synchronous music. Athlete 1 reported "*I just wanted the audio book to finish, it wasn't a good distraction*"; "*I never thought there would be a difference with the music being in time with my stride but it makes you run in time*"; and Athlete 2 reported "*I can't believe that session is over already",* "*I just felt more in sync*"; "*the time went quicker*"; "*that audio book was surprisingly rhythmic*"; and "*the neutral music just didn't quite do it*" comparing it to motivational music.

Table 4.1

Case Study Results for Two Athletes by Intervention Type, Including Outcomes by Time Point (N = 2)

Athlete ID	Intervention Type	HR 1	TIME 1	RPE 1	FS 1	HR 2	TIME 2	RPE 2	FS 2	HR 3	TIME 3	RPE 3	FS 3	HR 4	TIME 4	RPE 4	FS 4
1	1	144	745	5.0	1.00	154	783	6.0	1.00	157	713	6.0	2.00	154	796	7.0	2.00
1	2	145	780	6.0	0.00	151	820	7.5	0.00	149	828	7.5	0.00	155	730	6.0	1.00
1	3	128	910	3.0	0.00	113	942	4.0	0.00	134	855	5.0	0.00	120	940	5.5	1.00
1	4	125	777	5.0	0.00	146	860	5.0	0.00	142	755	5.0	0.00	148	848	6.0	0.00
2	1	117	851	7.0	3.50	120	954	7.5	3.50	121	864	7.5	3.00	124	931	7.5	3.00
2	2	117	897	7.0	3.50	118	984	7.5	3.00	123	883	7.5	3.00	127	969	7.5	3.00
2	3	122	873	7.0	3.00	128	986	7.0	3.00	124	898	8.0	3.00	128	974	8.0	3.00
2	4	119	893	7.0	3.00	124	968	7.5	3.00	126	888	7.5	3.00	128	978	7.5	2.50

Table 4.1 continued

Athlete ID	Intervention Type	HR 5	TIME 5	RPE 5	FS 5	HR 6	TIME 6	RPE 6	FS 6	HR 7	TIME 7	RPE 7	FS 7	HR 8	TIME 8	RPE 8	FS 8
1	1	160	740	7.0	2.00	157	796	7.0	3.00	161	724	8.0	3.00	161	781	8.0	4.00
1	2	153	803	7.0	2.00	161	746	8.0	2.00	154	774	8.0	0.00	154	759	8.0	0.00
1	3	140	851	6.0	1.00	140	911	7.0	2.00	145	815	7.5	2.00	146	894	8.0	2.00
1	4	149	771	7.0	1.00	159	820	8.0	1.00	164	729	9.0	1.00	165	813	9.0	1.00
2	1	125	848	8.0	3.00	129	920	8.0	3.00	129	856	8.0	3.00	134	936	8.0	3.00
2	2	123	891	8.0	3.00	125	979	8.0	3.00	124	889	8.0	2.50	131	990	8.0	2.50
2	3	128	880	7.5	2.50	132	975	7.5	2.50	133	902	7.5	2.50	137	983	7.5	2.00
2	4	128	887	7.5	2.50	132	970	7.5	2.50	132	878	8.0	2.50	135	978	7.5	3.00

Note. Athlete ID: 1 = runner, 2 = walker; HR = HR; Time = Time taken to complete half loop in seconds; RPE = RPE; FS = FS; Time points 1-8: 1 = First 2.3 km, 2 = First 5 km, 3 = Second 2.3 km, 4 = Second 5 km, 5 = Third 2.3 km, 6 = Third 5 km, 7 = Fourth 2.3 km, 8 = Fourth 5 km.

4.6 Discussion

The aim of Study 2 was to assess effects of music in a field setting among two ultra-distance athletes; a population that regularly stretch their physiological and psychological capabilities to their limits. The format of the study also allowed for the testing of protocols in preparation for Study 3.

Overall, it was found that motivational music provided the athletes with improved performance, psychological, physiological, and RPE benefits when compared to the no music and audio book conditions, finding support for the demonstrated benefits of music extending to field settings. Additionally, the disparity in results per athlete provided support for individual differences in outcomes previously found in music in sport and exercise research (Cohen et al., 2007; Doiron, Lehnhard, Butterfield, & Whitesides, 1999). The lack of psychological intervention research among ultra-athletes has begun to be addressed by this study, providing an alignment source for the biomedical studies in the field.

In addition to the music condition gains identified in the study, including their extension to race environments, the protocol showed itself to be a useful practical application. The ability for coaches to fine tune music prior to the commencement of a race, allows for the individual tailoring of music to maximise the outcomes for athletes. Differences in psychological responses have been found between music conditions, highlighting the importance of using optimal music selection procedures to maximise the desired outcome.

Music choice is very personal and has been found to be related to the individual's age, sex, and, perhaps surprisingly, income rather than personality (North, 2010). North (2010) also found gender differences in the reasons reported for listening to a particular musical style; with males emphasising the ability of the music to create an image for them and to please friends, and females reporting using music as a source of enjoyment and in the management of emotions.

4.7 Results Informing Study 3 Methods

Music preparation time was extensive in the current study and has implications for the time protocols set for Study 3. The sheer volume and specificity required for the use of synchronous music was underestimated by the researcher and pre-race time management and technology skills were the predominant protocol outcomes drawn from the current research. Additional to this, the means of providing athletes with a mechanism to review songs, and scoring procedures for doing so, were fine-tuned with a more consistent process formulated for use in Study 3. The increased number of athletes and subsequent music choices used in Study 3 would not have been as effectively managed without the process evaluation that occurred in Study 2.

Independent of its utility for Study 3, the case study provided further support for the demonstrated benefits of music with an extension to field settings. Performance, psychological, psychophysical, and physiological gains obtained in a training environment provide a benchmark for the racing setting used in Study 3.

Chapter 5 – Study 3

5.1 Introduction

This field experiment extended the research completed in Study 2 to test the effects of four interventions in a race setting. Nine elite ultra-athletes were assessed for effects of music in 6 hour, 24 hour, and 48 hour races. Athletes were provided with one, two, or four intervention sessions of six hours each, depending on the length of the race, with a rotating playlist of 30 minute intervals per intervention; namely, synchronous motivational music, synchronous neutral music, audio book, and no music. The aim of the study was to examine the effects of music on performance times, physiological functioning assessed via HR, and psychological responses assessed via FS, RPE and BRUMS scales. It was anticipated that further support would be found for the benefits of synchronous music in sport and exercise.

5.2 Overview of Study Aims and Hypotheses

This study aimed to assess if the ergogenic effects of music could be extended to race settings, among athletes who stretch their physiological and psychological capabilities to their limits.

The hypotheses tested were:

1. That both synchronous music conditions will be associated with significant benefits to performance, in-task physiological functioning and psychological responses over the audio book and no-music conditions.
2. That motivational synchronous music will show benefits over neutral synchronous music.

5.3 Method

5.3.1 Participants. Athletes from three races organised by the Australian Ultra Runners Association were approached to participate in the research. Race directors were contacted to obtain authorisation to complete research at the individual races. Athletes were recruited via electronic means including email, Facebook, twitter, www.coolrunning.com.au forums, and referral from other athletes. Across the three events, 10 athletes (male = 6, female = 4) were recruited for the research, with a mean age of 48 years (age range = 35-63 years). A combination of walkers (2) and runners (8) were included. One female runner withdrew from her race prior to the completion of sufficient data points to warrant inclusion. Of the remaining nine athletes, two performed twice so Study 3 reports data from 11 race performances (see Table 5.1).

Table 5.1

Athlete Identifiers, Gender, Age, Cadence, and Race Participation

Athlete Number	Gender	Age	Previous music use	Cadence (steps per minute)	Race participation
1	M	55(W)	No	145	Coburg 24 hour & Caboolture 48 hr
2	M	63	No	145	Coburg 24 hour & Caboolture 48 hr
3	M	50 (W)	Yes	150	Coburg 24 hour
4	M	35	No	90	Sri Chinmoy 6 hour
5	F	51	Yes	166	Sri Chinmoy 24 hour
6	M	46	No	168	Sri Chinmoy 24 hour
7	M	59	Yes	165	Sri Chinmoy 24 hour
8	F	41	Yes	165	Caboolture 24 hour
9	F	39	Yes	160	Caboolture 48 hour
10	F	Not specified	Not specified	180	Caboolture 24 hour (withdrew ill)

Note. (W) Denotes a walker.

5.3.2 Apparatus and measures.

5.3.2.1 Music selection instrumentation. The motivational qualities of potential music selections were rated using the BMRI-2 (Karageorghis et al., 2006; see Appendix F). Athletes rated if the style of each track would motivate them in relation to its rhythm, style, melody (tune), tempo (speed), sound of the instruments, and beat of the music. This single-factor, six-item instrument is considered to have psychometric properties that are superior to its predecessor, the original BMRI, with a mean Cronbach alpha coefficient for the single factor of .89 (Karageorghis et al., 2009). The scale is scored by participants on a 7-point Likert scale from 1 (*strongly disagree*) to 7 (*strongly agree*).

5.3.2.2 No music control condition. Audacity(R) version 1.2.6 recording and editing software was used to produce 30 minutes of complete silence for use in the no music control condition.

5.3.2.3 Non-music distraction. Audio books including *HRH* by Danielle Steel were used as the distractor intervention.

5.3.2.4 Music delivery apparatus. The music was delivered through iPod Nano™ devices carried using Belkin easy fit armbands. Headphones were attached to the relevant apparatus with over the ear attachments to provide maximum comfort. Athletes 8 and 9 requested that the music be loaded to their own iPod™ device, and this was achieved prior to the race.

5.3.2.5 Performance measurement. Lap times were recorded at each event by official lap scorers. The Coburg and Caboolture races provided electronic data, whereas Sri Chimnoy operated on a manual scoring basis requiring results to be transferred from the paper based format to an electronic spread sheet for analysis purposes.

5.3.2.6 Heart rate measurement. HR was measured using a chest strap to wrist receiver system. The majority of the athletes used researcher-provided (Polar) devices, with two athletes opting to use their own devices.

5.3.2.7 Perceived exertion measurement. The RPE scale (see Appendix J; Borg, 1998) is an incremental assessment of perception of their exertion levels, between 0 (*rest*) and 10 (*maximum effort*).

5.3.2.8 Feelings measurement. Hardy and Rejeski's (1989) bipolar Feeling Scale (see Appendix I) was used to measure in-task affect. The FS is an 11-point, single-item scale ranging from +5 (*very good*) to -5 (*very bad*) with a mid-point of 0 (*neutral*).

5.3.2.9 Mood measurement. The Brunel Mood Scale (BRUMS; Terry, A. Lane, H. Lane, et al., 1999; Terry, A. M. Lane, et al., 2003) was used to assess mood state. The 24-item BRUMS (see Appendix H) takes 1-2 minutes to complete and uses a 5-point response scale (0 = *not at all*, 1 = *a little*, 2 = *moderately*, 3 = *quite a bit*, 4 = *extremely*). The standard timeframe used when responding is "*How you feel right now*" (Terry, A. Lane, H. Lane, et al., 1999; Terry, A. M. Lane, et al., 2003). There are six subscales (anger, confusion, depression, tension and vigour) with four items in each subscale.

5.3.2.10 Cadence measurement. Individual athletes measured their cadence by completing three trials of running or walking and counting the beats within a 1-minute period.

5.3.2.11 Location. The research was undertaken at three different events:

1) 17-18 April 2010 – Harold Stevens Athletic Track, Coburg, Melbourne—10 am start—24 hour race—400 metre artificial surface, purpose-built track.
    - Victorian 24 hour track championship

- Australian Centurion event
- Australian 100 km walk championship for men
- Australian 100 km walk championship for women
- IAU bronze road label, qualifying race for IAU 24 hour World Challenge

2) 19-20 June 2010 – Sri Chinmoy 24 hour race—University of Queensland Athletics Track, St Lucia, Brisbane—9 am start—6/12/24 hour races—400 metre synthetic track.

- AURA National 24 hour championships

3) 30 July – 1 August 2010 - Caboolture 6/12/24/48 hour races—Caboolture Historical Village, Caboolture—9 am start—500 metre decomposed granite loop.

- AURA 48 hour championship
- IAU bronze road label, qualifying race for IAU 24 hour World Challenge

5.3.3 Procedure. Ethics approval was gained from University of Southern Queensland Ethics Committee for Human Research Approval No. H09REA148. Participants signed the participant information and consent form (see Appendix K).

5.3.3.1 Performance measurement procedure. Lap times were recorded at each event by official lap scorers. As each event was an accredited IAAF race it was deemed that the scoring process did not warrant researcher review and lap sheets were obtained from race directors after the event for each participant.

5.3.3.2 Music selection procedure. Initially, athletes were requested to provide the researcher with a list of music preferences either by song or artist to enable a compilation of suitable playlists for review by the athlete (see Table 5.2 for individual athlete's music preference). After being provided with this list, and the cadence of athlete, the researcher downloaded each song from the list. To ensure sufficient music was available to work with, an initial pool was required that included, on average, approximately 250 songs per athlete.

Where insufficient songs with the correct tempo were identified from these initial lists, participants were asked to provide specific musical genres (e.g., pop, rock, classical) that were considered when identifying appropriate music tracks for the motivational and neutral music conditions. The breadth of music genre, and the consistency of the anticipated choice of music as per the participant's age, did not present a pattern constituting response bias in choice of music. The researcher used Google searches (e.g., motivational music, Top 100), and input from regular music listeners to gauge music titles suitable for download and consideration. As synchronous music was essential, tracks approximating each athlete's preferred cadence range were filtered via Virtual DJ (Atomix Productions, Los Angeles, USA) to identify those within ±4 bpm of the reported cadence. This ensured that there would be no noticeable attenuation in fidelity of the sound when the tempo of the tracks was modified slightly to match individual athlete cadence exactly.

Table 5.2

Examples of Preferred Artists for Each Participating Athlete

				Athlete				
1	2	3	4	5	6	7	8	9
Queen	The Rolling Stones	Celine Dion	Elvis Presley	Florence and the Machine	Bob Dylan	Willie Nelson	Beck	Joe Cocker
The Doors	Benny Mardones	Tom Petty & the Heartbreakers	Morrissey	AC/DC	Siguendo la luna	Johnny Cash	Ween	Matchbox 20
Rolling Stones	Celine Dion	AC/DC	The Smiths	Chemical Brothers	Jimmy Barnes	Elvis Presley	Adam & the Ants	On Hit Wonder
The Beatles	Led Zeppelin	Cold Chisel	The Editors	Akon	INXS	The Drifters	Hilltop Hoods	Frankie Goes to Hollywood
AC/DC	Rolling Stones	Pink Floyd	Drake	Mumford & Sons	Angels	Randy Travis	Electric Six	John Mayer
Hunters & Collectors	Susan Boyle	Rolling Stones	Jay Electronica	Bruce Springsteen	Ian Moss	George Strait	50 cent	Twisted Sisters
Pink Floyd	Il Divo	Led Zeppelin	Nipsey Hussle	Van Halen	Noiseworks	Garth Brooks	REM	Hootie & the Blowfish
Led Zeppelin	The Ten Tenors	Bob Dylan	Corey Gunz	Franz Ferdinand	Skyhooks	Kenny Rogers	The Cure	Goo Goo Dolls
Split Enz	Placido Domingo	The Cure	Jay Z	Fergie	John Farnham	The Beatles	Cat Stevens	Counting Crows

Note. All athletes had *I Would Walk 500 Miles* by The Proclaimers as part of their playlists.

Song choices were rated by athletes for their motivational qualities using the BMRI-2. Individual results were collated and sorted into motivational (rated ≥ 36 on the BMRI-2 out of a possible range 6-42) and neutral (rated 18-30) music playlists of 26 songs each for the respective conditions. Each athlete was provided with various 6 hour interventions dependent upon the length of the race: with either one (6 hour race), two (24 hour race), or four (48 hour race) periods. Intervention conditions were provided to the athletes in the order shown in Table 5.3. To minimise interruption, each athlete's device was loaded with the full six hours for each intervention segment.

Table 5.3

Delivery Order of Interventions Segments per Intervention Period

Hour	Intervention conditions
0.5	Audio book
1.0	Neutral
1.5	No music
2.0	Motivational
2.5	Audio book
3.0	Neutral
3.5	No music
4.0	Motivational
4.5	Audio book
5.0	Neutral
5.5	No music
6.0	Motivational

Virtual DJ (Atomix Productions, Los Angeles, USA) provides the user with a function to record multiple songs as one playlist. Songs were individually entered into the program, adjusted to the individual athlete's designated stride rate, provided the original version was ±4 bpm of the stride rate, and then recorded in real-time. While one song was being recorded another was loaded into the program (two virtual turntables are provided; see Appendix B) and adjusted to the required bpm. At the conclusion of each song the next song is faded in. This task was repeated until a period of 30 minutes was recorded in each intervention condition even if mid-song. This process was replicated per music condition (motivational and neutral) for each athlete. The music file was then loaded into iTunes™ and synchronised with the relevant iPod™ technology. The participants adjusted music volume to a comfortable level.

Athletes were provided with an intervention segment for the entirety of their race if in a 6 hour race; between hours 6-12 and 18-24 for a 24 hour race; and hours 6-12, 18-24, 30-36, and 42-48 for a 48 hour race. The four intervention conditions were motivational music, neutral music, audio book, and no music, with each intervention of 30 minutes duration. The per race music requirements were 52 songs (6 hour race), 104 songs (24 hour race), and 208 songs (48 hour race; see Table 5.4). The two athletes who competed in both the 24 and 48 hour races required a total of 312 songs. A total of 1,456 songs were processed through Virtual DJ, totalling approximately 85 hours of real-time recording of music by the researcher for Study 3. Overall the search procedure, downloading of music, checking each song individually through Virtual DJ for assessment of tempo, preparation of spread sheets, loading into sharing folders (an electronic folder accessible in different locations by both researcher and athlete), scoring responses, and allocation of songs exceeded 500 hours of work by the researcher. With each athlete requiring about 3 hours to rate music, and taking into account the recording time, use of self-selected synchronous music for the present study required a time commitment in excess of 600 hours.

Table 5.4

Number of Songs Required per Race

Race duration	Condition	Intervention periods	Songs per athlete
6 hour	Motivational music	1	26
	Neutral music	1	26
24 hour	Motivational music	2	52
	Neutral music	2	52
48 hour	Motivational music	4	104
	Neutral music	4	104
24 & 48 hour	Motivational music	6	156
	Neutral music	6	156

Note. Average song is 3.5 minutes; 90/3.5 = approximately 26 songs required per athlete per intervention period.

5.3.3.3 No music and distractor procedure. The no music condition was delivered as an item on the playlist for each individual athlete. The condition was developed using Audacity software by choosing the Generate option within the software → selecting the silence generator → providing a time frame for period to be recorded (i.e., 30 minutes) → and finally exporting the file into the format necessary for the playlist.

The distraction intervention was designed to assess whether music functions purely as a distraction or provides additional benefits. The audio books were chosen by the researcher for the consistency of the voice reading the story and the regular pace of the reading. They were downloaded from disc to iTunes™ and then synchronised with the relevant iPod™ technology for delivery to the athletes. *HRH* was the only audio book used in the Coburg and Sri Chinmoy races, with athletes being provided with a choice of four books in the Caboolture race. Consistent with the music condition, the distractor condition ran for 30 minutes. Although it was initially expected that the audio books would need to be altered with Virtual DJ as described above, this was unnecessary as the subchapters were able to be combined into 30 minute blocks without modification.

5.3.3.4 Heart rate measurement procedure. HR monitors were attached to the athletes prior to each race. At each 30 minute juncture throughout the races the researcher presented at the side of the track and as they passed the athletes read their HR from the wrist receiver and verbally provided it for recording on the Record Keeping Sheet (sees Appendix D). In the case of Athlete 8 the HR monitor stopped working during the race, and consequently her HR data were not obtained.

5.3.3.5 Perceived exertion measurement procedure. Prior to testing, participants were provided with identical instructions regarding the use of Borg's RPE scale (Borg, 1998). Consistent with HR reporting times, the athletes also provided their RPE to the researcher for noting on the Record Keeping Sheet (see Appendix D).

5.3.3.6 Feelings measurement procedure. Prior to testing, participants were provided with identical instructions regarding the use of Hardy and Rejeski's (1989) Feeling Scale (FS). Participants were asked to report how they were feeling according to the FS at the same time periods as providing their HR and RPE for the researcher to record on the Record Keeping Sheet (see Appendix D). The athletes found it difficult to use the FS, which ranges from +5 (*very good*) to -5 (*very bad*) with a mid-point of 0 (*neutral*). Athletes adopted a model for the FS of 0 (*very bad*) to 10 (*very good*) with this change maintained through all races for consistency. Adjustments were made at the analysis stage to align athletes' ratings to the original scale ranges.

5.3.3.7 Mood measurement procedure. Participants completed the BRUMS (Terry, A. Lane, H. Lane, et al., 1999; Terry, A. M. Lane, et al., 2003) at a number of time points throughout the races (i.e., pre-race, 6 hours, 12 hours, 18 hours, 24 hours, 30 hours, 36 hours, 42 hours, and post-race) relevant to their race length. They completed the survey using the standard response timeframe of "*How do you feel right now*". Discussion with athletes prior to each race resulted in the consistent decision to opt for a slow lap to fill out the form whilst continuing to complete the course.

5.3.3.8 Record management procedure. All recordings were completed by the researcher with the exception of two 30 minute timeslots within each 24 hour period where either the race director (at the Coburg and Sri Chinmoy races) or a research assistant (Caboolture race) completed this task, whilst the researcher took a rest break. Data recorded were reviewed for consistency after each of these changes and was deemed to be acceptable. These breaks were taken after significant race time had elapsed, ensuring that the athletes were already familiar with the testing protocol.

5.4 Data analysis

The preparation of the data for analysis underwent several stages to ensure accuracy of results. Initially, the lap time data from each race was input into an excel spread sheet on a per athlete basis. The data were provided by race directors in a number of different formats. Coburg data was provided in a spread sheet with cumulative progression times necessitating the use of Excel formulations to convert each score into an individual lap time. Sri Chimnoy data were provided in paper form with cumulative progression times necessitating the manual input into Excel and conversion into individual lap time scores, using the same formulations as used for the Coburg race. Caboolture was provided in an Excel spread sheet of lap times; the course for this race was 500 m with conversion of lap times into their 400 m equivalent. After all lap times per athlete per race were completed, they were converted from minutes to seconds. It must be noted at this point that the use of Excel for this process carries a degree of potential human error.

The nature of these races often finds the athlete struggling to continue or finds them deliberately slowing right down, with these variations having the potential to skew the results. Each athlete's lap times were tested for outliers, which were removed, resulting in a data set that was a better reflection of the athlete's mean lap times for their performance. These results were then inputted into SPSS for further analysis.

All other outcome measures were also collated into SPSS from individual score sheets. Analysis of the mean lap time, FS, RPE, and HR scores for the four interventions was conducted using multivariate analysis of variance (MANOVA) for group and individual athlete results. Post hoc pairwise comparisons were completed using Tukey's HSD.

Results are presented for the group as a whole then as individual results. Individual results were predominantly reported for the first two interventions only (6-12 and 18-24 hours) due to low numbers in the third (30-36 hours) and fourth intervention (42-48 hours) periods. The last intervention period was not shown in the group results as it produced insufficient data points to warrant comparison to other periods. Coefficient of variation (CoV) was used as a normalised measure of dispersion of lap times; calculated as the ratio of the standard deviation to the mean. A lower CoV equates to greater consistency in lap times. As a result of the large number of data points (3,735) in the study, a decision was made to present the overall statistics for review, with the addition of a sample of individual statistics, but not all of them, in order to highlight individual differences in outcomes.

5.5 Results

5.5.1 Overall results. A summary of the distances completed and finish position is presented in Table 5.5.

Table 5.5

Distance Completed and Finish Position per Athlete

Athlete Number	Event	Length of Race (Hours)	State	Distance Completed (km)	Finish Position
1	Coburg	24(W)	QLD	171.968	1
	Caboolture	48(W)		280.203	2
2	Coburg	24	NSW	153.009	7
	Caboolture	48		182.849	7
3	Coburg	24(W)	QLD	119.690	4
4	Sri Chimnoy	6	QLD	57.5162	1
5	Sri Chimnoy	24	NSW	178.6413	2
6	Sri Chimnoy	24	QLD	190.9355	2
7	Sri Chimnoy	24	QLD	169.8143	2
8	Caboolture	24	VIC	182.705	2
9	Caboolture	48	NSW	228.183	5
10	Caboolture	24	WA	DNF	N/A

Note. Coburg placing per walker/runner. Sri Chimnoy placing per male/female. Caboolture placing per event (24/48 hour). Did not finish (DNF). (W) denotes a walker.

5.5.1.1 Lap times. The results of Study 3 are shown in Table 5.6. Overall, there was a significant difference between conditions, $F(4, 3875) = 32.871$, $p < .001$. The athletes were found to complete a lap 13 seconds faster with no intervention ($d = .30$ [when compared to no music]; i.e., left to their own devices) than with any of the intervention conditions ($p < .001$). Within the interventions it was found that the no music condition was associated with a one second per lap improvement over the motivational (*d* = .04) and neutral (*d* = .03) music conditions. The audio book intervention was associated with laps that were seven seconds slower than both the motivational (*d* = .14) and neutral (*d* = .16) music conditions.

Table 5.6

Comparison of Lap Times for All Race Performances (N = 11)

Condition	*N*	*M*	*SD*	CoV	CI (95%)
Overall					
Motivational music	634	211.99	46.44	.22	208.36 – 215.61
Neutral music	419	211.52	39.13	.18	207.77 – 215.28
Audio book	392	218.33	44.63	.20	213.90 – 222.76
No music	432	210.31	42.01	.20	206.34 – 214.28
No intervention	2003	197.13	44.44	.23	195.18 – 199.08
First 6 hour intervention					
Motivational music	405	195.47	35.41	.18	192.01 – 198.93
Neutral music	250	194.08	34.55	.18	189.77 – 198.38
Audio book	234	198.76	39.77	.20	193.64 – 203.88
No music	256	192.47	36.53	.19	187.90 – 196.89
Second 6 hour intervention					
Motivational music	140	218.52	37.07	.17	212.32 – 224.71
Neutral music	141	236.95	30.93	.13	231.80 – 242.10
Audio book	135	245.90	33.13	.13	240.26 – 251.54
No music	144	232.69	36.29	.16	226.71 – 238.67
Third 6 hour intervention					
Motivational music	25	273.86	21.96	.08	264.79 – 282.92
Neutral music	27	238.93	27.69	.12	227.98 – 249.89
Audio book	14	239.77	36.91	.15	218.46 – 261.08
No music	20	265.24	23.24	.09	254.36 – 276.12

A significant difference was found between intervention conditions in the second 6 hour intervention (18-24 hours), $F(3, 556) = 15.142$, $p < .001$. The motivational music condition was the most beneficial to the athletes with a 14 second improvement per lap when compared to the next fastest condition, no music (*d* = .39, $p < .01$). Motivational music laps were 18 seconds faster than for neutral music (d = .54, p < .001), and 27 seconds faster than the audio book condition (d = .54, p < .001).

5.5.1.2 Feelings. FS scores for all conditions are shown in Table 5.7. An overall significant difference was found between conditions (p < .01) with post hoc tests showing that athletes felt significantly better in the neutral music condition (d = .81, p < .05) followed by the audio book (d = .77, p < .05) when compared to the motivational music condition. There was no significant difference in feelings found between conditions for the second and third intervention periods.

Table 5.7

Comparison of Feeling Scale Scores for All Race Performances (N = 11)

Condition	*N*	*M*	*SD*	CoV	CI (95%)
Overall					
Motivational music	108	0.63	1.63	2.59	0.32 - 0.94
Neutral music	58	1.85	1.37	.74	1.49 – 2.21
Audio book	58	1.78	1.33	.75	1.43 – 2.14
No music	61	1.66	1.37	.83	1.31 – 2.02
No intervention	258	1.77	1.68	.95	1.56 – 1.98
First 6 hour intervention					
Motivational music	47	0.99	1.51	1.53	0.55 – 1.43
Neutral music	30	1.95	1.30	.67	1.47 – 2.43
Audio book	30	1.93	1.28	.66	1.46 – 2.41
No music	32	1.72	1.21	.70	1.28 – 2.16
Second 6 hour intervention					
Motivational music	20	1.58	1.29	.82	0.97 – 2.18
Neutral music	21	1.62	1.31	.81	1.02 – 2.22
Audio book	21	1.48	1.22	.82	0.92 – 2.03
No music	21	1.60	1.19	.74	1.05 – 2.14
Third 6 hour intervention					
Motivational music	6	1.33	2.71	2.04	-1.52 – 4.18
Neutral music	5	1.90	2.27	1.19	-0.93 – 4.73
Audio book	5	1.90	2.27	1.19	-0.93 – 4.73
No music	6	1.33	2.71	2.04	-1.52 – 4.18

5.5.1.3 Perceived Exertion. RPE scores for all conditions are shown in Table 5.8. An overall significant between-condition difference was identified, $F(4, 506) = 2.863$, $p < .05$ but none of the post hoc pairwise comparisons reached significance. Therefore, no significant differences were found between conditions for any of the intervention periods collectively or individually.

Table 5.8

Comparison of Rate of Perceived Exertion Scores for All Race Performances (N = 11)

Condition	*N*	*M*	*SD*	CoV	CI (95%)
Overall					
Motivational music	104	6.87	1.34	.20	6.60 – 7.13
Neutral music	53	6.85	1.47	.21	6.45 – 7.25
Audio book	54	6.90	1.57	.23	6.47 – 7.33
No music	55	6.84	1.66	.24	6.39 – 7.28
No intervention	245	6.38	1.73	.27	6.16 – 6.60
First 6 hour intervention					
Motivational music	45	6.74	1.58	.23	6.27 – 7.22
Neutral music	28	6.68	1.64	.25	6.04 – 7.31
Audio book	29	6.66	1.77	.27	5.98 – 7.33
No music	29	6.62	1.94	.29	5.88 – 7.36
Second 6 hour intervention					
Motivational music	18	7.22	1.33	.18	6.56 – 7.88
Neutral music	18	6.94	1.16	.17	6.37 – 7.52
Audio book	18	7.11	1.21	.17	6.51 – 7.71
No music	18	6.94	1.17	.17	6.36 – 7.53
Third 6 hour intervention					
Motivational music	6	7.25	1.75	.24	5.41 – 9.09
Neutral music	5	7.00	1.73	.25	4.85 – 9.15
Audio book	5	7.10	1.82	.26	4.84 – 9.36
No music	6	7.08	1.63	.23	5.38 – 8.79

5.5.1.4 Heart rate. HRs for all conditions are shown in Table 5.9. Overall differences in HR between intervention conditions were found to be significant, *F*(4,

447) = 8.706, $p < .001$, for all the interventions periods collectively. HRs during the motivational music condition were significantly lower than for the no music intervention ($d = .52$, $p < .05$) and where there was no intervention ($d = .65$, $p < .001$). No significant differences were found between conditions during any of the intervention periods individually.

Table 5.9

Comparison of Heart Rates for All Race Performances (N = 11)

Condition	*N*	*M*	*SD*	CoV	CI (95%)
Overall					
Motivational music	85	105.40	24.30	.23	100.16 – 110.64
Neutral music	47	114.06	15.80	.14	109.42 – 118.70
Audio book	47	114.49	14.37	.13	110.27 – 118.71
No music	50	115.94	15.66	.14	111.49 – 120.39
No intervention	223	119.64	18.94	.16	117.14 – 122.14
First 6 hour intervention					
Motivational music	29	127.41	16.35	.13	121.20 – 133.63
Neutral music	24	121.50	15.88	.13	114.80 – 128.20
Audio book	24	122.79	11.61	.09	117.89 – 127.69
No music	26	124.42	13.31	.11	119.05 – 129.80
Second 6 hour intervention					
Motivational music	15	109.67	16.98	.15	100.26 – 119.07
Neutral music	16	104.75	12.17	.12	98.27 – 111.23
Audio book	16	104.44	10.27	.10	98.97 – 109.91
No music	16	108.88	12.66	.12	102.13 – 115.62
Third 6 hour intervention					
Motivational music	6	99.17	11.64	.12	86.96 – 111.38
Neutral music	5	106.40	9.94	.09	94.06 – 118.74
Audio book	5	105.40	14.67	.14	87.18 – 123.62
No music	6	99.50	13.07	.13	85.79 – 113.21

5.5.1.5 Mood. Mean mood responses for the athletes are shown in Figure 5.1. Mood scores have been interpreted in accordance with the norms for adult athletes reported by Terry and Lane (2003). The results lend themselves to be reported as observed changes rather than formal statistical analyses. The limited variability in the mood subscales and the clear changes evident in both fatigue and vigour provided opportunity for a clearer observational presentation of the results across time points. A key feature of the overall mood profile for all race performances was the steady increase in fatigue, with its highest level being at the > 80th percentile at 42 hours. A steady decline in vigour was also apparent with the low point also experienced at 42 hours, at the 38th percentile.

Tension levels commenced at a normal level (50th percentile) continuing on a steady decline as the race progressed with a small elevation at the 30 and 42 hour time points, although still within the normal range. The athletes reported higher levels of confusion (58th percentile) combined with increased anger (71st percentile) and increased depression (> 80th percentile) at the 42 hour time period with a drop to near zero for these negative mood dimensions at the post-race stage.

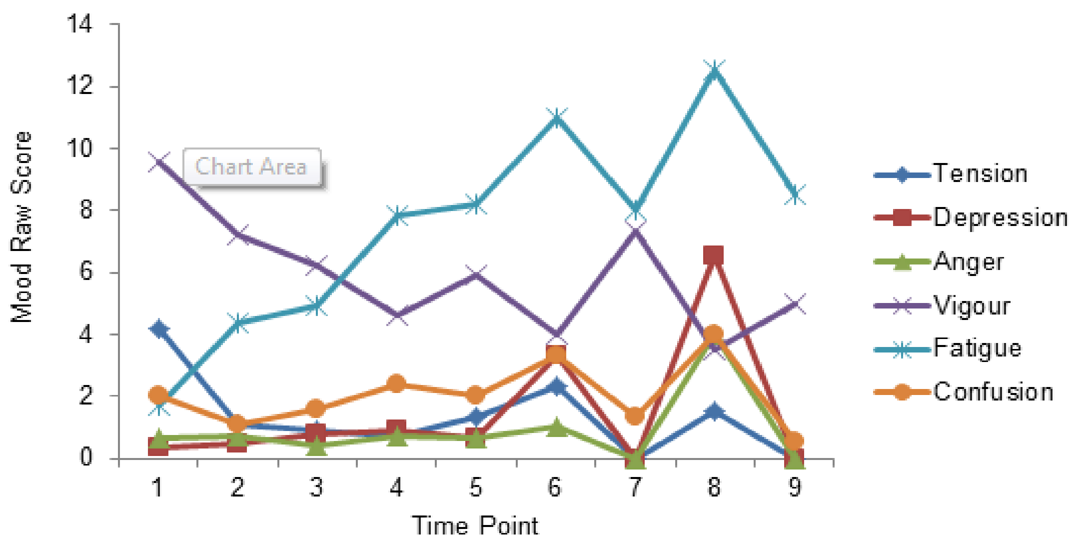

Figure 5.1. Cumulative mean mood scores for all race performances (*n* = 11). *Note.* 1 = Pre-race (*n* = 11), 2 = 6 hours (*n* = 11), 3 = 12 hours (*n* = 10), 4 = 18 hours (*n* = 10), 5 = 24 hours (*n* = 9), 6 = 30 hours (*n* = 3), 7 = 36 hours (*n* = 3), 8 = 42 hours (*n* = 2), 9 = 48 (*n* = 3).

5.5.2 Individual results. It was very evident from a review of the results that there were substantial individual differences across athletes per outcome measure.

As exemplars of these individual differences, results of Athletes 1, 2, & 7 are presented for review. Results are grouped per athlete to aid in inter-outcome comparison.

5.5.2.1 Athlete 1.

5.5.2.1.1 Lap time. Overall there was a significant difference found between conditions for Athlete 1, $F(4, 401) = 43.526$, $p < .001$ (see Figure 5.2). Post hoc tests showed a significant difference between the no intervention periods and all intervention conditions ($p < .001$). Within the intervention conditions, motivational music was found to yield the slowest mean lap time, 37.47 seconds slower than when no intervention was present ($d = -1.38$, $p < .001$), followed consecutively by neutral music (37.08 seconds, $d = -1.35$), audio book (33.06 seconds, $d = -1.22$), and no music (30.44 seconds, $d = -1.25$).

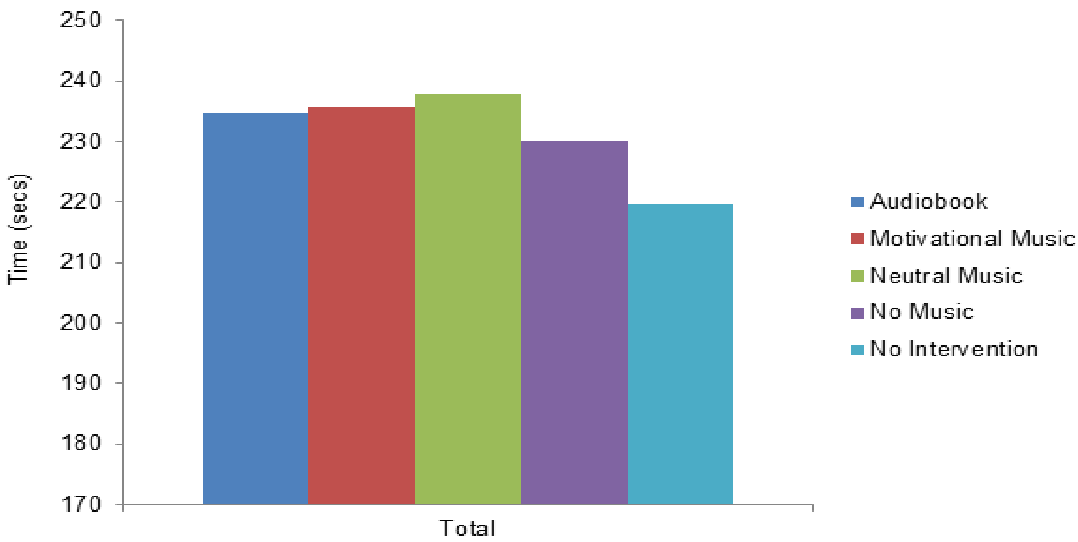

Figure 5.2. Athlete 1: Comparison of lap times per intervention condition.

5.5.2.1.2 Feelings. There was a significant difference found between conditions for FS scores, $F(4, 42) = 4.190$, $p < .01$. The athlete reported feeling better with the audio book, reporting anecdotally that he enjoyed getting back into the story he started in the case study (see Figure 5.3).

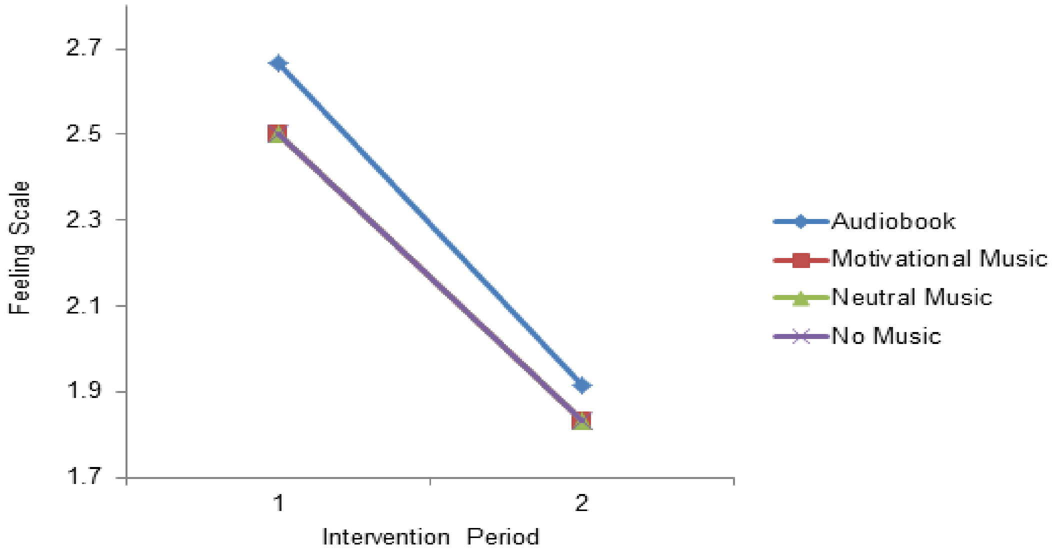

Figure 5.3. Athlete 1: Comparison of feelings responses per intervention period.

5.5.2.1.3 Perceived exertion. A significant difference was found between conditions for RPE, $F(4, 42) = 4.992$, $p < .01$ (Figure 5.4). The athlete reported working significantly harder in the motivational music and audio book conditions when compared to the no intervention periods ($p = .05$).

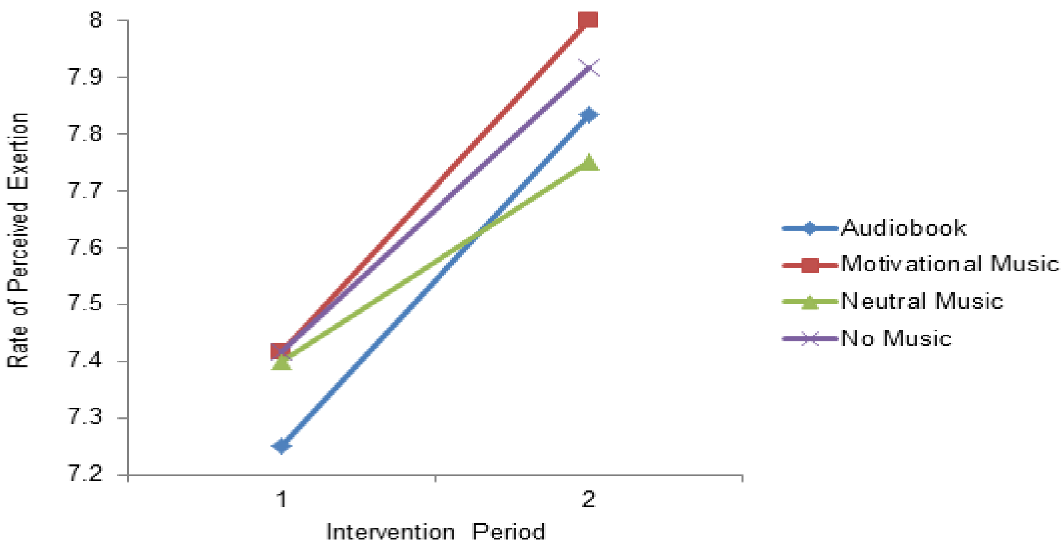

Figure 5.4. Athlete 1: Comparison of perceived exertion responses per intervention period.

5.5.2.1.4 Heart rate. There was no significant difference found between conditions for HR (see Figure 5.5). The athlete was working at a higher output rate for the first intervention period with the audio book but this waned by the second period (see Figure 5.5).

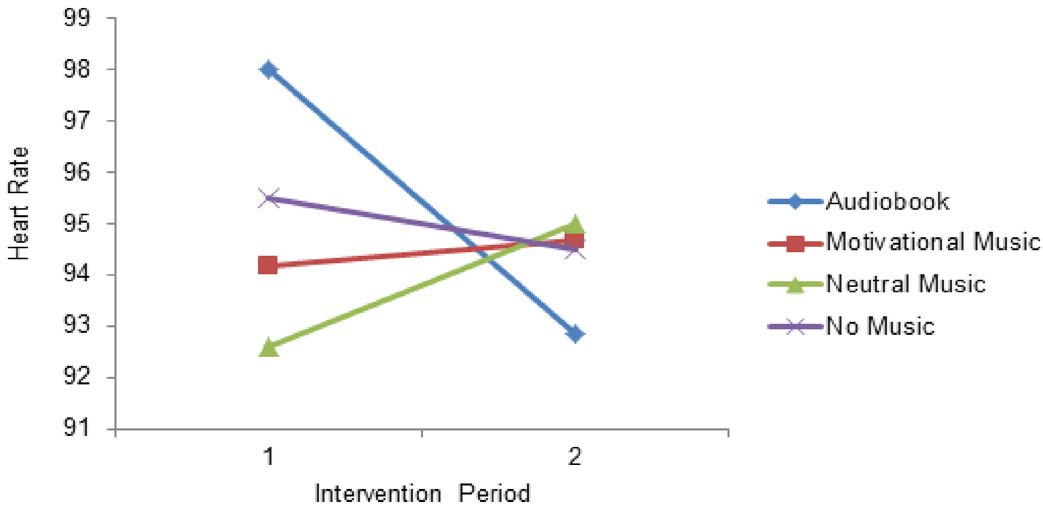

Figure 5.5. Athlete 1: Comparison of heart rate results per intervention period.

5.5.2.1.5 Mood. Athlete 1's profile represents the mean of his mood responses over both the 24 and 48 hour races (see Figure 5.6). Patterns of fatigue and vigour were consistent with overall mood profiles for all athletes. A spike in scores was evident at the 42 hour time point with increases in confusion (74th percentile), depression and anger (> 80th percentile). Although there was a small peak in tension at this point it was still within the normal range. Consistent with overall findings these mood decrements diminished to zero with the completion of the race.

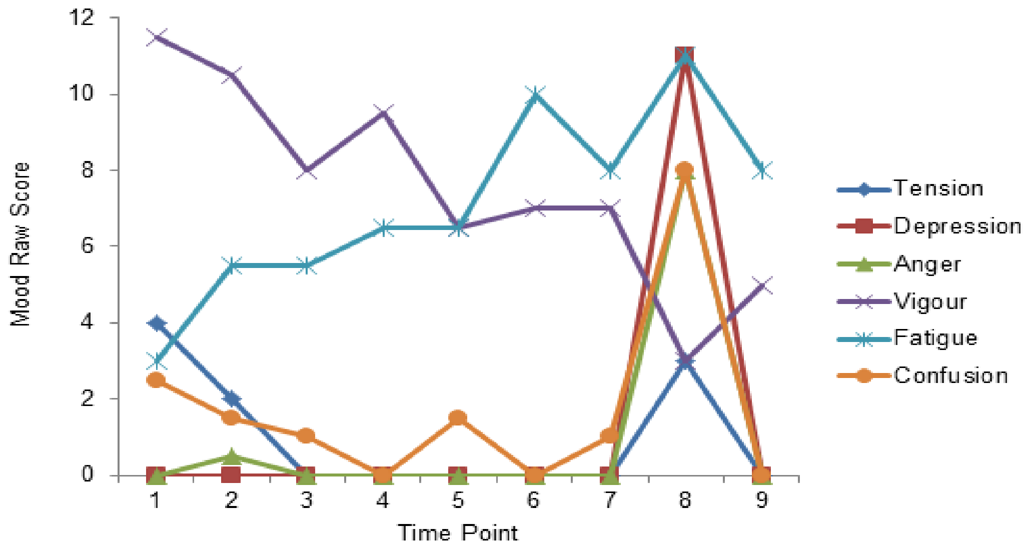

Figure 5.6. Athlete 1: Cumulative mood responses for the 24 and 48 hour races.

5.5.2.2 Athlete 2.

5.5.2.2.1 Lap time. Overall there was a significant difference between conditions for lap time, $F(4, 361) = 7.292$, $p < .001$ (see Figure 5.7). The athlete performed significantly better in the motivational music condition, 31.22 ($d = 1.62$) and 27.28 ($d = 1.14$) seconds faster respectively, when compared to audio book and no music conditions ($p < .001$). The audio book (19.86 seconds, $d = -.61$, $p < .01$) and no music (15.92 seconds, $d = -.45$, $p < .05$) conditions were significantly slower than during the periods of no intervention.

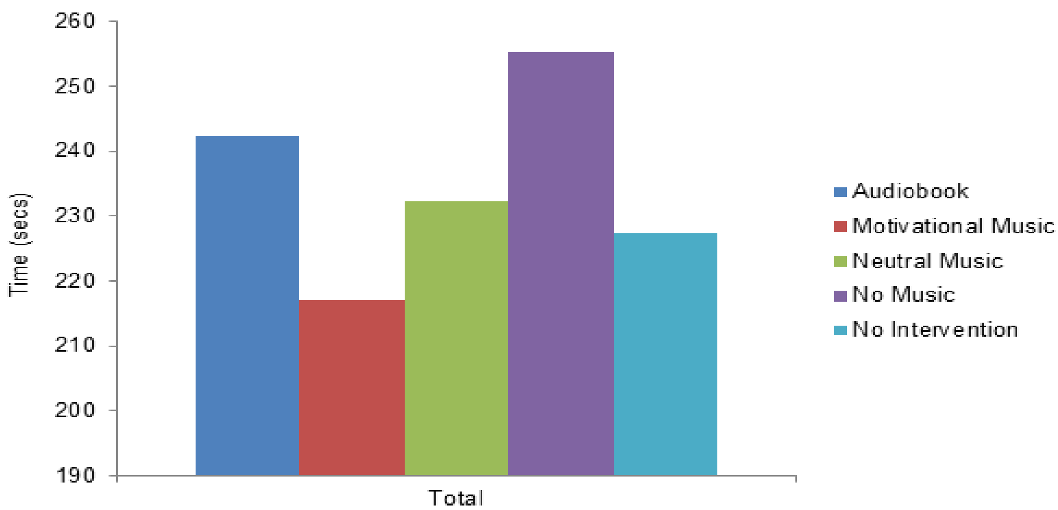

Figure 5.7. Athlete 2: Comparison of lap time per intervention condition.

5.5.2.2.2 Feelings. Overall, for Athlete 2, there was no significant difference between conditions for FS scores (see Figure 5.8).

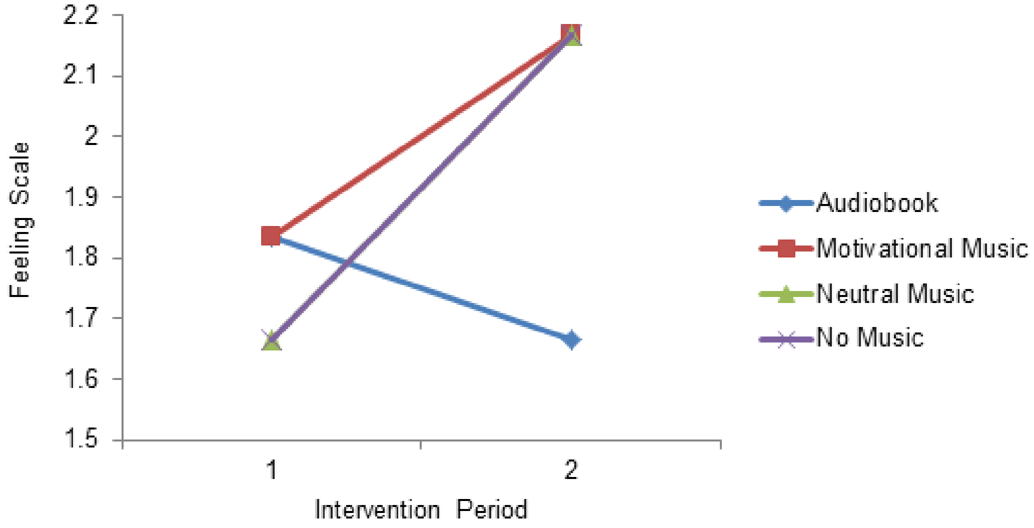

Figure 5.8. Athlete 2: Comparison of feelings responses per intervention period.

5.5.2.2.3 Perceived exertion. Athlete 2 reported no significant difference between intervention conditions for RPE (see Figure 5.9).

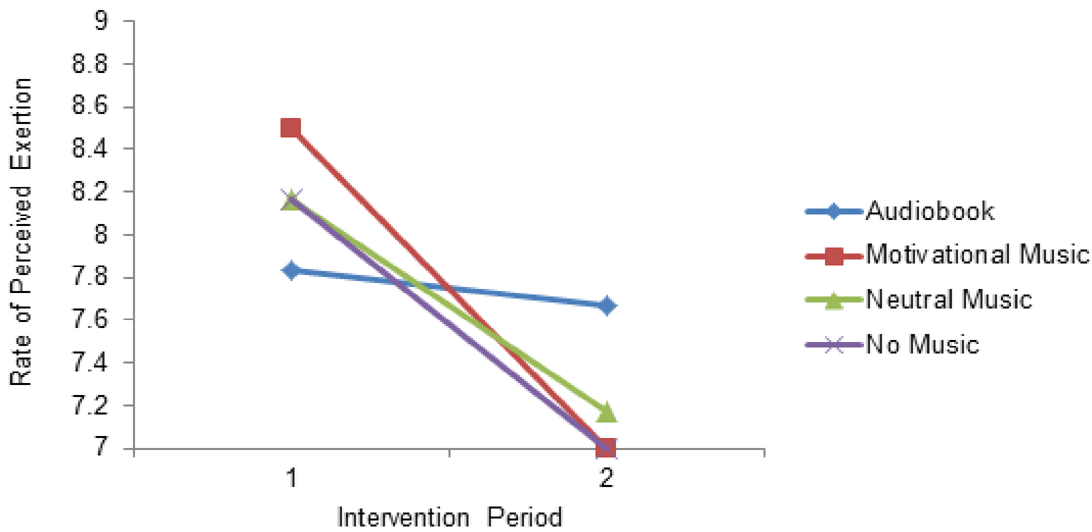

Figure 5.9. Athlete 2: Comparison of perceived exertion responses per intervention period.

5.5.2.2.4 Heart rate. No significant difference in HR between intervention conditions was found for Athlete 2, although HR during the no music condition was about 4-6 bpm higher than the other conditions (see Figure 5.10).

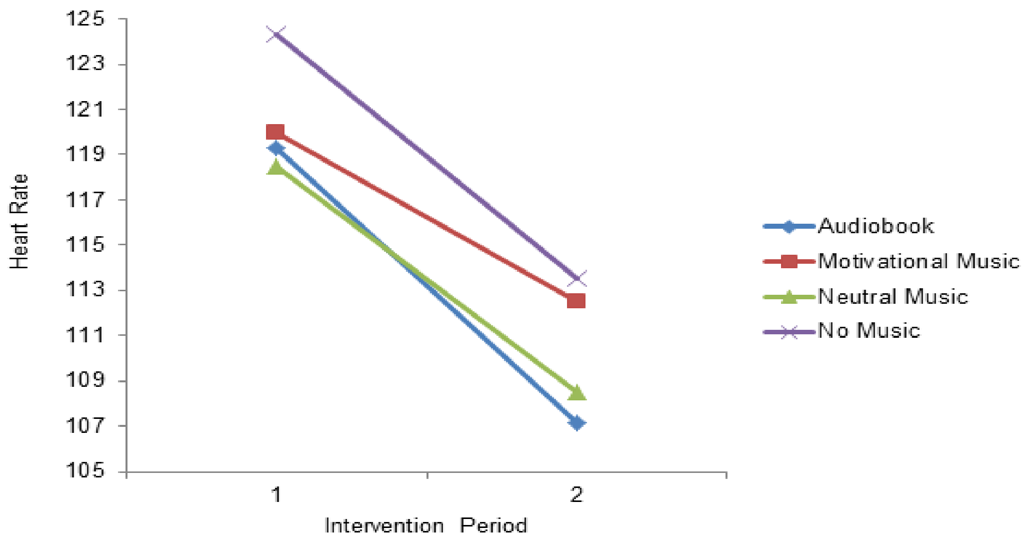

Figure 5.10. Athlete 2: Comparison of heart rate results per intervention period.

5.5.2.2.5 Mood. Athlete 2's profile represents the mean of his mood responses over both the 24 and 48 hour races. The high tension score at the pre-race time point may have been caused by the delay in arrival at the 48 hour race, due to transportation issues. Patterns of fatigue and vigour were consistent with overall mood profiles for all athletes. A spike in scores was evident at the 42 hour time point for confusion (66th percentile), depression (> 80th percentile) and tension (57th percentile). Consistent with overall finding these elevations subsided to zero in post-race mood responses.

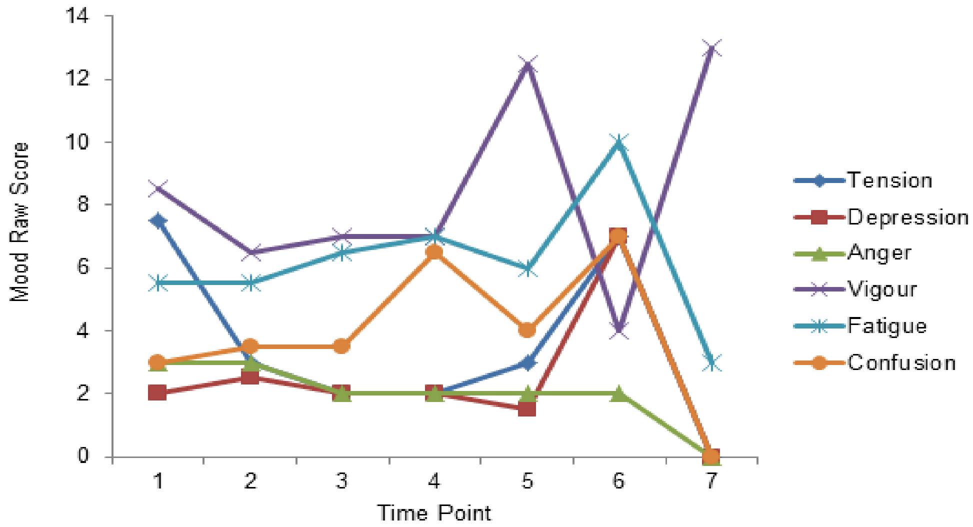

Figure 5.11. Athlete 2: Cumulative mood responses for 24 and 48 hour races.

5.5.2.3 Athlete 7.

5.5.2.3.1 Lap time. Overall a significant difference was found between conditions for lap time, $F(5, 400) = 49.548$, $p < .001$ (see Figure 5.12). The athlete performed significantly better when there was no intervention compared to all intervention conditions ($p < .001$). Within the intervention conditions, motivational music returned a significantly faster mean lap time compared to neutral music (24.80 seconds, $d = .55$, $p < .05$) and audio book (23.09 seconds, $d = .48$, $p < .05$).

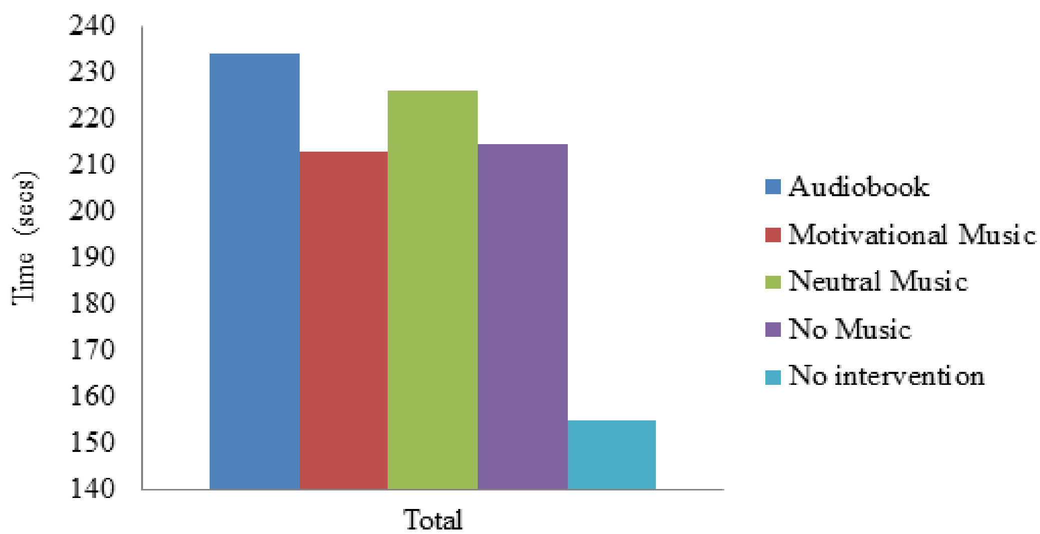

Figure 5.12. Athlete 7: Comparison of lap time per intervention condition.

5.5.2.3.2 Feelings. Overall a significant difference was found between conditions for Athlete 7, $F(4, 31) = 3.781$, $p < .05$ (see Figure 5.13). The athlete reported feeling significantly better during the no intervention period when compared to any of the intervention conditions ($p < .05$).

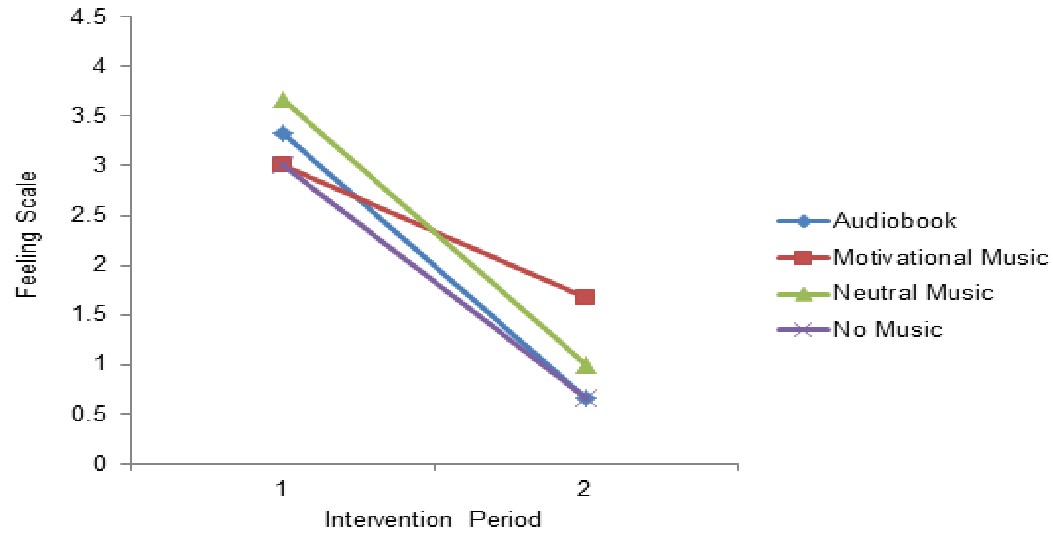

Figure 5.13. Athlete 7: Comparison of feelings responses per intervention period.

5.5.2.3.3 Perceived exertion. No significant between-condition differences in RPE were found for Athlete 7 (see Figure 5.14).

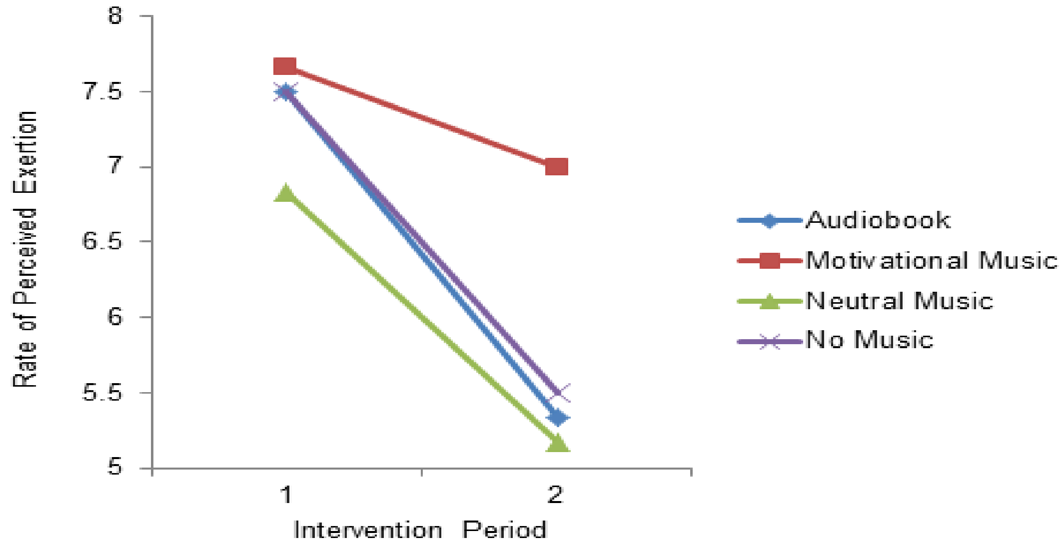

Figure 5.14. Athlete 7: Comparison of perceived exertion responses per intervention period.

5.5.2.3.4 Heart rate. Overall, a significant difference was found for HR, $F(4, 31) = 2.697$, $p < .05$, although post hoc pairwise comparisons showed that no two conditions were significantly different (see Figure 5.15).

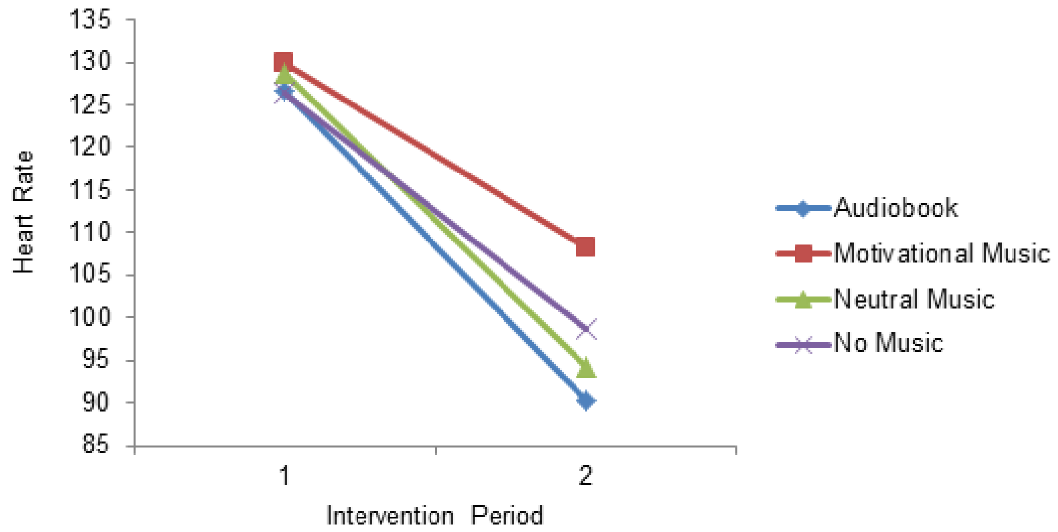

Figure 5.15. Athlete 7: Comparison of heart rate results per intervention period.

5.5.2.3.5 Mood. Athlete 7 presented an overall stable profile (see Figure 5.16) for the mood dimensions of tension, depression, anger and confusion. A small peak was seen at the 18 hour time point in depression; however this remained in the normal range. Consistent with other findings steady increases in fatigue were matched by decreases in vigour over time.

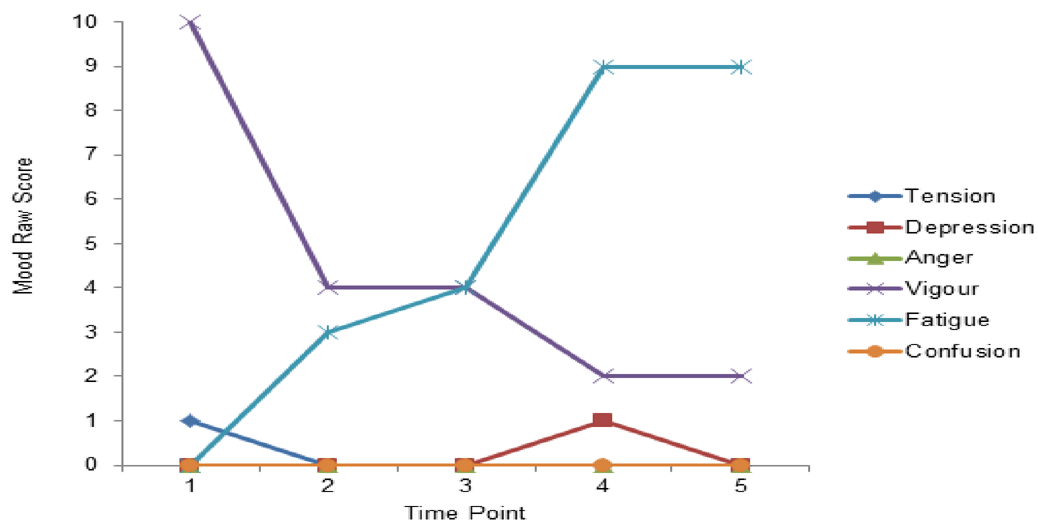

Figure 5.16. Athlete 7: Comparison of mood responses for 24 hour race.

5.5.3 Anecdotal reports. There were individual differences in anecdotal perceptions of the benefits of music. Athlete 2 reported "*I am surprised that I find classical music both calming and invigorating socially but in the race it is irritating*"; "*I was hanging out for the music to start again and when it did it really lifted me up*"; after being delayed by a late plane arrival and being late to the start of the 48 hour event "*I thought I was done in for arriving late but the music really lifted me and helped change my mood*". Athlete 3 did not finish the Coburg race as a result of injury and wanted to pull out 6 hours prior to when he did, commenting that *"I could never have kept going but for the music"*. Athlete 4 reported being in the study as rationale for keeping going, secondary to this was his enjoyment of the music, though he also reported "*I never realised how offensive the wording of the music I like socially is. It really put me off it (the music) when I was I had time to pay attention to the lyrics*". He then went on to win the men's 6 hour race. All athletes made comment at one stage about the uplifting nature of *Eye of the Tiger* and *I Would Walk 500 Mile*s. The athletes were unable to differentiate which was more uplifting when questioned. Athlete 7 was the only athlete who found his music choices matched his in-race mood and style. There was no consistency found when reviewing if there was a relationship between previous use of music and in-race liking, based on anecdotal reports. A number of athletes reported that some of their previously used preferred music did not meet their preferred cadence rate when calculated using Virtual DJ. They found that when running with it in the interim to receiving back their music list that met synchronicity parameters, they felt that they were more "in-time" than that music that was calculated to be synchronous.

5.6 Discussion

The aim of this study was to assess effects of music in a race setting, among athletes who stretch their physiological and psychological capabilities to their limits. The format of the study used the protocols designed in Study 2 with no further changes required.

Overall, in performance terms, it was found that athletes were better off being left to their own devices, with no intervention. Support for these findings can be found in Karageorghis and colleagues (2012), where the effects of music can be found to be detrimental when the athlete is exercising to volitional exhaustion. Macone, Baldari, Zelli, and Guidetti (2006) concluded that when an athlete exercises at these levels the high intensity overshadowed the effects of music. Karageorghis et al. commented on the consistency of these findings with Rejeski's (1985) predictions that at these high exercise intensities, physiological feedback dominates the nervous system negating the benefits of music experienced at lower exercise intensities.

Results for the 18-24 hour period were of particular note, and deviated from the overall findings. The findings for that period suggest that music may provide ultra-distance athletes with a tool to assist them in coping with, and moving forward through, the period where, in common parlance, they *hit the wall*. With time on track be a primary goal of an ultra-athlete this finding offers the potential for them to add to their repertoire of resources during time points in an event that can often overwhelm them. Individual differences were clearly apparent, with different athletes responding differently to the various music conditions, and some preferring the no interventions periods, presumably because they were able to follow their normal, tried and tested race strategies. As found in Study 2 and further amplified in Study 3, the sheer volume of music preparation was cumbersome but ultimately beneficial. Had the time not been taken to provide sufficient music for the entirety of the races, the findings may not have been as illuminating and meaningful.

Chapter 6 – General Discussion

The purpose of the present research was twofold; to quantify the impact of music on sport and exercise, specifically in terms of performance effects, psychological responses, physiological variables, and RPE; and to investigate the effects of music among ultra-distance athletes in both training and race environments. The trend in psychology to use meta-analysis as a tool that underpins evidence-based practice has extended to the field of sport psychology (Terry, 2011). This summation of the pooled evidence was used to quantify the complexities of the effects of music in sport and exercise by providing an overview of its potential benefits for the researcher and practitioner alike. The research protocol used in the meta-analysis provided detailed and accurate quantification that is judged to be superior to previous summaries in the area, setting a higher standard for future meta-analytic works. The case study approach in Study 2 was used to measure the effects of the intervention conditions (i.e., synchronous motivational music, synchronous neutral music, audio book, no music) in a training environment whilst testing research protocols for Study 3. The final study measured the effects of music in a race setting, among athletes who stretch their physiological and psychological capabilities to their limits.

The present research addressed gaps in the literature including: the imbalance in number of investigations between synchronous and asynchronous music; the tendency to test benefits of music in a laboratory rather than field settings; and the use of psychological interventions in ultra-athletes. These limitations have been addressed by the current dissertation and will be discussed.

6.1 Mechanisms by Which Benefits of Music Accrue

There have been many theoretical postulations as to the mechanisms that underpin responses to music (Juslin & Västfjäll, 2008; Steinbeis, Koelsch, & Sloboda, 2006). The underlying process when attempting to evoke or prevent a particular emotion lies in appraisal theory, explaining how different emotions are elicited by the different underlying appraisals (Demir, Desmet, & Hekkert, 2009). An athlete's subjective evaluation of the experience results in the enhanced or regulated affective responses, with the outcome of psychological benefits during exercise. In the context of exercise and sport, such appraisals could include the novelty value of the music; its contribution to the process of coping with the exertion involved either via a distraction effect or the synchronicity between music tempo and the activity; or the appropriateness of the music to the goal of the activity, which might be to keep running for as long as possible. The athlete's emotional response to music reflects the cognitive appraisals of their exercise experience.

In a recent theoretical framework Juslin and Västfjäll (2008) hypothesised six other psychological mechanisms by which music influences emotional responses. The first mechanism, *brain stem reflex*, refers to the process by which the fundamental acoustic properties of music stimulate emotional responses by signalling a potentially important or urgent event. For example, fast, loud music would automatically stimulate the listener by activating the central nervous system irrespective of how the music is subsequently appraised. The second hypothesized mechanism, *evaluative conditioning*, refers to the repeated pairing of a particular piece of music with other positively or negatively valenced stimuli. For example, a specific song may, through repetition, become inextricably linked with a particularly pleasurable exercise or sporting experience. This process represents a form of classical conditioning, whereby a previously neutrally-valenced conditioned stimulus (i.e., a piece of music) gains the ability to evoke the same emotional response as a positively-valenced unconditioned stimulus (i.e., a pleasurable exercise experience).

A third mechanism by which music induces emotional responses is referred to as *emotional contagion.* This refers to the process by which a listener “catches” the emotion inherent in a piece of music. Musical characteristics of a song produce qualities that are, for instance, identifiably angry or sad or happy. Listeners appear to have little trouble in interpreting the emotions inherent in music (Gabrielsson & Juslin, 2003) and by doing so may induce the same emotions in themselves. Although somewhat speculative, the idea of emotional contagion has received recent support from neuroscientific research (e.g., Koelsch, Fritz, v. Cramon, Müller, & Friederici, 2006) showing that listeners internally mimic brain activity associated with the emotional content of music.

Visual imagery is the fourth mechanism by which music is hypothesized to engender emotional responses. Music has been shown to be particularly effective in stimulating visual imagery (McKinney & Timms, 1995) and visual imagery is known to be an effective emotion regulation strategy (Plutchik, 1984; Terry et al., 2006). A large proportion of athletes are adept at using visual imagery to, for example, induce relaxation or generate aggression prior to a competition. It appears highly likely, therefore, that emotional responses to music listening originate, in part at least, from the visual images generated by the listener.

Another mechanism for music-induced emotional responses is referred to as *episodic memory*, which is where a piece of music evokes the memory of a specific incident that has happened previously in the listener’s life. Just as a specific song often stimulates memories of a first love, so athletes develop memories of particular performances via a specific piece of music. Moreover, athletes might seek to produce a particular mindset by listening to a song that carries associations of specific emotions, such as the link between the song *Eye of the Tiger* from the Rocky movies and determination to overcome adversity. Both episodic memory and evaluative conditioning are associative mechanisms, very similar in nature to the mediating variable referred to as *associations* in the Terry and Karageorghis (2006) model.

The final mechanism hypothesised by Juslin and Västfjäll (2008) to link music and emotions is known as *musical expectancy.* This refers to the process whereby emotions occur in response to some expected or unexpected characteristic of the music. Music, like language, is comprised of discrete elements that can be combined in very many different ways. An exerciser listening to the regular beat of her favourite musical genre (i.e., expected, familiar sounds) is likely to feel happier than one listening to the unexpected or discordant sounds of an unfamiliar musical idiom.

The mechanism by which music lowers RPE has typically been explained in terms of the limited capacity of the afferent nervous system (Hernandez-Peon, 1961), which controls impulses heading inwards towards the central nervous system. Given the limitations in channel capacity in the afferent nervous system, stimuli such as music can impede the physiological feedback associated with exertion. The processing of sensory cues through different levels of consciousness to focal awareness was modelled by Rejeski (1985). Stimuli emanating from music (external) or physical work (internal) are processed at a pre-conscious level and filtered into perception. A tenet of Rejeski's model is that affective information is processed in parallel with sensory information in a pre-conscious phase. In essence, music reduces perceived exertion via a distraction effect.

Sensory cues resulting from physical work may interact with psychological factors such as the emotion evoked by music. The intensity of the exercise stimulus determines the extent to which psychological factors influence the pre-conscious processing of sensory cues. Specifically, at high intensity levels of exercise, physiological cues appear to dominate processing capacity whereas psychological variables exert a greater influence at lower levels of intensity. This aspect of Rejeski's (1985) model is referred to as the *load-dependent hypothesis*. According to this hypothesis, reductions in perceived exertion should disappear during high intensity exercise, and while some studies have shown this to be the case (e.g., Pujol & Langenfeld, 1999; Tenenbaum et al., 2004) others have found that music reduces perceived exertion even at high intensities (e.g., Terry, Karageorghis, Mecozzi Saha, & D'Auria, 2012).

The beneficial effects of music on physiological functioning is perhaps the most intriguing finding and perhaps the most difficult to explain. When comparing exercise to music with the same work output completed without music or with inappropriate music, physiological benefits have included lower HR (e.g., Copeland & Franks, 1991), lower systolic blood pressure and blood lactate production (Szmedra & Bacharach, 1998) and reduced oxygen consumption (e.g., Bacon et al., 2012), all of which should logically contribute to improved physical performance especially in endurance activities. In the present meta-analysis, a small but significant benefit in heart rate and a small but not significant benefit in oxygen consumption were demonstrated. One plausible explanation for how such physiological benefits occur is that music used appropriately creates a generalized relaxation response that increases blood flow which, in turn, improves economy of effort. Blood, Zatorre, Bermudez, and Evans (1999) reported that as the intensity of physiological and psychological responses to music increase, so too does the cerebral blood flow, potentially activating the brain regions associated with emotion and arousal including reward/motivation centres.

The demonstrated improvements in physical performance associated with music would most likely accrue as a result of the combined effects of beneficial psychological responses, reduced perceived exertion and improved physiological efficiency, however marginal those improvements might be. In terms of the nexus between physiological changes and psychological responses, biochemistry plays a key role. Compared to silence, it has been shown that relaxing music facilitates recovery from psychologically stressful activities by reducing the production of cortisol, the stress hormone (e.g., Khalfa, Dalla Bella, Roy, Peretz, & Lupien, 2003), indicating that music may be an effective component of stress management programs. The ergogenic properties of music commonly proposed in the literature have been supported by the present meta-analysis. The extent of potential performance enhancements has been exemplified recently by the findings of Karageorghis et al. (2009) who showed that time-to-exhaustion when exercising synchronously to motivational music was 15% longer than without music and 6% longer than with neutral music, and those of Terry et al. (2012) who showed that elite triathletes increased their time-to-exhaustion during treadmill running by 18.1% and 19.7% respectively when running to synchronous motivational and neutral music compared to no music.

Beedie et al. (2005) identified feelings that occur as a result of listening to music that do not meet the criteria for either an emotion or a mood. Such feelings might include the fleeting experience of feeling fast or strong as a result of listening to a driving beat or a heroic lyric. These momentary feelings can have a profound effect upon physical performance. Additionally, physiologists have shown that only about 50% of muscle fibres are recruited during a voluntary muscle contraction (Allen, Lamb, & Westerblad, 2008), leaving a considerable reservoir of unused strength. In a study of grip strength performance after listening to music, Karageorghis et al. (1996) showed that stimulating music was associated with higher grip strength than relaxing music or white noise. At the moment when an athlete initiates a muscular contraction, for example, having the cognitive perception of being strong, or at least strong enough to meet the immediate physical challenge, is far more advantageous than having a fleeting feeling of weakness.

Extending the notion of emotional contagion as a mechanism by which music affects human experience, it seems plausible that music produces what might be termed movement contagion where listeners "catch" the rhythms inherent in a tune and reproduce them in their own movement. In the context of physical activity, this might result in a listener replicating rhythms that are fast, powerful, persistent, or driving; all qualities associated with superior physical performance. Whether this possibly extends to lyrical contagion, whereby athletes and exercisers respond intuitively to exhortations to "Jump" (Van Halen), "Keep on Running" (Spencer), or "Search for the Hero Inside Yourself" (M People), can only be a matter of speculation, although qualitative evidence from exercisers (Crust 2008; Priest et al., 2004) suggests that lyrical content exerts a powerful influence on the whole exercise experience.

Another mechanism by which music provides beneficial outcomes to athletes and exercisers is via the process of synchronization of music and movement.

Producing movement that is in perfect synchrony with the regular, distinctive beat of a piece of music appears to create sensations that extend beyond prosaic feelings to border on a spiritual experience. Exercisers report intense pleasure that comes from working in harmony with musical rhythm, particularly when they are sharing the experience with others (Karageorghis, 1999; Karageorghis & Priest, 2008; Karageorghis & Priest, 2012a). Synchronization contagion, as it might be termed, where individual exercisers catch the sense of moving in perfect harmony from other exercisers around them, might provide benefits to physical performance beyond those available to lone exercisers. Synchronization of music and movement provides a powerful motivator to continue but the collective sense of communion through movement may further intensify a person's reluctance to stop working and thereby destroy the sense of harmony.

Michael Phelps, the American swimmer, who has won more Olympic gold medals that any other athlete in history, is perhaps the highest profile devotee of pre-competition music. His pre-event routine includes listening to favourite music until about two minutes before he races. He favours rap music by artists such as Lil' Wayne and Young Jeezy, whose lyrics contain aggressive messages of dominance and invincibility (e.g., "Yes, I'm the best, and no I ain't positive I'm definite, I know the game like I'm reffing it"), which Phelps seeks to transfer into his swimming performance.

6.2 Overview of Main Findings

This research has confirmed the significant benefits of music used in the context of exercise and sport for several categories of outcome constructs. A consistent overarching theme present in the outcomes of individual studies within the meta-analysis, and both Study 2 and 3 is the recognition that although music shows benefits, there are often distinct individual differences reported.

An element of these individual differences lies in an athlete's choice of their own preferred music. The present meta-analysis has confirmed that significant benefits of music have been shown for several categories of measures of outcome constructs. Specifically, music was found to enhance psychological responses, reduce RPE, make physiological processes more efficient, and improve physical performance. Mechanisms by which these benefits accrue are not well understood, although a number of potential mechanisms have been proposed, some of which have been supported by empirical evidence.

The results of the meta-analysis found music to have a small-to-moderate effect in sport and exercise generally. In examining the measures of outcome constructs music was found to have the largest effect on feelings, followed by performance, perceived exertion, with heart rate showing the smallest effect and oxygen utilisation yielding a non-significant effect.

Further support for the use of music in sport and exercise was found in Study 2. Overall, irrespective of activity modality (walking or running), motivational music was found to provide performance gains when compared to no music. The large effect found for both athletes showed the benefit of the intervention on performance. The results did not differ whether the athlete had experience of previous music use or not.

In Study 3 there was continued theme of individual differences, though the overall benefits of music were not consistent with the meta-analysis findings or Study 2 outcomes. The most significant finding of Study 3 was that, in a race setting, ultra-athletes derive more positive outcomes where no intervention is in place. The self-regulated nature of ultra-athletes helps to explain this finding. It was anticipated that the rhythmic nature of movement engaged in by the ultra-athlete would have benefited from synchronicity with music; including helping to dissociate from pain and exhaustion.

These anticipated benefits were found only during the 18-24 hour period. It is at the juncture that the athlete attempts to extend beyond their capabilities to push through physical and mental barriers commonly aligned with *hitting the wall*. The small-to-moderate effect found in this period did not match levels gained in the training environment but combined with other race stressors could be seen to be beneficial by increasing *time on track*. When reviewing outcomes in the critical 18–24 hour period of an ultra-distance marathon, the true benefits of music were actualised. The athletes used motivational music to improve performance times, working to exhaustion and covering longer distances. Additionally, whilst decreasing lap times, athletes typically reported feeling better when listening to motivational music compared to no music. Athletes also reported consistently lower RPE and showed a lower HR while listening to motivational music, providing an overall picture of positive performance gains.

6.3 Application of Main Findings

An ultra-athlete during the course of the event extends their mind and body beyond what a traditional athlete would conceive to be possible. This takes the athlete to limits often not thought possible, even by the athletes themselves. The current research found music to benefit these athletes in a training environment and at the critical stage of a 24 hour event.

Further, the finding that motivational music was most beneficial in the training environment can allow for the extension of the benefits of music to sports where music is not permitted in competition. The potential for the gains in training to provide an athlete with an increased base benchmark and improved self-efficacy could translate to benefits in race environments.

6.4 Limitations

Perhaps the main limitation of the current study, and previous work with the use of synchronous music, is the question of whether participants actually kept their stride rate in time with the musical tempo (see Anshel & Marisi, 1978; Hayakawa et al., 2000; Karageorghis et al., 2009; Simpson & Karageorghis, 2006). Athletes were requested to synchronise their stride rate with the beat of the music; however, accurate measurement of this synchronisation would have required videotaping the athletes whilst training/racing. Videotaping athletes whilst training/racing may have impeded their performance and may not have met with race director approval.

Another limitation to the current study lies in the *time on track* for the researcher. To ensure maximum accuracy and consistency of recording results, the researcher was required to stay awake for 24 and 48 hour periods continuously. The lack of psychological intervention research in the field may simply be a result of this limitation.

6.5 Future Research Directions

The results of the present research have shown that the previous emphasis placed on the use of synchronous rather than asynchronous music to gain performance, psychological, perceived exertion, and physiological benefits may not be warranted. The cumbersome task of tailoring synchronous music to individual athletes, as experienced in Studies 2 and 3, warrants serious consideration given that synchronous music use did not show significant benefits over asynchronous music in the meta-analysis. Additional research needs to be done in order to support the limited difference in outcome benefits between synchronous and asynchronous music found in the current study. Further understanding of the differences between types of music may be gained through a replication study with the use of asynchronous instead of synchronous music, providing a comparative measure of the effects.

The extension of research to combine biochemical and psychological outcomes in the current target population could yield greater insights about the integration of mind and body in an event, maximising potential outcomes. The ability to further measure the in-task physiological functioning of an ultra-athlete could provide value when considered in conjunction with psychological outcomes.

Finally, future research in sport psychology would be enhanced by the provision of adequate detail when reporting findings. The ability to extract sufficient detail in specific areas of the meta-analysis was limited by the lack of pertinent information provided by researchers. One example was the lack of detail provided when reporting the gender of the participants in individual studies. A large number of articles noted their athlete gender to be mixed (k = 96/162). When reporting research, the first priority is clearly not that sufficient detail be given for the inclusion of the study in a meta-analysis but perhaps greater consideration to that issue should be given by researchers.

6.6 Conclusions

Participating in ultra-athletics has become more popular in the last 10 years and as a result, research being done in the field has increased. However, the majority of existing research focuses on biomechanical reactions to pushing a body to extreme exhaustion. Due to the increased participation in ultra-athletics, more research needs to focus on psychological interventions that can be utilized during ultra-events. As a result of the current findings, it is clear that additional research in the field of ultra-athletics and the use of synchronous/asynchronous music is desirable.

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Appendix A

Table A.1

Effect Sizes and Study Characteristics (k =162)

Author	*N*	*d*	Activity Domain	Age Group	Participant Gender	Publication Status	Publication Quality	Music Type	Outcome Measure	Properties of Music
Abraham & Thomas (1999)	15	0.300	1	2	2	2	4	2	4	2
		0.100	1	2	2	2	4	2	5	2
Annesi (2001)	56	0.444	1	2	3	1	3	2	1	1
		-0.068	1	2	3	1	3	2	4	1
Anshel & Marisi (1978)	32	0.219	1	2	3	1	2	2	1	2
		0.578	1	2	3	1	2	1	1	2
Atkinson et al. (2004)	16	0.308	2	2	3	1	2	2	1	2
		0.736	2	2	3	1	2	2	3	2
		-0.727	2	2	3	1	2	2	5	2
Ayers (1911)	46	0.627	2	4	1	1	3	2	1	2
Bacon & Hookway (2003)	10	0.576	1	2	2	1	2	2	1	2
Becker et al. (1994)	60	0.410	1	2	3	1	3	2	1	2
		0.312	1	2	3	1	3	3	1	2
Becker et al. (1995)	20	-0.078	1	3	3	1	3	2	1	2
Beckett (1990)	32	0.438	1	2	3	1	1	2	1	1

table continues

Author	*N*	*d*	Activity Domain	Age Group	Participant Gender	Publication Status	Publication Quality	Music Type	Outcome Measure	Properties of Music
Beckett (1990)	32	0.411	1	2	3	1	1	2	3	1
Bharani et al. (2004)	20	0.587	1	2	1	1	2	2	1	1
		0.604	1	2	1	1	2	2	3	1
		1.104	1	2	1	1	2	2	5	1
Birnbaum et al. (2009)	11	0.171	1	2	3	1	3	2	3	2
		0.527	1	2	3	1	3	2	4	2
		0.000	1	2	3	1	3	2	5	2
Bishop et al. (2009)	54	0.041	3	1	3	1	2	2	1	2
		-0.025	3	1	3	1	2	2	3	2
Boutcher & Trenske (1990)	24	0.292	1	2	2	1	2	2	2	1
		0.232	1	2	2	1	2	2	5	1
Brohmer & Becker (2006)	17	0.148	1	2	3	1	3	2	1	2
Brownley et al. (1995)	16	-0.014	1	2	3	1	2	2	1	1
		-0.118	1	2	3	1	2	2	2	1
		-0.319	1	2	3	1	2	2	3	1
		-0.256	1	2	3	1	2	2	5	1
Ciccomascolo et al. (1995)	12	0.151	1	2	2	2	4	2	3	2
		-0.043	1	2	2	2	4	2	5	2
Cohen et al. (2007)	25	0.153	1	2	3	1	3	2	1	1

table continues

Author	*N*	*d*	Activity Domain	Age Group	Participant Gender	Publication Status	Publication Quality	Music Type	Outcome Measure	Properties of Music
Copeland & Franks (1991)	24	0.122	1	4	3	1	3	2	1	2
		0.302	1	4	3	1	3	2	3	2
		0.025	1	4	3	1	3	2	5	2
Crust (2004a)	27	0.554	1	2	1	1	3	2	1	1
Crust (2004b)	15	0.609	1	2	2	1	3	2	1	1
Crust & Clough (2006)	58	0.261	1	2	3	1	2	2	1	2
Davis et al. (2007)	25	0.000	1	2	3	2	4	2	1	2
		-0.084	1	2	3	2	4	2	3	2
		0.107	1	2	3	2	4	2	5	2
Dillon (1952)	240	0.230	2	4	4	1	2	2	1	2
Doiron et al. (1999)	13	0.534	1	2	2	1	3	2	4	2
Dorney et al. (1992)	30	0.049	2	2	3	1	3	3	1	2
Dryland & Wininger (2008)	200	0.090	1	2	3	1	1	2	2	2
		0.000	1	2	3	1	1	2	5	2
Edworthy & Waring (2006)	30	0.074	1	2	3	1	1	2	1	2
		0.452	1	2	3	1	1	2	2	2
		0.114	1	2	3	1	1	2	3	2
		0.155	1	2	3	1	1	2	5	2
Eliakim et al. (2007)	24	0.168	1	1	2	1	2	3	1	2

table continues

Author	*N*	*d*	Activity Domain	Age Group	Participant Gender	Publication Status	Publication Quality	Music Type	Outcome Measure	Properties of Music
Eliakim et al. (2007)	24	-0.443	1	1	2	1	2	3	3	2
		0.311	1	1	2	1	2	3	5	2
Elliiot (2007)	18	0.583	1	2	3	1	3	2	1	2
		0.518	1	2	3	1	3	2	2	2
		-0.212	1	2	3	1	3	2	5	2
Elliot et al. (2004)	18	0.628	1	2	3	1	3	2	1	2
		0.977	1	2	3	1	3	2	2	2
Elliot et al. (2005)	18	0.545	1	2	3	1	3	2	1	2
		0.957	1	2	3	1	3	2	2	2
		-0.227	1	2	3	1	3	2	5	2
Fatouros et al. (2005)	12	1.209	1	2	3	2	4	2	1	1
		1.490	1	2	3	2	4	2	3	1
		0.407	1	2	3	2	4	2	4	1
		0.812	1	2	3	2	4	2	5	1
Ferguson et al. (1994)	14	2.000	2	2	3	1	3	3	1	2
Gallagher (1996)	6	0.001	1	2	1	2	4	2	1	1
		-0.046	1	2	1	2	4	2	3	1
		-0.046	1	2	1	2	4	2	4	1
Ghaderi et al. (2009)	30	0.369	1	2	1	1	3	2	1	2

table continues

Author	*N*	*d*	Activity Domain	Age Group	Participant Gender	Publication Status	Publication Quality	Music Type	Outcome Measure	Properties of Music
Ghaderi et al. (2009)	30	1.513	1	2	1	1	3	2	5	2
Hall & Erickson (1995)	15	0.466	2	2	1	1	3	3	1	2
Helper & Kapke (1996)	10	0.566	1	4	4	1	4	2	3	2
Hutchinson et al. (2010)	25	0.167	1	2	3	1	2	2	1	2
		1.077	1	2	3	1	2	2	2	2
		-0.344	1	2	3	1	2	2	5	2
Jansen van Rensburg et al. (2004)	14	0.750	1	2	2	1	4	3	1	2
Jing & Xudong (2008)	30	0.160	1	2	1	1	3	2	1	2
		0.190	1	2	1	1	3	2	3	2
		0.421	1	2	1	1	3	2	5	2
Johnson & Siegel (1987)	26	0.487	1	2	2	1	1	2	5	2
Karageorghis & Deeth (2002)	24	0.464	1	2	1	2	4	2	1	2
Karageorghis & Jones (2000)	20	0.853	1	2	3	2	4	2	1	2
		-0.016	1	2	3	2	4	2	3	2
		1.432	1	2	3	2	4	1	1	2
		0.390	1	2	3	2	4	1	3	2
Karageorghis & Lee (2001)	31	0.301	1	2	3	2	4	2	1	2
Karageorghis et al. (1996)	50	-0.007	3	2	3	1	3	3	1	2
Karageorghis et al. (2009)	26	0.275	1	2	3	1	3	1	1	2

table continues

Author	*N*	*d*	Activity Domain	Age Group	Participant Gender	Publication Status	Publication Quality	Music Type	Outcome Measure	Properties of Music
Karageorghis et al. (2009)	26	0.247	1	2	3	1	3	1	2	2
		-0.091	1	2	3	1	3	1	5	2
Karageorghis et al. (2010)	26	0.105	1	2	3	1	2	1	1	2
		-0.172	1	2	3	1	2	1	2	2
Karper (1979)	71	-0.245	3	1	1	1	3	2	1	2
Kasi & Brooks (2009)	15	0.254	1	2	4	2	4	2	1	1
Keramidas et al. (2004)	24	1.400	2	1	1	2	4	2	1	2
Kiel et al. (2008)	8	-0.091	1	2	4	2	4	1	1	2
		-0.153	1	2	4	2	4	1	3	2
		-0.023	1	2	4	2	4	1	4	2
		0.077	1	2	4	2	4	1	5	2
		0.000	1	2	4	2	4	2	1	2
		-0.250	1	2	4	2	4	2	3	2
		-0.024	1	2	4	2	4	2	4	2
		0.000	1	2	4	2	4	2	5	2
Lim et al. (2009)	11	0.123	2	2	1	1	2	2	1	2
		-0.069	2	2	1	1	2	2	5	2
MacEneaney et al. (2004)	15	0.545	1	2	1	2	4	2	1	1
		-0.543	1	2	1	2	4	2	3	1

table continues

Author	*N*	*d*	Activity Domain	Age Group	Participant Gender	Publication Status	Publication Quality	Music Type	Outcome Measure	Properties of Music
MacEneaney et al. (2004)	15	0.385	1	2	1	2	4	2	4	1
		0.125	1	2	1	2	4	2	5	1
Macone et al. (2006)	27	0.590	1	2	3	1	3	2	1	2
Marin-Hernandez & Aragon-Vargas (1999)	18	0.095	1	2	3	2	4	2	3	2
		0.201	1	2	3	2	4	2	5	2
McMordie (2009)	9	0.489	1	2	2	2	4	2	1	1
Mesango et al. (2009)	3	0.885	2	2	3	1	2	2	1	2
Mikol & Denny (1955)	80	-0.093	1	4	3	1	3	1	1	2
		-0.085	1	4	3	1	3	2	1	2
Miller & Donohue (2003)	90	0.761	2	1	3	1	2	2	1	2
Miller et al. (2006)	29	0.371	1	2	4	2	4	2	2	1
Mohammadzedeh et al. (2008)	24	0.559	1	2	3	1	1	2	1	2
		0.603	1	2	3	1	1	2	5	2
Nakamura et al. (2010)	15	0.173	1	2	1	1	3	2	1	1
		0.156	1	2	1	1	3	2	3	1
		-0.005	1	2	1	1	3	2	5	1
Nethery (2002)	13	0.210	1	2	1	1	3	2	3	1
		1.479	1	2	1	1	3	2	5	1

table continues

Author	*N*	*d*	Activity Domain	Age Group	Participant Gender	Publication Status	Publication Quality	Music Type	Outcome Measure	Properties of Music
Nethery & Roberts (2006)	10	0.270	2	2	4	2	4	2	1	2
Owlia et al. (1995)	15	0.856	1	1	3	1	3	2	1	2
Potteiger et al. (2000)	27	0.027	1	2	3	1	3	2	3	2
		0.642	1	2	3	1	3	2	5	2
Pujol & Langenfeld (1999)	15	0.327	1	2	3	1	3	2	1	2
Razon et al. (2009)	60	0.480	3	2	3	1	2	2	1	1
Rendi et al. (2008)	22	0.145	2	2	3	1	2	2	1	2
Rhea et al. (2004)	12	0.467	1	4	4	2	4	2	1	2
		0.332	1	4	4	2	4	2	3	2
Roberts et al. (2004)	6	0.360	1	2	3	2	4	2	3	1
		0.294	1	2	3	2	4	2	4	1
Sanchez et al. (2005)	18	0.292	1	2	2	2	4	2	5	1
Schie et al. (2008)	30	0.290	1	2	3	1	4	2	3	2
		-0.200	1	2	3	1	4	2	5	2
Schmid et al. (2008)	8	0.306	1	4	3	2	4	2	1	2
		-0.225	1	4	3	2	4	2	3	2
Seath & Thow (1995)	34	0.794	1	2	3	1	3	2	2	2
		1.109	1	2	3	1	3	2	5	2
Shaulov & Lufi (2009)	28	0.498	1	2	3	1	3	2	2	2

table continues

Author	*N*	*d*	Activity Domain	Age Group	Participant Gender	Publication Status	Publication Quality	Music Type	Outcome Measure	Properties of Music
Shaulov & Lufi (2009)	28	0.138	1	2	3	1	3	2	3	2
Simpson & Karageorghis (2006)	36	0.385	2	2	1	1	2	1	1	2
Starkes et al. (1987)	16	0.946	2	1	3	1	2	2	1	2
Szabo & Hoban (2004)	9	1.957	2	2	2	1	4	2	5	2
Szabo et al. (1999)	24	0.105	1	2	3	1	3	2	3	2
Szmedra & Bacharach (1998)	10	0.491	1	2	1	1	4	2	5	2
Thornby et al. (1995)	36	0.968	1	3	3	1	1	2	1	2
		0.167	1	3	3	1	1	2	3	2
		0.588	1	3	3	1	1	2	5	2
Urakawa & Yokoyama (2005)	12	-0.137	1	2	2	1	3	3	3	1
White & Potteiger (1996)	24	0.079	1	2	3	1	3	2	3	2
		0.000	1	2	3	1	3	2	5	2
Yamashita et al. (2006)	8	1.120	1	2	1	1	3	3	5	1
Young et al. (2009)	15	-0.224	1	2	2	1	4	2	1	2
		0.209	1	2	2	1	4	2	3	2

Note. Positive effect sizes indicate a *benefit* of music. Activity domain: 1 = exercise, 2 = sport, 3 = motor task. Age group: 1 = child/youth, 2 = adult, 3 = senior, 4 = not specified. Participant gender: 1 = male, 2 = female, 3 = mixed, 4 = not specified. Publication status: 1 = full article, 2 = abstract. Publication quality: 1 = A, 2 = B, 3 = C, 4 = other [Journal rankings derived from Australian Research Council (2010)]. Music type: 1 = synchronous, 2 = asynchronous, 3 = pre task. Outcome measure: 1 = performance, 2 = FS (FS), 3 = HR, 4 = VO_2, 5 = RPE (RPE). Properties of music: 1 = self-selected, 2 = researcher-selected, 3 = not specified.

Appendix B

Virtual DJ

Figure A.1. Virtual DJ (Atomix Productions, Los Angeles, USA).

Appendix C

Case Study Route

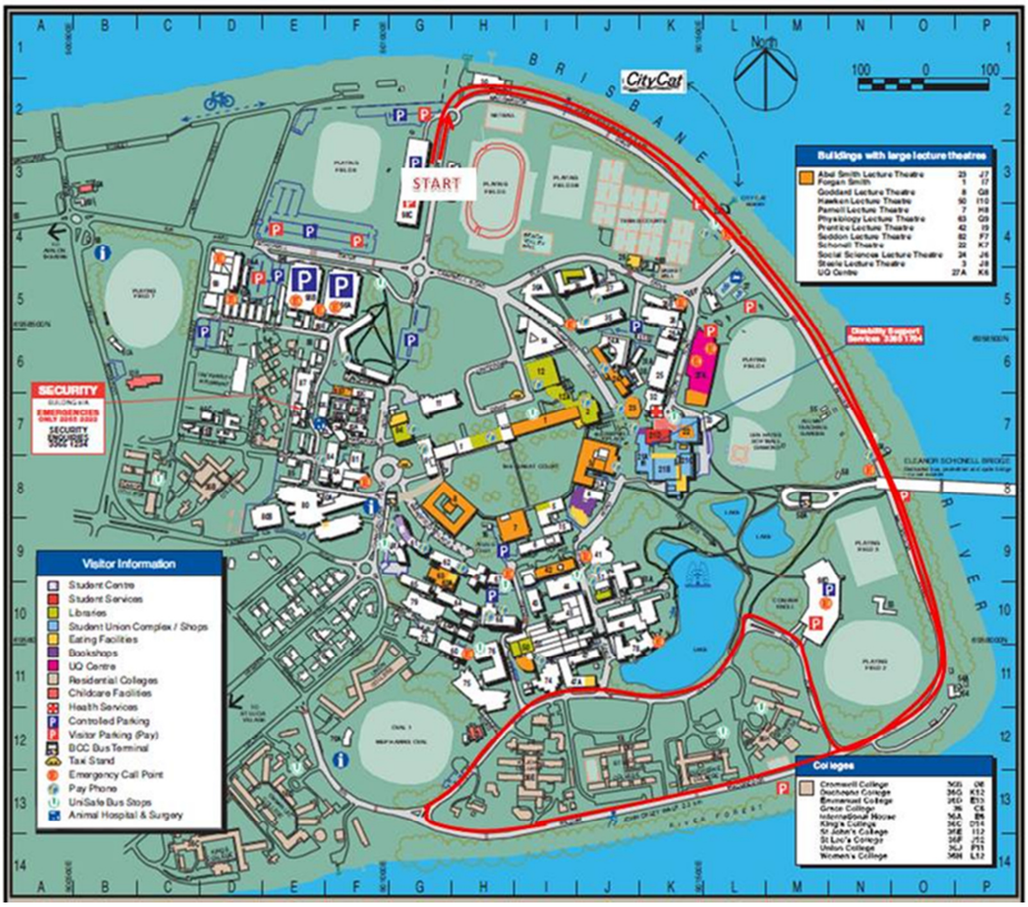

Figure A.2. University of Queensland: Case study route.

Appendix D

Case study/6/24/48 hour race Record Sheet

Sussanah	(No Music)					Peter	(Audiobook)				
Lap	RPE	Feeling	Time	HR		Lap	RPE	Feeling	Time	HR	
0.5						0.5					
1						1					
1.5						1.5					
2						2					
2.5						2.5					
3						3					
3.5						3.5					
4						4					
How was this session any different to the last session?											
Did you check in with yourself anymore than last time?											
Was your journey to the training session any different to last time?											

Figure A.3. Case study record sheet.

Appendix E

Consent form Case Study

Participant Information and Consent Form

Dear Athlete,

You are invited to participate in an investigation of the effects of music on ultra-distance athletes, which is being conducted by researchers from the University of Southern Queensland (USQ). Participants will complete four different training sessions on separate days where different music conditions will be introduced. HR will be measured at all times during training sessions and psychological measures will be taken during these sessions followed by a brief interview.

If you agree to take part in the study, please sign the consent form below. If you have any questions about the research, please do not hesitate to contact one of the research team or the Human Research Ethics Committee at USQ via Ashley Steel (Steel@usq.edu.au). Thank you for considering being involved in this study.

Professor Athlete 1 Terry	Michelle Curran
Principal Investigator	QAS Doctoral Scholar
peter.terry@usq.edu.au	d1111501@usq.edu.au

- I have read the information above and agree to take part in the study.
- I undertake to respond truthfully to the questions asked of me.
- I understand that my participation is voluntary and that I may withdraw at any time.
- I understand that the results of the study will be reported in a doctoral dissertation and journal articles, but that I will not be identified individually.

Name: ____________________________ Date: __________________

Signature: __________________________________

(or signature of parent/guardian if under 18)

Appendix F

Brunel Music Rating Inventory – 2

USQ

AUSTRALIA

Brunel Music Rating Inventory – 2

(Karageorghis, Priest, Terry, Chatzisarantis, & Lane, 2005)

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

Strongly disagree In-between Strongly agree

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

Appendix G

BMRI-2 Scoring Sheet

Song title	Artist	Item 1 (Rhythm)	Item 2 (Style)	Item 3 (Melody)	Item 4 (Tempo)	Item 5 (Instrum ents)	Item 6 (Beat)	Rating

Figure A.4. BMRI-2 score sheet.

table continues

Appendix H

Brunel Mood Scale

Brunel Mood Scale

(Terry et al., 1999,2003)

Below is a list of words that describe feelings. Please read each one carefully. Then cross the box which best describes HOW YOU FEEL RIGHT NOW. Make sure you answer every question.

Please cross one box for each word.

		Not at all	A little	Moderately	Quite a bit	Extremely
1.	Panicky	❑	❑	❑	❑	❑
2.	Lively	❑	❑	❑	❑	❑
3.	Confused	❑	❑	❑	❑	❑
4.	Worn out	❑	❑	❑	❑	❑
5.	Depressed	❑	❑	❑	❑	❑
6.	Downhearted	❑	❑	❑	❑	❑
7.	Annoyed	❑	❑	❑	❑	❑
8.	Exhausted	❑	❑	❑	❑	❑
9.	Mixed-up	❑	❑	❑	❑	❑
10.	Sleepy	❑	❑	❑	❑	❑
11.	Bitter	❑	❑	❑	❑	❑
12.	Unhappy	❑	❑	❑	❑	❑
13.	Anxious	❑	❑	❑	❑	❑
14.	Worried	❑	❑	❑	❑	❑
15.	Energetic	❑	❑	❑	❑	❑
16.	Miserable	❑	❑	❑	❑	❑
17.	Muddled	❑	❑	❑	❑	❑
18.	Nervous	❑	❑	❑	❑	❑
19	Angry	❑	❑	❑	❑	❑
20.	Active	❑	❑	❑	❑	❑
21.	Tired	❑	❑	❑	❑	❑
22.	Bad tempered	❑	❑	❑	❑	❑
23.	Alert	❑	❑	❑	❑	❑
24.	Uncertain	❑	❑	❑	❑	❑

Appendix I

Feeling Scale

Feeling Scale

(Hardy & Rejeski, 1989)

While participating in exercise, it is common to experience changes in mood. Some individuals find exercise pleasurable, whereas others find it to be unpleasant. Additionally, feelings may fluctuate across time. That is, one might feel good and bad a number of times during exercise. Scientists have developed this scale to measure such responses.

+5 Very good

+4

+3 Good

+2

+1 Fairly good

0 Neutral

-1 Fairly bad

-2

-3 Bad

-4

-5 Very bad

Appendix J

Rating of Perceived Exertion

USQ

PER STUDIA MENS NOVA

AUSTRALIA

Rating of Perceived Exertion

(RPE: Borg, 1982)

Choose a number that best describes the level of exertion you are feeling:

0 - Nothing at all

1 - Very light

2 - Fairly light

3 - Moderate

4 - Somewhat hard

5 - Hard

6

7 - Very hard

8

9

10 - Very, very hard

Appendix K

Consent form 6/24/48 hour Race

Participant Information and Consent Form

Dear Athlete,

You are invited to participate in an investigation of the effects of music on ultra-distance athletes, which is being conducted by researchers from the University of Southern Queensland (USQ). Participants will agree to intervention of four music conditions during competition. HR will be measured at all times during competition and psychological measures will be taken during the competition.

If you agree to take part in the study, please sign the consent form below. If you have any questions about the research, please do not hesitate to contact one of the research team or the Human Research Ethics Committee at USQ via Ashley Steel (Steel@usq.edu.au). Thank you for considering being involved in this study.

Professor Athlete 1 Terry
Principal Investigator
peter.terry@usq.edu.au

Michelle Curran
QAS Doctoral Scholar
d1111501@usq.edu.au

- I agree to have all time sheets and official race records provided to the researcher.
- I have read the information above and agree to take part in the study.
- I undertake to respond truthfully to the questions asked of me.
- I understand that my participation is voluntary and that I may withdraw at any time.
- I understand that the results of the study will be reported in a doctoral dissertation and journal articles, but that I will not be identified individually.

Name: ________________________________ Date: ___________________

Signature: _________________________________

(or signature of parent/guardian if under 18)

Appendix L

Ethics Approval

USQ
AUSTRALIA

University of Southern Queensland
TOOWOOMBA QUEENSLAND 4350 CRICOS: QLD 00244B NSW 02225M
AUSTRALIA
TELEPHONE +61 7 4631 2300

www.usq.edu.au

OFFICE OF RESEARCH AND HIGHER DEGREES
Ashley Steele
Ethics Officer
PHONE (07) 4631 2690 | FAX (07) 4631 2955
EMAIL steele@usq.edu.au

Thursday, 29 October 2009

Prof Peter Terry
Faculty of Sciences
USQ, Toowoomba Campus

Dear Peter,

Thankyou for submitting your project below for human ethics clearance. The Chair of the USQ Human Research Ethics Committee (HREC) recently reviewed your responses to the HREC's conditions placed upon the ethical approval for the above project. Your proposal meets the requirements of the *National Statement on Ethical Conduct in Human Research* and full ethics approval has been granted.

Project Title	Improving training effectiveness using music interventions
Approval no	H09REA095
Period of Approval	29/10/2009 – 29/10/2010
HREC Decision	**Approved**

The standard conditions of this approval are that:

(a) you conduct the project strictly in accordance with the proposal submitted and granted ethics approval, including any amendments made to the proposal required by the HREC;
(b) you advise the HREC (email: ethics@usq.edu.au) immediately if any complaints or expressions of concern raised, or any other issue in relation to the project which may warrant review of ethics approval of the project;
(c) You make submission to the HREC for approval of any amendments, or modifications to the approved project before implementing such changes;
(d) in the event you require an extension of ethics approval for this project, please make written application in advance of the end-date of this approval;
(e) you provide the HREC with a written "Annual Progress Report" for every year of approval. The first progress report is due 12 months after the start date of this approval (by **29/10/2010**);
(f) you provide the HREC with a written "Final Report" when the project is complete;
(g) if the project is discontinued, you advise the HREC in writing of the discontinuation.

For (c) to (f) proformas are available on the USQ ethics website: http://www.usq.edu.au/research/ethicsbio/human

Please note that failure to comply with the conditions of approval and the *National Statement on Ethical Conduct in Human Research* may result in withdrawal of approval for the project.

You may now commence your project. I wish you all the best for the conduct of the project

Yours sincerely

Ashley Steele
Ethics Officer
Office of Research and Higher Degrees