THE EFFECTS OF MUSIC TEMPO ON PERFORMANCE, PSYCHOLOGICAL AND PHYSIOLOGICAL VARIABLES DURING 20KM CYCLING IN WELL-TRAINED CYCLISTS

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ABSTRACT

Introduction

Music is commonly used to accompany exercise and has been viewed as a type of legal performance enhancing drug due to its beneficial effects such as reduced RPE, increased work output, enhanced mood, enhanced motor skill acquisition, and increased performance during a variety of exercise tasks. Despite the fact that athletes report using music before, during and after training to increase performance and self-regulate mood, the majority of evidence available has been based on untrained, non-athletic populations. This highlights the need for further research into the effects of music on well-trained individuals engaging in exercise.

Objectives

The purpose of this study was to investigate the effects of different music tempi on performance, psychological and physiological responses of well-trained, experienced cyclists to time trial cycling.

Methods

Ten male road cyclists (age:35yrs ± 7, VO_2 peak: 5.6 L/min ± 0.4; sum of 7 skinfolds: 58 ± 9.4) performed four 20km time-trials on a Computrainer™ Pro 3D electromagnetically braked indoor cycle trainer over a period of four weeks. The time-trials were spaced a week apart. The music conditions for each trial were randomised between fast-tempo (140 bpm), medium-tempo (120 bpm), slow-tempo (100 bpm), and no-music. Measures recorded during the time-trials included (1) physiological: heart rate, oxygen consumption, breathing frequency, respiratory exchange ratio, (2) psychological: mood states (Profile of Mood States (POMS) pre and post time-trial), (3) Performance: peak and average power output, time to completion, pedal cadence and (4) rating of perceived exertion. Averaged data were compared using one-way analysis of variance. Data for heart rate, oxygen consumption, breathing frequency, RPE, cadence and power output were also collected at three minute intervals during each trial. These were compared using two factor (time x condition) repeated measures analysis of variance. For all data sets, where a significant difference was

observed, a Bonferroni post-hoc test was used to determine specific differences. Significance was set at $P < 0.05$.

Results

Results revealed no significant changes in physiological variables or performance variables. Total mood disturbance and tension as measured by the POMS were increased significantly in response to the fast-tempo trial.

Conclusion

Fast tempo music is often perceived as highly motivational and results in increased arousal in the listener. It is likely that prolonged exposure to arousing stimuli such as fast tempo music in conjunction with the intense sensations associated with time-trial exercise could have led to the disturbances in mood state observed during the fast-tempo music trial.

DECLARATION

I, Barry Dyer declare that

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PRESENTATIONS

Oral Presentations

Dyer, B. J and McKune, A. J September, 2012, Effects of music on performance, physiological and psychological responses during time-trial cycling, paper presented at the 1st Life through Movement International Conference of the Biokinetics Association of South Africa, Potchefstroom, South Africa.

Poster Presentations

Dyer, B. J and McKune, A. J July, 2012, Effect of music on performance, physiological and psychological responses during time-trial cycling, poster presented at the International Congress of Science, Education and Medicine in Sport (ICSEMIS 2012), Scottish Exhibition and Conference Centre, Glasgow, Scotland.

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LIST OF ABBREVIATIONS

1. Analysis of Variance – ANOVA
2. Rating of Perceived Exertion – RPE
3. Heart Rate Reserve – HRR
4. Heart Rate – HR
5. Beats per Minute – BPM
6. Oxygen consumption – VO2
7. Profile of Mood States – POMS
8. University of KwaZulu-Natal – UKZN
9. Kilopascals – kPa
10. Statistical Package for Social Sciences – SPSS
11. Peak Power Output – PPO
12. Respiratory Exchange Ratio – RER
13. Total Mood Disturbance - TMD

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1: INTRODUCTION

Music is an important part of everyday life and has been associated with a number of complex psychological and neurological changes (Bernardi, Porta, & Sleight 2006) and is known to influence the emotional state of the listener (Scherer 2004). Regardless of their individual backgrounds people are generally exposed to music or sound everyday whether it is for cultural or religious reasons or simply for entertainment. Bishop, Karageorghis and Kinrade (2009) has stated that modern technology has made a significant impact on how people experience music daily, essentially allowing people to develop their own private auditory environment and tailor their music listening to suit certain tasks or desired outcomes. Some examples of how music has been used in this way include regulating psychological arousal, facilitating emotional expression and improving mood (Juslin & Vastfjall 2008). Furthermore, music has been used as a method of healing (Schneck & Berger 2006) and has been shown to influence certain behaviours (Milliman 1982). An important avenue of research that has gained attention more recently is the benefits of music when used in the domain of sports and exercise.

The use of music in the exercise domain is widespread. Gymnasiums inevitably tend to have a sound system set up to provide clients with a soundtrack to their workouts and group fitness classes often tend to be performed in time with musical rhythms. Those who wish to have their own playlist can do so through the use of personal digital music players such as the *iPod*. Even modern cellphone applications such as *DjRun* and *FIT Radio* and websites such as *RunOnBeat.com* have been designed to facilitate the use of music to compliment workouts. The use of MP3 players has also been suggested as an effective means for coaches to improve their training for athletes under their supervision (Harris 2010).

In terms of the effects of music on the listener there has been substantial investigation into the benefits of combining music listening with exercise. Generally, the effects of music have been assessed in four main categories which are, as defined by Karageorghis and Priest (2012), ergogenic, psychological, psychophysical and psychophysiological effects. An ergogenic effect refers to the tendency for music to improve work output or a general performance measure such as race time or time to exhaustion (Karageorghis & Priest 2012).

Psychological effects refer to the interaction between music and the mood, emotions, cognition and behaviours of the listener (Karageorghis & Priest 2012). Psychophysical refers to the listeners subjective perceptions of effort or fatigue generally quantified as the rating of perceived exertion (RPE) and lastly psychophysical effects refer to physiological changes that occur as a manifestation of the psychological effects of music listening (Karageorghis & Priest 2012).

In terms of music selection itself, a number of factors have been identified which are thought to influence the impact that a music piece might have on the listener within these areas. These factors may include the age, gender and personal preference of the listener (Priest, Karageorghis & Sharp 2004) as well as the exercise intensity, preferred attention strategy during exercise and the characteristics of the music piece itself. In terms of the musical characteristics, Karageorghis, Terry and Lane (1999) developed a conceptual framework to define the main factors underlying the psychophysical effects of music. They suggested that four primary factors exist which are likely to determine the motivational potential of a music piece and that these factors exhibit a hierarchical relationship. In order from the most important to least important these four factors were identified as (1) rhythm response, relating to the natural responses to musical rhythm, specifically tempo (2) musicality, referring to the pitch-related elements such as melody and harmony (3) cultural impact referring to the presence a certain music piece holds within certain societies and cultural groups and (4) association which refers to the external association that music tends to evoke for the listener (Karageorghis et al. 1999). Further investigation into the tempo effects has revealed that an upbeat tempo is more preferable during exercise and the ideal tempo range is generally quite narrow, between 125 and 140bpm (Karageorghis et al. 2011).

With regard to exercise intensity, it has been shown that the ergogenic and psychophysical (reduced RPE) benefits of music are more pronounced during low to moderate intensity exercise (Elliot, Carr & Orme 2005; Waterhouse, Hudson & Edwards 2009) but as exercise intensity increases toward the point where anaerobic metabolism starts to dominate these effects are reduced (Tenenbaum et al. 2004). This has been attributed the so called attentional processing theory which suggests that at low to moderate exercise intensities, distractive stimuli such as music are able to block afferent feedback signals and thus distract the listener from the physiological sensations associated with exertion (Karageorghis &

Priest 2012; Tenenbaum et al. 2004). At high exercise intensities however (particularly above 80% of HRR Max), physiological cues become more powerful and eventually dominate the listener's attention capacity, reducing the ability to attend to musical stimuli, thereby reducing the ergogenic effect (Tenenbaum et al. 2004). Whether or not the listener prefers to adopt an associative or dissociative attention strategy during exercise will also influence this response. Association involves focussing attention internally toward bodily sensations or task-relevant cues whereas a dissociative strategy comprises of focussing attention away from the exercise task and the accompanying physical sensations (Brewer & Buman 2006). It is likely that individuals who prefer to adopt an associative strategy during exercise are less inclined to attend to dissociative stimuli and therefore may not gain as much benefit from dissociative techniques such as music listening (Brownley, McMurray, & Hackney 1995).

Another factor which may influence the effects of music is training status, although this area has not been fully investigated. Well-trained individuals are generally more accustomed to exercising at higher intensities than the general population and are thought to more commonly adopt an associative attention strategy (Morgan & Pollock 1997). As these are both factors that influence the response to music, it stands to reason that well-trained individuals may also differ from the untrained populations in this regard. Despite this, only a handful of studies have investigated the impact of music listening on psychological, psychophysical and physiological effects and performance outcomes during exercise using well-trained, task-habituated individuals (Brownley et al. 1995; Hagen et al. 2013; Mohammedzadeh, Tartibyan, & Ahmadi 2008; Schie, Stewart, Becker, & Rogers 2008; Terry, Karageorghis, MecozziSaha, & D'Auria 2012). With regard to the use of music during endurance tasks, significant benefits have been observed although these have been largely based on research using untrained or inexperienced exercise populations (e.g.: Atkinson, Wilson & Eubank 2004; Elliot et al. 2005; Waterhouse et al. 2009). Studies investigating the use of music in conjunction with endurance exercise in well-trained populations have produced less consistent results although, apart from one study in particular (Terry et al. 2012), current findings tend to suggest that music may not be as effective in improving psychophysical, physiological and performance measures (Brownley et al. 1995; Hagen et al. 2013, Schie et al. 2008). Terry et al. (2012) did show that synchronous music (80 – 97bpm) was able to provide ergogenic, psychological and physiological benefits for elite triathletes performing a time to exhaustion running task although these findings do not seem to be supported by other studies specifically where closed-loop (time-trial) tasks have been used (Hagen et al. 2013; Schie et al. 2008). In contrast to Atkinson et al. (2004) who showed that fast tempo music (140 bpm) could alter work rate distribution characterised by increased power output in the early stages of a 10km time trial, Hagen et al. (2013) found that self-selected motivational music had no effect on performance or physiological measures in a group of well-trained cyclists performing a 10km time trial which supports the suggestion that well-trained athletes might respond differently. Hagen et al. (2013) did report that some participants perceived the time trial to be easier in the presence of music although this was not measured in any way. Furthermore, it is uncertain whether the researchers also used fast tempo music similar to that in the study by Atkinson et al. which may also explain the differences. Results of the study by Schie et al. (2008) were similar in that the majority of the well-trained cyclists who participated reported that they found a 20-minute submaximal cycling session less demanding in the presence of music. However, no change in RPE and no physiological benefit of music listening was reported. The findings of Brownley et al. (1995) were different as they found that very fast tempo music (154-162bpm) in conjunction with high intensity exercise was counterproductive for well-trained runners in that it seemed to exacerbate the exercise stress, characterised by an increased cortisol response and RPE and reduced positive affect. This may be due to the fact that such high tempo music may be unfamiliar, over-arousing or contain too much information for the afferent nervous system as has been suggested previously by Karageorghis et al. (2011). It is uncertain to what extent the abovementioned findings can be compared or relied on due to the large methodological differences that exist between them. Therefore an investigation into the effects of different music tempi on psychological, psychophysical and physiological variables as well as performance outcomes in well-trained populations using a standardised exercise task would provide more insight as to which is most beneficial.

1.1. Problem Statement

The general consensus within the literature is that music provides the listener with benefits such as dissociation from fatigue, increased work output, reduced ratings of perceived exertion, improved mood and increased overall performance (Terry & Karageorghis 2006) however, these findings have largely been based on exercise populations who are not well-trained or who are inexperienced at performing the exercise task in question. Well-trained athletes tend to differ from the general population in terms of their general mood states, the preferred attention strategy they tend to adopt during exercise and the exercise intensities they are accustomed to. These are all factors that may affect an individual's response to musical stimuli and thus it is likely that well-trained athletes may also differ from untrained populations in this regard. With specific regard to endurance exercise tasks, few studies have investigated well-trained populations and these few have produced mixed results largely due to methodological differences such as inconsistent music selection and exercise protocols. Given that many well-trained athletes use music as a part of their training regimes it is important that the effects of music be more closely examined in this population using a standardised exercise task.

1.2. Research Hypotheses

Based on previous findings (Atkinson et al. 2004; Brownley et al. 1995) three hypotheses were tested: (1) Fast tempo music would influence the pattern of power output adopted by well-trained cyclists during a 20km cycle time-trial characterised by an increase in work output compared to slow and medium tempo music and a no-music control; (2) heart rate, oxygen consumption, RPE and breathing frequency would differ between trials as a consequence of the changes in work rate distribution; and (3) fast tempo music in conjunction with the high intensity endurance task such as 20km time-trial cycling would result in increased mood disturbances as compared to slow and medium tempo music and a no-music control.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

Traditional sports practice sees the use of various ergogenic aids as a means to enhance sports performance. These aids are usually very expensive and/or illegal and are thus not ideal. Research has indicated that music is a cheap and legal method that people can use to enhance exercise performance and increase exercise enjoyment. The exact mechanisms underlying the benefits of music listening are not yet fully understood, although some have been suggested. Furthermore, an important consideration is that most studies to date have assessed musical benefits using untrained or non-task habituated individuals as opposed to well-trained athletes. What follows is a summary of the existing research surrounding the use of music in conjunction with sport and exercise. The first part of the review will focus on the underlying mechanisms and conceptual frameworks that have been developed to date. The second part of the review will focus more closely on the types of benefits that music has been shown to provide during exercise with a specific focus on cycling. Lastly, the differences between well-trained and untrained populations will be assessed and possible directions for future research will be discussed.

2.2. Underlying mechanisms and conceptual framework

An original conceptual framework designed to predict the psychophysical effects of music was first presented by Karageorghis et al. (1999). The framework suggested that four primary factors are responsible for determining the motivational effects of music tracks and that these factors exhibit a hierarchical relationship. In order from most important to least important these four factors were identified as (1) rhythm response, relating to the natural responses to musical rhythm, specifically tempo (2) musicality, referring to the pitch-related elements such as melody and harmony (3) cultural impact referring to the presence a certain music piece holds within certain societies and cultural groups and (4) association which refers to the external association that music tends to evoke for the listener (Karageorghis et al. 1999). In 2006 this model was adapted to focus more specifically on the use of music within the domain of sports and exercise (Terry & Karageorghis 2006; Figure 1.1). The revised model also included personal factors such as age and preference of the listener and situational factors such as type of exercise and the exercise environment; both important considerations that had previously been overlooked. It is thought that music is likely to induce these effects through more than one process. The first refers to the natural tendency of humans to synchronise with musical rhythms, the second refers to the stimulative properties of music and the link between psychological or physiological arousal and the third mechanism which has been proposed states that music may be able to interfere with the processing of physiological cues and thus distract the listener from perceptions of effort (Karageorghis & Priest 2012). These mechanisms are discussed in more detail below.

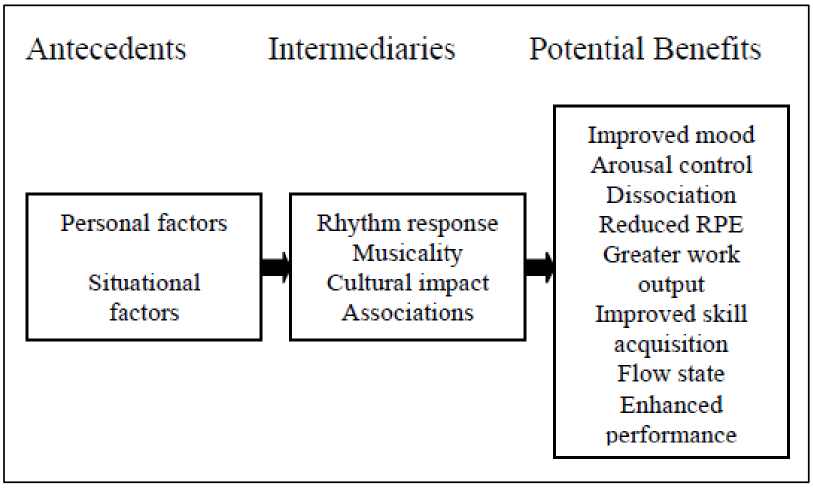

Figure 2.1: Conceptual framework for benefits of music in sport and exercise contexts (reproduced from Terry et al. 2006).

2.2.1. Synchronisation with musical beats and the central pattern generator hypothesis

Certain activities or biological rhythms have been shown to resonate closely with common musical tempi to which people are exposed. For example, MacDougall and Moore (2005) conducted a study in which 20 subjects were observed over a wide range of locomotor activities performed under natural circumstances over three 10 hour periods. Using vertical linear acceleration of the head as an indicator of step frequency, they found that regardless of age or height, subjects consistently obtained a 2 Hz frequency of movement during activities such as walking, running, dancing, shopping and cycling. The synchronisation of exercise movements to musical rhythms has been shown to improve both anaerobic (Simpson & Karageorghis 2004) and aerobic (Terry et al. 2012) endurance performance. It has been hypothesised that a common core of neurons or "central pattern generator" (CPG) might exist in humans, responsible for driving basic rhythmical motor patterns (Zehr 2005). According to Zehr (2005) the rhythm generated by the CPG can be regulated by supraspinal and somatosensory feedback. One hypothesis is that musical rhythms may integrate with the natural efferent nerve signals, essentially allowing music to "fine-tune" the rhythm of certain motor tasks (Karageorghis & Priest 2012; Safranek, Koshland & Raymond 1982). In addition to enhancing work output it believed that synchronising to musical rhythms may also increase exercise efficiency by creating greater relaxation and providing a more regular, rhythmical exercise pattern (Karageorghis & Priest 2012).

2.2.2. Stimulative effects of music

This theory is based on the assumption that music has stimulative effects on people which may lead to increased motivation and work output or performance in some exercise settings (Karageorghis & Priest 2012). It has been shown that musical stimuli are capable of influencing psychobiological arousal (Husain, Thompson & Schellenberg 2002; North & Hargreaves 1997). The potential arousal effect of a music piece is determined by a number of factors such as familiarity, tempo and certain extra-musical associations or emotions it may evoke (Terry & Karageorghis 2006). Musical selections can therefore be tailored toward achieving a desired level of arousal whether high or low. Generally, loud, fast tempo music seems to be most effective for increasing arousal which may explain why it is perceived as more motivational (Priest et al. 2004). For example, Yamamoto et al. (2003) investigated the ergogenic effects of fast or slow tempo classical music heard 20 minutes prior to a supra-maximal cycling task. Based on changes measured in catecholamine levels just before the end of the 20 minute listening period they concluded that fast tempo music increased arousal whereas slow tempo music reduced arousal. Music has also been shown to increase or decrease physiological arousal (Bernardi et al. 2005; Iwanaga, Kobayashi & Kawasaki 2005; Khalfa, Roy, Rainville et al. 2008). Bernardi et al (2005) assessed the changes in cardiovascular and respiratory systems induced by music. Their findings indicated that music produces an arousal effect in proportion to the musical tempo. Fast tempi induced increases in ventilation, breathing rate, blood pressure and heart rate whereas slower tempi had a proportionally smaller effect (Bernardi et al. 2005). Khalfa et al. (2008) found fast music stimuli elicited higher arousal ratings and also resulted in an increased respiration rate relative to a slow music condition. Iwanaga et al. (2005) investigated heart rate variability with repetitive exposure to either a sedative, excitative or no-music condition. They found sedative music to induce a high level of relaxation whereas excitative music elicited higher levels of tension and a reduction in the high frequency component of heart rate variability indicating an interaction with parasympathetic nervous system activation. The stimulative effects also likely linked to the ability of music to elicit emotional responses. Detection of emotions within musical excerpts have been shown to induce physiological responses such as blood pressure and electrodermal activity (Khalfa et al. 2008).

2.2.3. Attentional Processing Model

One of the reported benefits of music listening is a reduction in RPE during exercise (eg.: Nethery 2002; Potteiger, Schroeder, & Goff 2000; Thornby, Haas & Axen 1995) or an increase in work output for a given RPE (Elliot, Carr & Savage 2004). These effects are most pronounced during low to moderate intensity exercise however and tend to diminish as exercise intensity increases (Jarraya et al. 2012;Schie et al. 2008; Tenenbaum et al. 2004).The underlying mechanism thought to explain this has been termed the attentional processing model (Karageorghis & Priest 2012). This is based on Rejeski's parallel processing theory (Rejeski 1985) which assumes that sensory stimuli can interfere with physiological feedback. In this way, music is able to distract listeners from the sensations of exertion they feel during exercise and thus RPE is reduced. This effect is, however, regulated by the inclination of the listener to attend to the music. At low to moderate exercise intensities, auditory information and physiological feedback may be processed simultaneously allowing for a greater influence from psychological cues (Rejeski 1985). As exercise intensity increases, however, especially toward the point where anaerobic metabolism begins to dominate, the relative strength of physiological cues increase and thus these sensations begin to dominate the processing capacity of the nervous system rendering musical stimuli less effective at distracting from perceptions of exertion (Hutchinson & Tenenbaum 2007; Karageorghis & Priest 2012). Many studies have reported no reduction in RPE during high intensity exercise (Elliot et al. 2005; Hagen et al. 2013; Schie et al. 2008; Elliot et al. 2005; Tenenbaum et al. 2004) which serves to re-enforce this theory.

2.3. The Importance of Tempo

As stated previously the tempo of music played during exercise has been identified as one the key factors in determining the motivational and ergogenic effects it may have (Terry &

Karageorghis 2006). Therefore, knowing which specific tempi will be effective in different situations is valuable in the music selection process. Priest and Karageorghis (2008) performed a qualitative investigation into the factors responsible for the ergogenic properties of music. Of the 13 participants they interviewed, 11 reported that an "upbeat tempo" is most motivational, most enjoyable and likely to provide a performance benefit during exercise (Priest & Karageorghis 2008). This is supported by data from studies that have tried to investigate music tempo preferences at various exercise intensities (Karageorghis, Jones & Low 2006; Karageorghis et al. 2011). Karageorghis et al. (2006) investigated the interaction between exercise intensity and music tempo preference during treadmill running. Participants reported preferences for slow (80bpm), medium (120bpm) or fast (140bpm) tempo music whilst running at 40%, 60% and 75% of their maximal heart rate reserve. What the researchers found was a definite preference for medium and fast tempo music at low to moderate intensity whereas fast tempo music was preferred for the high intensity condition. There was no preference for slow music in any condition. A similar study was performed by Karageorghis, Jones and Stuart (2009) in which participants were exposed to four different conditions namely fast tempo, medium tempo, mixed tempo and a no-music control. Throughout all four trials each participant exercised at 70% of maximal heart rate reserve whilst the researchers recorded their levels of intrinsic motivation and music preferences. The findings differed from previous work in that the medium tempo (115 – 120bpm) condition resulted in the highest levels of enjoyment and intrinsic motivation. The researchers explained that this may have been due to the more moderate workload (70%) resulting in the moderate tempo being better matched to the intensity or that participants may have become more familiar with medium tempi through day to day exposure resulting in increased preference. As a follow up to the original investigation into the interaction between exercise intensity and music tempo preference Karageorghis et al. (2011) conducted a study in which 28 undergraduate students exercised at intensities ranging from 40 to 90% of their maximal heart rate reserve whilst music preference was measured on a ten point scale. Participants reported lower preferences for slow music at all intensities and lower preference for very fast music at low intensities. There were higher preferences for medium and fast music at the midrange (50 – 60%) whilst preferences for fast-tempi increased beyond the 70% mark. Beyond 80% there was attenuation in the response in that preference for more moderate tempo seemed to increase again and an increase in tempo did not result in an increased preference. The authors suggested this may be due to the music tracks containing too much information for an already limited attention span or perhaps an arousal potential that was too large for the listener to handle (Karageorghis et al. 2011). This is supported by the fact that the link between arousal potential and music preference has been shown to exhibit an inverted-U relationship (Figure 2.2) (North & Hargreaves 1997).

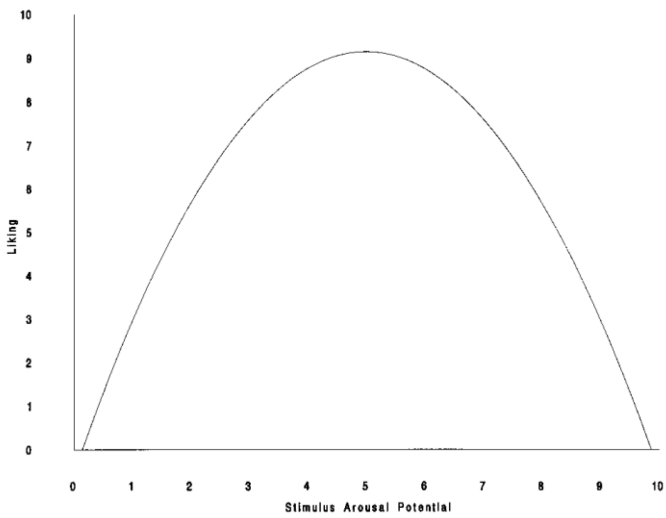

Figure 2.2: The relationship between liking for music and it's arousal potential. Taken from North and Hargreaves (1997).

2.4. Music and cycling performance

The effects of music have been investigated using both high intensity (Yamamoto et al. 2003; Schie et al. 2008) and low to moderate intensity (Elliot et al. 2005; Potteiger et al. 2000; Yamashita et al. 2006) cycling tasks of various durations revealing mixed results.

2.4.1. Supra-maximal cycling tasks

With regard to short duration high intensity cycling tasks, research suggests that appropriate music selections may help to regulate arousal or positive feelings during exercise although performance benefits are less likely to be observed (Atan 2013; Pujol & Langenfeld 1999; Yamamoto et al. 2003). Yamamoto et al. (2003) investigated the ergogenic effects of fast or slow tempo classical music heard 20 minutes prior to a supra-maximal cycling task. Based on changes measured in catecholamine levels just before the end of the 20 minute listening period they concluded that fast tempo music increased arousal whereas slow tempo music reduced arousal. Despite the change in arousal there were no changes in resting or exercise heart rate or power output during the trial. Pujol and Langenfeld (1999) investigated the effects of music played at 120bpm on supramaximal cycle performance. Participants were asked perform three Wingate Anaerobic Tests with 30 seconds rest in between for both a music and non-music condition. On the third effort they were instructed to pedal to exhaustion. Findings indicated no effect on performance or time to fatigue. Atan (2013) performed a similar investigation but in addition to the Wingate Anaerobic Test effects were also assessed during an anaerobic running test. Performance in both tasks was assessed under slow, fast and no-music conditions and results indicated no significant differences between the three conditions for anaerobic power assessments, heart rate or blood lactate. These findings further re-enforce the assumptions of the attentional processing model that benefits of music listening are reduced when physiological load is high. However, some studies have reported improvements in anaerobic performance in the presence of music (Hutchinson, Sherman, Davis et al. 2011; Jarraya et al. 2012). Hutchinson et al. (2011) also made use of the Wingate test and compared peak and mean power outputs and rate of fatigue in 25 participants for a music and no-music condition. Their findings indicated that peak and mean power output was increased in the presence of music. Participants also reported increased motivation and feelings of positive affect following the music condition. Jarraya et al. (2012) investigated the effects of high tempo music (120-140 bpm) music on heart rate, rating of perceived exertion, fatigue index, peak power and mean power output of twelve young male athletes performing the Wingate test. They found that listening to music during a 10 minute warm up prior to supra-maximal cycling led to improved peak and mean power outputs, however, HR, RPE and fatigue index were unchanged. These results are in contrast with similar studies that have found no improvement using similar procedures, however, direct comparison between studies is problematic due to differences in methodology. This is an issue that has been raised previously in the literature (Terry & Karageorghis 2006). A possible explanation may be the musical selections, for example, Pujol and Langenfeld (1999) played songs at a standard 120bpm whereas Jarraya et al. (2012) used songs with a slightly higher tempo. Given the fact that higher tempi are associated with increased arousal, this may have influenced performance.

2.4.2. Endurance cycling tasks

Similar differences also exist in research examining the effects of music in endurance cycling tasks. These findings tend to vary according to the exercise intensity and type of music selected. One of the most important findings regarding the use of music with endurance type tasks is the apparent ability to modify work output (Atkinson et al. 2004; Elliot 2007; Elliot et al. 2005; Lim, Atkinson, Karageorghis & Eubank 2009; Szabo, Small & Leigh 1999; Waterhouse et al. 2009). Atkinson et al. (2004) exposed sixteen participants to two (music and no-music) 10-km time trial cycling conditions. The music condition comprised of trance music played at a tempo of 142 beats per minute and a volume of 87 decibels (dB). Findings indicated that listening to music caused exercise participants to select higher work rates during the initial stages of time-trial cycling as compared to cycling without music. They concluded that music seems to be most beneficial as a means to increase speed during the first few minutes of 10km time trial cycling performance. Similarly, Lim et al. (2009) found that the introduction or removal of music during a 10km cycle time trial was able to influence the way in which the participants performed. During this investigation, participants were exposed to three time-trial conditions: no-music, music played only for the first 5km, and music played only during the last 5km. The primary finding was that the prior knowledge that music would be introduced in the second half of the time-trial caused participants to accept a higher workload by increasing speed at the start of the music-introduced time-trial. “The fact that participants exercised harder when they expected music to be introduced at a late stage illustrates the behavioural influences that music can engender during self-paced exercise” (Lim et al. 2009). Szabo et al. (1999) compared the effects of different music intervention on performance in an incremental cycle test to exhaustion. Twenty-four participants were tested whilst exposed to five separate conditions: a no music control, slow music, fast music, a slow to fast tempo condition and a fast to slow tempo condition in which tempo was either increased or decreased once participants reached 70% of maximal heart rate reserve. Results indicated that transitioning from slow to fast tempo music resulted in better performance possibly due to the increased motivational and distracting effect of fast tempo music in comparison to slow tempo music. Elliot et al. (2005) examined the effect of motivational music on performance in a 20 minute submaximal cycling task. Eighteen untrained students performed three cycle trials under no music, motivational music and neutral music conditions during which they could vary exercise intensity within 60 and 80% HR Max. Results revealed a significant increase in performance for both music trials in that participants cycled farther as compared to the no music trial. Mean RPE did not differ according to experimental condition although there was a time x condition effect observed with RPE being higher in the latter stages of both music trials when compared to the no music trial. This led the researchers to conclude that listening to music may have motivated the participants to accept a higher workload. Both music conditions also resulted in higher post-task positive attitudes compared to no-music with no difference between the two music trials both immediately and 24 hours post-task. The similarity between the two music conditions is an interesting finding as it implies that music need not be motivational in nature in order to induce the desired effect on exercise performance. The researchers offer two possible explanations for this in their analysis. Firstly, due to the submaximal nature of the task, participants may have been able to synchronise to the rhythm of both music types and secondly, both music conditions would have induced a dissociation effect (Elliot et al. 2005). As a follow on to this Elliot (2007) examined psychophysical responses to participants partaking in four experimental conditions; no-music, slow music, moderately fast music and fast music. Total distance travelled in a 20-minute trial and average power outputs were the main performance measures. Results indicated that moderately fast and fast tempi induced significant increases in performance as measured by power output and distance covered. Waterhouse et al. (2009) investigated the effects of varying music tempo on self-paced cycling performance. Twelve undergraduate students participated in three cycle trials of approximately 25 minutes whilst listening to the same six music tracks for which the tempo was either normal, increased by 10% or decreased by 10%. The researchers found that distance pedalled, cadence and task enjoyment increased as music tempo increased, however, RPE also increased. These findings are similar to those of Elliot et al. (2005), and suggest that participants were aware of their increased work output but chose to accept it. Possible explanations for these findings are again a combination of motivation, distraction (Waterhouse et al. 2009) and a possible synchronisation effect (Karageorghis & Priest 2012). These findings indicate that music seems to be an effective method for improving work output during endurance cycling tasks. Despite methodological differences and inconsistencies in some findings, the general consensus in the literature is that music may either reduce perception of effort or allow greater work output for a given perception of effort. In the event where no change in RPE or performance is observed, music seems to still be perceived as beneficial by listeners and may still result in improvements in positive affect and attitudes during or post-task. However, a key component that all the above mentioned studies have in common is the use of untrained participants. With regard to well-trained, task-habituated individuals, findings have been less consistent.

2.5. Music during exercise in well-trained populations

Few studies have investigated the effects of music on performance of well-trained individuals and have yielded mixed results (Brownley et al. 1995; Hagen et al. 2013; Mohammedzadeh et al. 2008; Schie et al. 2008; Terry et al. 2012). Brownley et al. (1995) compared the influence of music on the physiological and affective responses of both trained and untrained runners during low, moderate and high intensity exercise whilst exposed to either no, slow or fast music conditions. Similar to other studies that have assessed physiological responses, fast tempo music (154-162bpm) was shown to elicit higher respiratory frequencies and plasma cortisol levels suggesting an increase in exercise stress. However, no significant change in performance, as measured by time to exhaustion, was observed across any of the conditions. Interestingly, affective responses indicated that trained runners reported the lowest ratings of affect following the fast music condition. Based on these results, the authors concluded that fast, upbeat music during exercise may be beneficial for untrained runners but is counterproductive for trained runners. The authors suggested that listening to music may have disrupted the trained runners' ability to maintain an internal focus during exercise which may explain this response. It has been shown that well-trained individuals tend to adopt different attention strategies during exercise as compared to untrained individuals (Morgan & Pollock 1997). Based on this, Mohammedzadeh et al. (2008) also set out to compare the psychophysical and ergogenic properties of music in trained and untrained runners during a standardised exercise task. According to their results, time to exhaustion was improved and RPE was reduced during the music condition although improvements in RPE were dependant on fitness level indicated by greatly reduced effect in the trained group as compared to the untrained group. Schie et al. (2008) investigated the effects of music on responses 30 well-trained cyclists to a 20 minute cycle time-trial. They found no change in heart rate, plasma lactate concentration or RPE between music and no music; however, no performance measure such as distance covered was recorded. Interpreting these results is somewhat problematic for a number of reasons. Firstly, participants were asked to maintain their exercise intensity within a narrow range (78-82% of peak oxygen consumption) presumably to determine if music could reduce RPE for a given workload. Given that effects of music on RPE at such intensities have been shown to be reduced it is difficult to determine whether this effect is due solely to intensity or training status of the cyclists. Therefore, comparison with an untrained group might be recommended. Furthermore, participants were allowed to view their physiological data throughout the trial and therefore knew that they were working at the same intensity on both occasions. It is unsure to what extent this may have influenced RPE. The findings of Hagen et al. (2013) are particularly interesting as they are in direct contrast to the previous findings regarding the effects of music on work output (Atkinson et al. 2004; Lim et al. 2009). They found that self-selected motivational music had no effect on performance, physiology or RPE in a group of well-trained cyclists performing a 10km time trial which strengthens the suggestion that well-trained athletes might respond differently although direct comparison with previous works is difficult as these researchers did not report any details about the music used. Atkinson et al. (2004) made use of music with a high tempo (142bpm) which has been shown to be more motivational. If Hagen et al. (2013) did not use a similar music intervention this may have accounted for some of the difference. Despite observing no measurable benefits, they did report that some participants found the time trial easier in the presence of music. This adds to the hypothesis that although music may not be beneficial in all exercise settings it is still able to improve cognitive or affective evaluations of the exercise experience (Karageorghis & Priest 2012). One study by Terry et al. (2013) produced clear benefits of using music for well-trained runners. They investigated the responses of 11 elite triathletes during exhaustive treadmill running under self-selected motivational music, neutral music and no-music conditions. They found motivational and neutral music improved time to exhaustion relative to the no-music control. Motivational music induced more positive mood responses and feeling states and both music conditions resulted in improved running economy. The authors concluded that the use of music by elite triathletes during training should be considered. The fact that only one study has provided unequivocal findings regarding well-trained participants highlights the need for further investigation in this avenue. Furthermore, there is a need for a more standardised approach. For example, Mohammedzadeh et al. (2008) defined well-trained male runners as having a predicted VO_2 peak of greater than 42 ml/min/kg whereas Brownley et al. (1995) defined well-trained males as having a VO_2 peak of greater than 59 ml/min/kg. These methodological differences combined with incomplete reporting of the type of music used makes comparisons of findings between studies problematic.

Although music is often banned during competition it is reported to be a common tool used by athletes before, during and after training to self-regulate mood and improve performance (Stevens & Lane 2001). Athletes tend to display different mood characteristics to the general population such as lower scores of tension, depression, anger, fatigue and confusion along with higher scores for vigour (Leunes & Burger 2000). Furthermore, there is some evidence to suggest that elite endurance athletes tend to adopt a more associative attentional strategy as opposed to "dissociating" during exercise (Morgan & Pollock 1977). This is an important consideration, as it would reduce the potential benefit to be derived from dissociative techniques such as listening to music (Morgan & Pollock 1977). Association involves the allocation of cognitive resources toward internal bodily cues such as pain, fatigue or breathing rate whereas dissociation is described as an external focus through the use of various methods to distract attention from internal cues (Morgan & Pollock 1977). Findings such as those of Brownley et al. (1995) and Mohammedzadeh et al. (2008) tend to support this hypothesis. Also, although dissociative strategies have been shown to be effective for enhancing performance for non-athletic populations, Stevinson and Biddle (1998) suggest that in some cases this attention style may increase likelihood of "hitting the wall". This is because it may encourage them to increase work output and thus not regulate their pace correctly (Stevinson & Biddle 1998). With regard to well-trained endurance athletes, they tend to use internal information to regulate their pace according to a template that is developed through experience gathered through training and competition (Foster et al. 2009). Adhering to a pacing strategy often requires concentration from the individual and any distractions in these circumstances may result in reduced performance (Morgan & Pollock 1977). Although strong dissociative stimuli such as fast tempo music have been shown to modify patterns of work rate during endurance cycling for the average population it is uncertain whether this effect will hold true with more experienced exercisers who have developed a preferred pattern of exercise through experience. As suggested by the findings of Brownley et al. (1995), it is possible that when music is used that counteracts or distracts from the specific goals that athletes are trying to achieve that music preference will be reduced and furthermore, a negative impact on factors such as mood states and even performance may be observed.

2.6. Summary

Current research indicates that music is able to increase work output, performance, reduce perception of exertion and produce more favourable mood states when used in conjunction with endurance exercise. The type of music most likely to induce these effects is loud music with an upbeat tempo generally in the region of 125 to 140 bpm. These effects tend to be reduced during higher intensity exercise which has been attributed to the fact that physiological cues tend to dominate the capacity for attention at such workloads thus reducing potential impact of dissociative stimuli. Despite this, music has still been implicated as an effective method of improving mood and positive attitudes following exercise irrespective of whether improvements in RPE or performance are observed. With regard to well-trained individuals engaging in endurance tasks benefits are less clear with only one study having produced clear benefits. Therefore, the use of music to accompany training in well-trained populations is a potentially fruitful area of future research.

CHAPTER 3: SCIENTIFIC MANUSCRIPT

The following paper has been submitted to the DoE Accredited Journal: Perceptual and Motor Skills. The Appendix F provides a copy of the letter from the editor indicating that the paper has been submitted.

THE EFFECTS OF MUSIC TEMPO ON PERFORMANCE, PSYCHOLOGICAL AND PHYSIOLOGICAL VARIABLES DURING 20KM CYCLING IN WELL-TRAINED CYCLISTS

3.1. Abstract

Few studies have investigated the effects of music on well-trained individuals during high intensity endurance tasks. Therefore, this study investigated the effects of different music tempi on performance, and the psychological and physiological responses of well-trained cyclists to time trial cycling. Ten well-trained male road cyclists (age: 35 ± 7 yrs), with a minimum of three years racing experience, performed four 20km time-trials on a Computrainer™ Pro 3D indoor cycle trainer over a period of four weeks. The time-trials were spaced a week apart. The music conditions for each trial were randomised between fast-tempo (140 bpm), medium-tempo (120 bpm), slow-tempo (100 bpm), and no-music. Performance, (completion time, power output, average speed and cadence) physiological, (heart rate, oxygen consumption, breathing frequency and respiratory exchange ratio), psychophysical (RPE) and psychological (mood states) data were collected for each trial and analysed using a repeated measures ANOVA. Results indicated no significant changes in performance, physiological or psychophysical variables. Total mood disturbance and tension as measured by the Profile of Mood States questionnaire was increased significantly in the fast-tempo trial when compared with medium and no music conditions.

3.2. Introduction

Karageorghis and colleagues (1999) identified musicality, cultural impact, rhythm response and extra-musical association as the four primary musical factors likely to determine the motivational effect a music piece will have on the listener. Of these four, rhythm response, which relates to natural human responses to musical rhythm, particularly tempo, is thought to be the most important (Terry & Karageorghis 2006). Generally, loud, upbeat music is thought to be preferred when used in conjunction with exercise (Priest & Karageorghis 2008). More specifically, the ideal range for the ideal music tempo has been found to be quite narrow, between 125 and 140 beats per minute (bpm) (Karageorghis et al. 2011).

There has been substantial investigation into the ergogenic (performance enhancing), psychological (mood, cognitions and behaviour), psychophysical (rating of perceived exertion) and physiological effects of music in the domain of sports and exercise (Karageorghis & Priest 2012). These investigations have been done using a variety of exercise activities, such as running (e.g.: Karageorghis et al. 2006; Karageorghis et al. 2007; Karageorghis et al. 2009; Tenenbaum et al. 2004), cycling (e.g.: Atkinson et al. 2004; Elliot et al. 2005; Karageorghis et al. 2011; Waterhouse et al. 2009), and resistance training (Biagini et al. 2012; Karageorghis, Priest, Williams et al. 2010) and exercise intensities such as high-intensity anaerobic tasks (e.g.: Yamamoto et al. 2003) as well as low to moderate (e.g.: Waterhouse et al. 2009), and high-intensity endurance tasks (e.g.: Schie et al. 2008). Furthermore, a number of types of music application have been investigated such as pre- and post-task music and in-task synchronous (exercising in time with a musical beat), (e.g.: Terry et al. 2012) and asynchronous music (no conscious synchronisation with musical beat) (e.g.: Atkinson et al. 2004).

With regard to the use of music during endurance tasks, significant benefits have been observed (e.g.: Atkinson et al. 2004; Elliot et al. 2005; Waterhouse et al. 2009). The study by Atkinson et al. (2004) found that fast tempo music (140bpm) played during a 10km cycle time-trial altered the pattern of work-rate distribution characterised by an increased work output during the first three minutes. Similarly, Elliot et al. found that both motivational and non-motivational fast tempo music (140bpm) increased distance travelled in a 20-minute submaximal cycle task but did not reduce RPE. They also found that music tended to encourage more positive attitudes toward the exercise experience post-task. In the study by Waterhouse et al. (2009) the researchers increased or decreased the tempo of a music playlist by 10%. Accelerating the tempo improved performance in a self-paced cycle task by increasing cadence, power output and distance per unit time whereas decelerating the tempo had the opposite effect.

However, an important factor to be mindful of is that only a handful of studies have investigated the benefits of music for well-trained, task-habituated individuals during endurance exercise (Brownley et al. 1995; Hagen et al. 2013; Mohammedzadeh et al. (2008); Schie et al. 2008; Terry et al. 2012). Well-trained athletes tend to differ from the general population in terms of the intensity of exercise they are likely to perform during training and their preferred attention strategy (Morgan & Pollock 1977). These are both factors which may influence the effects of music. It has been shown that the ergogenic and psychophysical (reduced RPE) benefits of music are more pronounced during low to moderate intensity exercise (Elliot et al. 2005; Waterhouse et al. 2009) but as exercise intensity increases toward the point where anaerobic metabolism starts to dominate these effects are reduced (Tenenbaum et al. 2004). This has been attributed the so called attentional processing theory which suggests that at low to moderate exercise intensities, distractive stimuli such as music are able to block afferent feedback signals and thus distract the listener from the physiological sensations associated with exertion (Karageorghis & Priest 2012; Tenenbaum et al. 2004). At high exercise intensities however (particularly above 80% of HRR Max), physiological cues become more powerful and eventually dominate the listener's attention capacity, reducing the ability to attend to musical stimuli, thereby reducing the ergogenic effect (Tenenbaum et al. 2004). The natural focus of attention that the listener prefers to adopt, whether associative or dissociative, has also been highlighted as a factor which may influence how the listener responds to musical stimuli (Brownley et al. 1995). Association involves focussing attention internally toward bodily sensations or task-relevant cues whereas a dissociative strategy comprises of focussing attention away from the exercise task and the accompanying physical sensations (Brewer & Buman 2006). It is likely that individuals who prefer to adopt an associative strategy during exercise are less inclined to attend to dissociative stimuli and therefore may not gain as much benefit from dissociative techniques such as music listening (Brownley et al. 1995). It is thought that associative strategies are more commonly preferred amongst well-trained, task-habituated individuals (Morgan & Pollock 1977). Athletes also tend to display different mood characteristics compared to the general population such as lower scores of tension, depression, anger, fatigue and confusion along with higher scores for vigour (Leunes & Burger 2000) which highlights another important avenue where the response to music may differ. Although many studies have indicated the mood-enhancing benefits of music, few have investigated these effects in conjunction with a high intensity endurance task using well-trained, task habituated individuals (Terry et al. 2012).

To date, the research aimed at well-trained participants has yielded mixed results although evidence seems to suggest that music may not be as beneficial (Brownley et al. 1995; Hagen et al. 2013; Mohammedzadeh et al. 2008; Schie et al. 2008). Terry et al. (2012) did show that synchronous music (80 – 97bpm) was able to provide ergogenic, psychological and physiological benefits, during a time to exhaustion running task, in elite triathletes although these findings do not seem to be supported by other studies specifically where closed-loop (time-trial) tasks have been used (Hagen et al. 2013; Schie et al. 2008). In contrast to Atkinson et al. (2004) who showed that fast tempo music (140 bpm) could alter work rate distribution, Hagen et al. (2013) found that self-selected motivational music had no effect on performance or physiology in a group of well-trained cyclists performing a 10km time trial which strengthens the suggestion that well-trained athletes might respond differently. Hagen et al. (2013) did report that some participants commented that the time trial seemed easier in the presence of music although this was not measured in any way. Furthermore, it is uncertain whether the researchers also used fast tempo music similar to that in the study by Atkinson et al. which may also explain the differences. Results of the study by Schie et al. (2008) were similar in that the majority of the well-trained cyclists who participated reported that they found a 20-minute submaximal cycling session less demanding in the presence of music. However, no change in RPE and no physiological benefit of music listening was reported. The findings of Brownley et al. (1995) were different as they found that very fast tempo music (154-162bpm) in conjunction with high intensity exercise was counterproductive for well-trained runners in that it seemed to exacerbate the exercise stress, characterised by an increased cortisol response and RPE and reduced positive affect. This may be due to the fact that such high tempo music may be unfamiliar, over-arousing or contain too much information for the afferent nervous system as has been suggested previously by Karageorghis et al. (2011). It is uncertain whether these effects are due only to the music intervention, or an interaction between the music and exercise intensity. Furthermore, the methodological differences between the studies highlight the need to investigate the effects of different music tempi during a standardised exercise task to clarify which is most beneficial.

Therefore, the purpose of this study was to investigate the effects of different music tempi on performance, and psychological and physiological responses of well-trained, task-habituated cyclists to 20 km time trial cycling. Based on previous findings (Atkinson et al. 2004; Brownley et al. 1995) three hypotheses were tested: (1) Fast tempo music would influence the pattern of power output adopted by well-trained cyclists during a 20km cycle time-trial characterised by an increase in work output during the initial stages of the trial compared to slow and medium tempo music and a no-music control; (2) heart rate, oxygen consumption, RPE and breathing frequency would differ between trials, particularly in the early stages, as a consequence of the changes in work rate distribution; and (3) fast tempo music in conjunction with the high intensity endurance task such as 20km time-trial cycling would result in increased mood disturbances as compared to slow and medium tempo music and a no-music control.

3.3. Methods

All procedures were carried out in the Human Performance Laboratory situated at the University of KwaZulu-Natal (UKZN) Discipline of Biokinetics, Exercise and Leisure Sciences following approval from the UKZN Biomedical Research Ethics Committee.

3.3.1. Study Design and Participant Recruitment

This study made use of a repeated measures design comprised of three experimental musical conditions and a no-music control. An initial baseline testing session was also included which resulted in each participant having to be present for data collection in the laboratory on five separate occasions. The minimal sample size for this study was determined using the laboratory cycle time trial data of Palmer et al. (1996). Assuming that the smallest meaningful difference is 1.0% (Currell et al. 2008; Paton et al. 2001; Paton et al. 2005) with a SD of 0.5%, the sample size required for this study to achieve a statistical power of 80% and a significance level of 5% was n = 5 for each group (Altman 1991). Ten well trained, male road cyclists (age: 35 ± 7 yrs) were recruited to participate in the study through advertising at local cycling retailers and cycling clubs. Potential participants were offered a free VO_2 peak assessment to encourage response to the advert. Respondents who met the criteria in terms of training history and status were then invited to participate in the study. Well-trained cyclists were defined as those training at least six hours per week with a minimum of three years competitive cycling experience and a VO_2 Peak of at least 5 l/min (Jeukendrup, Craig, & Hawley 2000). The following inclusion and exclusion criteria were applied:

Inclusion criteria:

- Males
- Road cyclists
- 20 - 40 years
- A minimum of 3 years competitive road cycling experience

- A minimum of 6 training hours per week
- Non-smokers

Exclusion criteria:

- Females
- Full or Partial Deafness/ Hearing Problems
- Recent Orthopaedic Injury (Incomplete Recovery)
- Disability
- Prescription Medication
- Smokers

Subsequent to ethical clearance being granted for the study by the UKZN Biomedical Research Ethics Committee (REF: BE113/010) (Appendix G), all participating cyclists read and indicated their understanding of the participant information letter explaining the research project (Appendix A). The document outlined the testing programme, the length and duration of testing procedures and the possible discomforts that might be experienced during testing procedures. All participants were informed that they were free to withdraw consent and discontinue participation at any time and were assured that all data would be treated as confidential. Thereafter, written consent (Appendix B) was provided to participate in the tests.

3.3.2. Protocol

All testing was performed in Human Performance Laboratory (HPL) based at the Discipline of Biokinetics, Exercise and Leisure Sciences at the University of KwaZulu-Natal's Westville Campus. Each visit to the laboratory was organised so that participants performed each test at the same time of day on the same day of the week. All cycling tasks were performed on each participant's own road bicycle which was connected to a Computrainer™ Pro 3D, electromagnetically-braked indoor cycle trainer (Racermate, Seattle, USA). The Computrainer measures torque as applied by the rear wheel of the bicycle to a load generator. A cadence lead is placed on the left crank arm and chain stay of the bicycle to allow for measurement of cadence and crank position (Swart et al. 2008).

3.3.3. Baseline Testing Session

An initial baseline testing session was performed upon each participant's first visit to the laboratory. During this initial visit each participant was asked to complete a physical activity readiness questionnaire (PAR-Q) (Appendix C) and full cycling history and medical history questionnaire (Appendix D). The purpose of these questionnaires was to assess the eligibility of each cyclist for participation in the study in accordance with the inclusion criteria. Following the completion of these questionnaires, the following baseline measures were recorded:

Standing height

This was recorded using a stadiometer. Participants stood barefoot on the stadiometer with their arms hanging loosely at their sides and their chin level. Measurements were recorded in metres and rounded off to the nearest centimetre

Body mass

This was recorded using a digital scale. Participants stood barefoot on the scale in their cycling kit with their hands hanging loosely at their sides and chin level. Measures were recorded in kilograms and rounded off to the nearest gram.

Sum of seven skinfolds

The purpose of this was to assess baseline body composition. Skinfolds were measured using a Harpenden Skinfold Caliper. Measurements were taken at seven sites (bicep, tricep, subscapular, supra-iliac, abdominal, mid-thigh and calf). All measurements were taken on the right hand side of the participant's body and were repeated. Initial and repeat measurements were checked to ensure they fell within 2 millimetres (mm) of each other. In the event of a larger difference, the measurement was taken again. All measurement were recorded in mm and added to give a total sum of skinfolds.

Peak oxygen consumption ($\dot{V}O_2$ Peak)

The purpose of this test was to assess the baseline aerobic fitness of each participant and assess their eligibility for participation in the study according with the inclusion criteria for aerobic capacity (Jeukendrup et al. 2000). The test began with a fifteen minute self-paced warm-up after which the initial workload was set at 2.5 watts/ kg of the cyclists bodyweight. The workload was then increased in increments of 20 watts every minute until volitional exhaustion or until the cyclist could not maintain a cadence of greater than 70 revolutions per minute (RPM). VO_2 peak was recorded as the highest value in litres per minute achieved over the final 30 seconds of the test (Van Laetham et al. 2006). During the test, oxygen consumption (VO_2) was recorded using a Cosmed™ K_4b^2 portable breath by breath gas analyser (Cosmed™, Rome, Italy). The device was calibrated as per manufacturer guidelines prior to each test.

3.3.4. Music Selection

The music used in this study was self-selected by each participant. Each individual was accustomed to exercising with music and was asked to provide a list of 25 songs they found motivational and enjoyed listening to during exercise. A playlist was then constructed by the researchers using the tracks provided. Using the same playlist, the tempo of each of the tracks was digitally altered by increasing or decreasing the tempo to meet the requirements of each trial. As a result, all tracks were played at a standard tempo of either 100bpm (slow tempo), 120bpm (medium tempo) or 140bpm (fast tempo). To ensure some homogeneity in the extent to which tempi were altered the researchers selected the songs which fell within a narrow tempo range of 115 – 120 bpm. The tracks were altered using Magix™ Digital DJ Software which possesses a special pitch-lock function. This allowed the researchers to alter the tempo of the music whilst maintaining the original pitch. During each trial, music was played through headphones (Skullcandy™, Park City, USA) connected to a laptop computer and all music was played at 75% of the maximum volume that was possible.

3.3.5. Experimental Protocol

One week after the baseline testing session each participant began the experimental protocol. This consisted of four 20km cycle time trials which were performed whilst listening to fast-tempo, medium-tempo or slow-tempo music or no-music which served as the control trial. The participants performed one time-trial per week on the same day of the week and at a similar time of day. This was done to allow a full recovery between trials and also to limit the possibility of factors such as training and living routines having an effect on the outcome of the time-trial. The order in which participants were exposed to each trial was randomised.

Pre-test procedure

Upon arrival at the laboratory the following baseline measures were recorded:

Body mass

This was recorded using a digital scale. Participants stood barefoot on the scale in their cycling kit with their hands hanging loosely at their sides and chin level. Measures were recorded in kilograms and rounded off to the nearest gram. The purpose of recording body mass prior to each time trial was to keep track of fluctuations in body mass over the four weeks of the experimental protocol. Relative oxygen consumption is also expressed as a function of body mass therefore any fluctuations in body mass need to be recorded to ensure accurate reporting of these values.

Resting heart rate

Participants were asked to remain seated for a five minute rest period. Thereafter, resting heart rate was recorded manually using a digital stopwatch. This was done using the radial pulse of the right arm whilst the participant remained seated. Heart rate was recorded in beats per minute measured over a one minute time period. The purpose of recording resting heart rate was to ensure that participants were in a similar state of arousal prior to each time-trial.

Pre-trial questionnaire

Participants remained seated following the heart rate measurement and were asked to complete a brief questionnaire regarding their training history for the previous week and their dietary intake and sleeping patterns for the 12 hours prior to arrival at the laboratory. Participants were asked to maintain similar sleeping patterns, training and dietary habits and to avoid heavy physical activity in the 24 hours leading up to each trial. This was done in an attempt to limit the impact of these external variables on the test outcomes as much as possible.

Profile of Mood States (POMS) Questionnaire

Following completion of the pre-trial questionnaire regarding training, dietary and sleeping patterns participants completed the Profile of Mood States (POMS) Questionnaire. The POMS is a 65 item inventory commonly used to measure changes in mood state in exercise studies (McNair, Lorr & Droppelman 1971). Participants rated how they were feeling at that instant for each of the 65 mood descriptors (e.g.: “cheerful”) on a 5-point scale ranging from 0 (“not at all”) to 4 (“extremely”). The questionnaire comprises of six subscales: Tension, Depression, Anger, Vigor, Fatigue, and Confusion. The test is scored by calculating the sum of the five negative subscales and subtracting the score for vigor. A higher total score indicates a higher total mood disturbance (TMD) therefore the lower the score the better the result. The POMS inventory typically takes approximately five minutes to complete and has been shown to be both a valid and reliable method of monitoring mood changes in association with exercise (McNair et al. 1971).

Time-trial procedure

The exercise protocol began with a 15 minute self-paced warm up (Swart et al. 2009) under no-music conditions. Participants then stopped briefly for a 2 minute rest period during which they remained seated on their bicycles to have the headphones fitted. Subsequently, the time-trial commenced from a standing following a visual countdown using hand signals once the music playlist had been started. In the case of the no- music trial, no music was played but participants were still required to wear the headphones.

The time trial protocol consisted of a simulated flat 20km time trial which participants were instructed to finish as quickly as possible. Information regarding performance was withheld from the participants to reduce the likelihood of personal goal setting; however, they were informed by means of hand signals when they were ten and five kilometres from the end of the test.

The following measures were recorded during the course of each time trial.

Psychophysical measures:

Rating of Perceived Exertion (RPE)

RPE was recorded every three minutes using the Borg ten-point category ratio scale (CR-10) (Borg 1990). The Borg CR-10 is a graded scale which ranges from 0 to 10 and includes descriptive words to describe the level of exertion the participant is feeling at the time. These range from “nothing at all” to “maximal”. The Borg CR-10 scale has demonstrated its validity and reliability in evaluating different physical tasks (Borg 1982).

Physiological and Performance measures

Two separate sets of physiological and performance data were collected for each time-trial. The first data set comprised of average measurements over the entire duration of the time-trial whereas the second data set consisted of average measurements of selected variables for 3 minute intervals in order to assess the effects of music at different time points throughout the trial. All performance data was recorded by means of the Computrainer™ coaching software whereas all physiological data was recorded using the Cosmed K_4b^2 system. The following measurements were recorded:

Performance Data:

Completion time

This provides an indication of overall performance. This was recorded to assess whether different music tempi were able to influence performance outcome in the time trial condition. Time was recorded in minutes and milliseconds (min:ms) rounded off to the nearest two decimal places.

Average Speed

Average speed was also recorded as an overall indication of performance. Speed was measured in kilometres per hour (km/h) rounded off to the nearest two decimal places.

Average Power Output (W)

Average power output is related to performance. If power output is increased, one would expect to see an improvement in overall performance. Power output was recorded in watts.

Average Cadence

Average cadence was recorded to assess for the possibility of a synchronisation effect. Previous research has shown that increasing the tempo of music can engender an increase in pedalling cadence. Average cadence was recorded in revolutions per minute (RPM).

Physiological Data:

Heart rate, oxygen consumption and breathing frequency, respiratory exchange ratio (RER)

Previous research has indicated that musical tempo can influence heart rate, oxygen consumption and breathing frequency. These physiological variables were measured in order to determine any possible music effect or to see if work output could be increased without an increase in physiological cost.

3.3.6. Bicycle and Computrainer Calibration Protocol

As per the request of the researchers, there were no modifications made to the participants' bicycles for the duration of the testing schedule. Tire pressure was inflated to 800kPa prior to each warm up. The Computrainer™ was calibrated as per manufacturer guidelines by setting the rolling resistance applied to the bicycle tire between 1.96 and 2.06.

3.3.7. Statistical Analyses

All statistical analyses were performed using SPSS version 19. Physiological and performance data were collected as an average for the entire duration of the trial and analysed by means of a one-way analysis of variance (ANOVA). Average RPE and pre, post and percentage change from pre to post scores for the POMS inventory were also analysed by means of one-way ANOVA. Where the overall F value was significantly different data were subject to a Bonferroni post-hoc test to determine specific differences between conditions. Significance was set at $p < 0.05$.

Selected physiological (heart rate, oxygen consumption and breathing frequency) and performance data (power output) and RPE collected as averages for each three minute period of the trial and analysed by means of a two-way (time x condition) repeated measures ANOVA.

3.4. Results

3.4.1. General characteristics of the study population

The general characteristics of the study population can be seen in table 3.1. As shown in Table 1, participants achieved peak power output values of 368±29.49 watts and VO_2 Peak scores of 5.57±0.39 l/min during the VO_2 peak protocol. Participant characteristics and results from other preliminary tests can also be seen in Table 1. All participants achieved an absolute VO_2 peak score of greater than 5 litres per minute (l/min) indicating their high level of aerobic fitness (Jeukendrup et al. 2000). In addition, participants were similar in terms of their history of cycling experience and weekly level of training they were performing prior to participation in the study.

TABLE 1: Characteristics of the participants (n = 10)

	Mean	SD
Age (years)	35.7	6.71
Height (cm)	1.79	0.04
Weight (kg)	77.83	4.89
VO2 Peak (l/min)	5.57	0.39
Sum of 7 Skinfolds (mm)	57.6	9.39
Resting Heart Rate (bpm)	53.4	7.33
PPO (watts)	368	29.49
Training History (years)	9.3	3.5
Weekly Training (hours)	9	3.2
Average Distance Per Week (km)	222.5	123.9

3.4.2. Time Trial Data

A summary of the data collected from the time-trials can be seen in Table 2. Results of one-way ANOVA indicated no significant changes between music conditions in any of the performance or physiological variables measured over the entire duration of the time trial. There was also no significant difference in psychophysical (RPE) response between music conditions. These findings indicate that participants were able to reproduce very similar performances for all time trials regardless of the music condition. Results of the two-way repeated measures ANOVA also revealed no significant music effect for any of the selected variables although some significant time effects were observed for the physiological variables. These findings are depicted in figures 3.1, 3.2, 3.3, 3.4, and 3.5 below.

TABLE 2: Average performance data collected over the entire duration of each time trial (mean ±SD)

Trial	No Music		Slow Tempo		Medium Tempo		Fast Tempo		F Ratio (3, 36)	P Value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
Time to Completion (min:ms)	30.9	1.2	30.9	1.1	30.1	1.4	31.0	0.9	0.045	0.987
Speed (km/h)	38.7	1.4	38.5	1.3	38.7	1.6	38.4	1.1	0.117	0.950
Power Output (watts)	276.1	29.3	274.5	30	277.4	32.5	275	27.4	0.018	0.997
Cadence (rpm)	92.1	7.1	91.6	7.1	91.4	6.4	92.1	8.1	0.024	0.995
Heart Rate (bpm)	164.6	11.2	161.9	12	166.5	10.1	165	9.3	0.319	0.812
Breathing Frequency (breaths/min)	43.4	7.7	43.6	5.5	44.8	6.9	44.9	6.1	0.155	0.926
Oxygen Consumption (ml/kg/min)	62.8	7.2	62.3	7.6	62.1	7.7	61.7	7.3	0.042	0.989
Respiratory Exchange Ratio	0.87	0.04	0.88	0.1	0.88	0.05	0.89	0.04	0.357	0.785
Rating of Perceived Exertion	6.3	1.3	6.4	1.1	6.1	1.3	6.4	1.1	0.133	0.940
% VO_2 Peak	86.4	3.8	87.3	3.8	86.2	4.7	85.6	3.7		

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Power Output

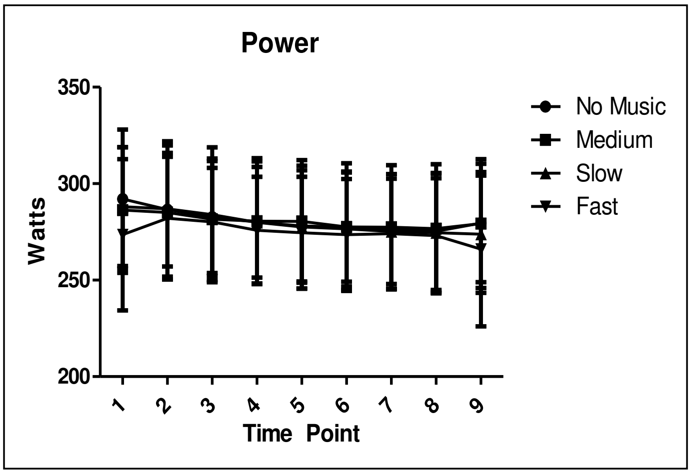

Figure 3.1 - Graph showing power output during time trials averaged for three minute intervals

Oxygen Consumption

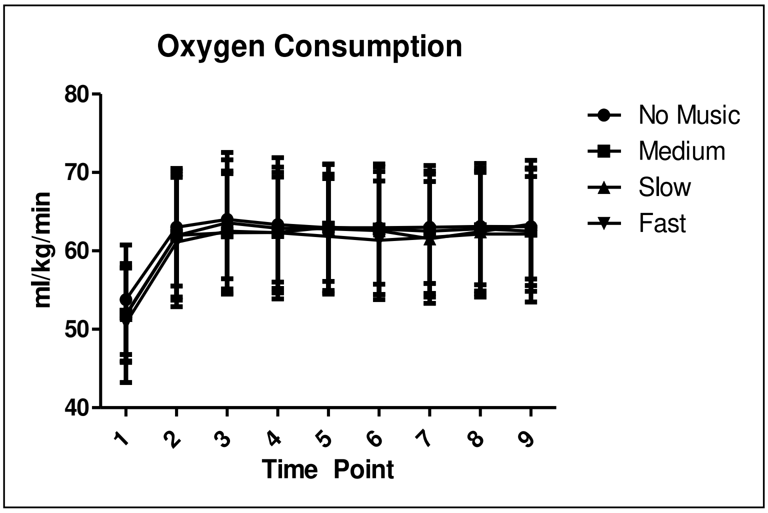

Figure 3.2 - Graph showing oxygen consumption during time trials averaged for three minute intervals

Heart Rate

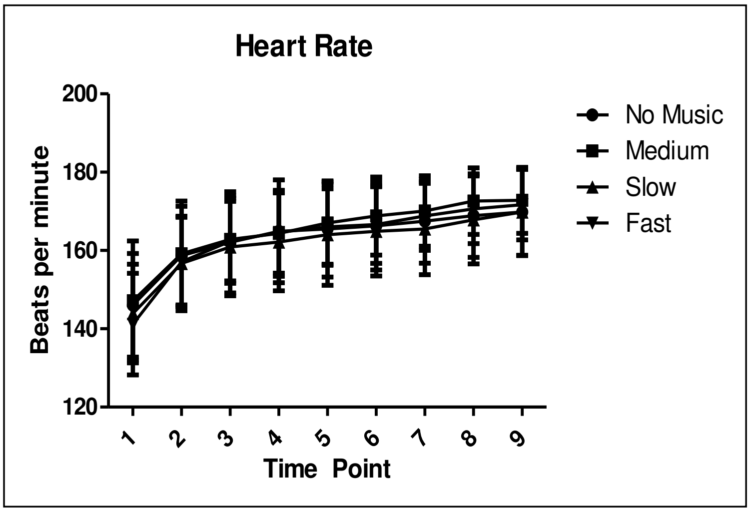

Figure 3.3 - Graph showing heart rate during time trials averaged for three minute intervals

Breathing Frequency

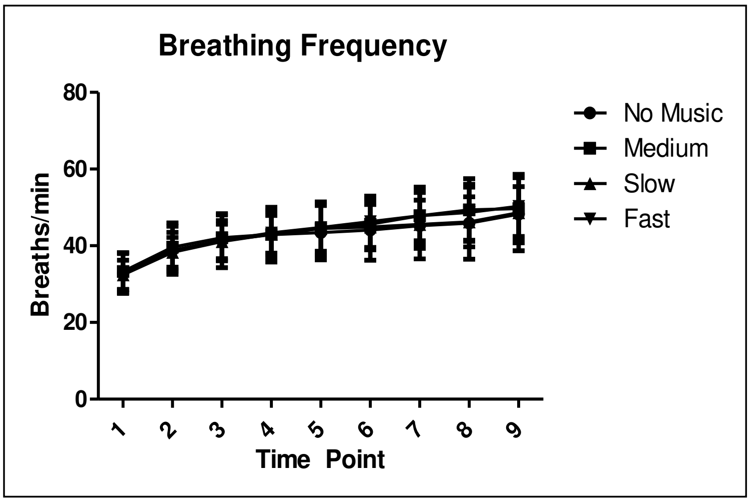

Figure 3.4 - Graph showing breathing frequency during time trials averaged for three minute intervals

Rating of Perceived Exertion

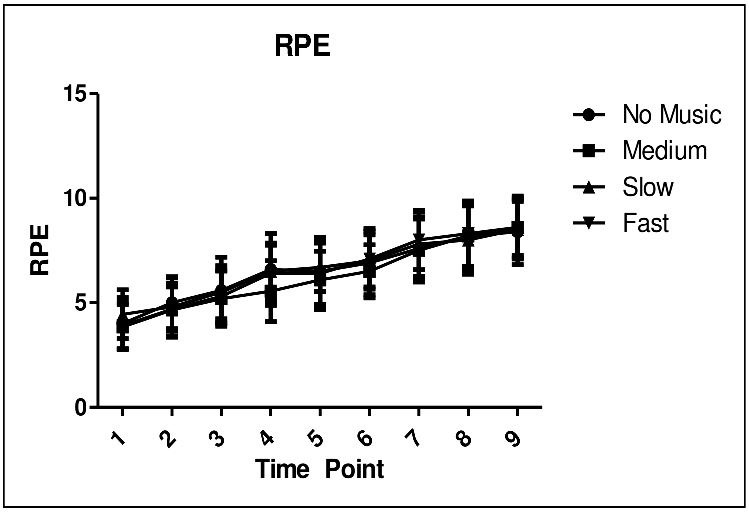

Figure 3.5 - Graph showing RPE during time trials averaged for three minute intervals

3.4.3. POMS Scores

Results for percentage changes from pre-trial to post-trial in Profile of Mood States subscales can be seen in Table 3.3. One-way ANOVA results indicated no significant changes in depression, anger, vigour and fatigue subscales as a result of the music condition. Total mood disturbance (TMD) and tension were found to be significantly elevated following the fast tempo music condition. Post hoc analysis indicated that TMD was significantly elevated in the fast tempo condition relative to the medium tempo condition (95% CI = 2.3556, 24.3344, p=0.012). Tension was found to be significantly elevated following the fast tempo condition as compared to the no-music control (95% CI = 0.5275, 344,4725, p=0.049). Tension was also elevated in the fast tempo condition relative to the medium tempo condition although this was only approaching significance.

TABLE 3:

Results for percentage change from pre time trial to post time trial in mood state sub-scales for the no music (*N* = 10), slow (*N* = 10), medium (*N* = 10) and fast tempo (*N* = 10) trials as measured by the POMS questionnaire

Variable	Music Tempo	Percentage Change		95%*CI*	*F* (df)	*P* value
		Mean	SD			
Total Mood Disturbance (TMD)	Fast	10.65	10.98**	2.8, 18.5	3.97 (3, 36)	0.015*
	Medium	-2.69	9.26	-9.3, 3.9		
	Slow	5.44	9.1	-1.1, 12.0		
	No-music	1.05	6.62	-3.7, 5.8		
Tension	Fast	189.17	135.4***	92.3, 286	3.13 (3, 36)	0.037*
	Medium	35	166.38	-84.0, 154		
	Slow	40.24	178.92	-87.8, 168		
	No-music	16.67	59.32	-25.8, 59.1		
Depression	Fast	32.33	63.33	-13.0, 77.6	0.23 (3, 36)	0.87
	Medium	10.83	52.41	-26.7, 48.3		
	Slow	22.71	64.12	-23.2, 68.6		
	No-music	25.1	53.01	-12.8, 63.0		
Anger	Fast	25	171	-98.0, 148	0.24 (3, 36)	0.87
	Medium	-15	57.98	-56.5, 26.5		
	Slow	1.66	102.79	-71.9, 75.2		
	No-music	10.89	57.09	-30.0, 51.7		
Vigour	Fast	-12.47	12.31	-21.3, -3.7	1.21 (3, 36)	0.32
	Medium	-21.31	24.27	-38.7, -4.0		
	Slow	-9.04	16	-20.5, 2.4		
	No-music	-8.37	13.23	-17.8, 1.1		
Fatigue	Fast	117	97.5	47.3, 186.7	1.62 (3, 36)	0.20
	Medium	81.19	42.58	50.7, 111.6		
	Slow	86.94	68	38.3, 135.6		
	No-music	309.85	524.77	-65.6, 685.3		
Confusion	Fast	-23.57	57.05	-64.4, 17.2	0.89 (3, 36)	0.46
	Medium	-20.5	173.31	-144.5, 103.5		
	Slow	52.5	148.35	-53.6, 158.6		
	No-music	44	140.33	-56.4, 144.4		

*Indicates a significant difference between groups ($P < 0.05$)
** Indicates significant increase relative to the medium tempo condition ($P < 0.05$)
*** Indicates significant increase relative to the no-music condition ($P < 0.05$)

3.5. Discussion

The study assessed the effects of different music tempi on performance, psychological and physiological variables during 20 km time-trial cycling. The primary findings were that there were significant increases in total mood disturbance TMD and tension following the fast tempo condition compared with the medium-tempo and no-music control, respectively, indicating a relatively negative mood response to the fast tempo music. This disturbance in mood state occurred despite the finding that the participants were exercising at very similar workloads throughout all four trials as indicated by the results for heart rate, power output, RPE and time to completion (Table 2). The absence of a music effect for physiological and performance variables is not unusual given the high intensity (± 85% VO_2 Peak) at which participants were exercising during each trial. Previous research has revealed the ergogenic properties of music to be diminished at exercise intensities above approximately 80% HR Max (Tenenbaum et al. 2004). However, some of these studies have still reported improvements in positive affect and post-task attitudes even in the absence of any ergogenic benefit (Karageorghis et al. 2009). Therefore, the fact that participants experienced negative mood changes following the fast-tempo trial is particularly interesting.

Well-trained, task-habituated individuals tend to develop a template or pattern of exercise which they adhere to when completing closed-loop exercise tasks such as the time trial cycle included in this study. The fact that participants were able to reproduce almost identical efforts on four occasions serves to re-enforce this. The increased mood disturbance following the fast tempo trial does suggest that although performance and psychophysical responses in-task did not change it may have required more of a psychological effort by the cyclists to adhere to their desired exercise pattern. Indeed, anecdotal reports from participants suggested a preference for no-music with many reporting that they felt “agitated” during the fast-tempo condition stating inability to focus on task-relevant cues as the primary reason. This suggests that these cyclists may have preferred an associative attention strategy which is more common amongst well-trained populations (Brewer & Buman 2006; Morgan & Pollock 1977). In this case dissociative tools are thought to be less effective which may explain why no significant changes were observed in the medium and slow tempo trials. The difference with the fast tempo trial is possibly due to the fact that music of a high tempo is more likely to demand the attention of the listener. This may have perhaps made it more difficult for cyclists to concentrate on the task at hand as opposed to the medium and slow tempo music which could be more easily confined to the background.

The findings of the present study are similar to those of Schie et al. (2008) and Hagen et al. (2013) in that no performance or psychophysical effects were observed using well trained cyclists. Despite this, both the abovementioned studies did report that cyclists felt that the exercise task was easier in the presence of music although this was not measured. The major difference between these studies and the present study is perhaps the tempo of the music intervention. The tempo used by Hagen et al. is not reported making it difficult to compare, however, Schie et al. made use of a playlist consisting largely of slow tempo tracks which may explain the difference. In the case of Brownley et al. (1995), presentation of fast tempo music during a high intensity running task produced similar results to the current study in that trained participants seemed to respond negatively characterised by an increased cortisol response and reduced positive affect.

Although performance was unchanged, the practical application of these findings is that athletes should possibly avoid practices in training that could lead to negative mood changes. Despite research indicating that fast-tempo music may have a beneficial effect on performance these findings are largely based on research conducted using untrained or inexperienced individuals (Atkinson et al. 2004; Elliot et al. 2005; Waterhouse et al. 2009). The benefits that well-trained participants can derive from such interventions are less clear although the current findings suggest these cyclists may benefit the most from music-listening if it is confined to the pre or post-exercise environment whilst exercising either without external auditory stimulation.

3.6. Limitations

There were a number of limitations in the present study. Firstly, the music selection process used in this study resulted in each cyclist listening to different music tracks. It may be argued that this could confound the results due to differences between music tracks such as melodies, harmonies and associations these have for the participants. However, this was done in an attempt to standardise the participant’s liking for the music somewhat. Had the researchers merely selected a standard playlist it is likely that not all cyclists would have found the music personally enjoyable. Another limitation with regard to the music selection is that the adjustment of the tempo might have confounded results. Tracks were selected as close to the 120bpm mark as possible to maintain some homogeneity although in some cases tracks may have been accelerated to a greater extent than they were decelerated due to differences in the original tempo. The primary reason for this method was to investigate the effect of manipulating the tempo only on selected variables however the degree of change may have been too great allowing participants to become aware of it. This may have influenced feelings of tension as it was contrary to what they were expecting and thus may have become an irritation. Nevertheless, this response was only observed in the fast tempo condition which still indicates that a high tempo is an important component. Lastly, although all participants were experienced time-trialists, a familiarisation period with respect to the experimental protocol itself might have strengthened the methodology.

3.7. Conclusion

Self-selected music had no effect on the performance times or physiological responses of well-trained cyclists during a 20km time-trial regardless of the tempo of music that they listened to. Music played with a fast-tempo resulted in increased mood disturbance as a result of increased feelings of tension. Although performance was unchanged, the practical application of this finding is that athletes should possibly avoid practices in training that could lead to negative mood changes. Despite research indicating that fast-tempo music may have a beneficial effect on performance these findings are largely based on research conducted using untrained or inexperienced individuals (Elliot et al. 2005; Waterhouse et al. 2009). Music is used as a tool to facilitate dissociation from exercise and the accompanying physical sensations. Well-trained athletes commonly adopt an associative focus during exercise (Brewer & Buman 2006; Morgan & Pollock 1977), choosing to concentrate on the task at hand therefore dissociative tools such as music may not hold the same benefit or may have negative consequences in some cases (Brownley et al. 1995). Therefore, these cyclists may benefit the most from music-listening if it is confined to the pre or post-exercise environment whilst exercising without external auditory stimulation. Further research is required to investigate the time course of negative alterations in mood state following high intensity exercise along with the cumulative effect of frequent high intensity training combined with upbeat, arousing music.

CHAPTER 4: CONCLUSIONS AND RECOMMENDATIONS

The purpose of this study was to establish the effects that music played at different tempi might have on physiological and psychological responses and performance of well-trained cyclists during a cycling time trial. The results of this study are in contrast with the majority of research available in that no changes in any physiological or performance variables were observed. This is likely due firstly, to the fact that the participants were well-trained and task-habituated and therefore able to produce similar performances on repeat occasions. Secondly, the average exercise intensity that these participants were required to work at was approximately 85% HR Max. Previous research has indicated that at such high workloads, a dissociative focus becomes near impossible and therefore dissociative strategies such as music listening are rendered ineffective. However, previous research has still indicated that in such cases, music can still induce more favourable mood states and encourage positive attitudes post-exercise. Again, this study has presented contrasting findings. When listening to fast tempo music, well-trained cyclists exhibited increased feelings of tension and increased overall mood disturbance. This suggests an adverse response to the presentation of music during time-trial cycling, specifically fast tempo music and is a particularly interesting finding. Although it has been suggested previously that fast-tempo music may exacerbate exercise stress for well-trained individuals there is still a lack of evidence on this topic. The fact that only fast-tempo music induced a negative mood response also warrants further investigation.

A possible explanation for the study result is that loud, fast tempo music provides a much stronger dissociative stimulus than moderate or slow tempo music and this, in conjunction with intense physiological cues, may increase the difficulty with which athletes are able to process information during high intensity exercise tasks. However, there is currently no research to support this assumption. Based on the findings of the present study, it is evident that special consideration may be necessary when selecting musical playlists for well-trained cyclists to use during training. In light of some of the limitations, this study warrants replication although future research should make use of more moderate alterations in tempo to avoid having participants become aware of the modifications to music. Further research into the effects of chronic use of music to accompany training on psychological variables such as mood state in well-trained athletes is another area of investigation that should be considered.

REFERENCES

Altman, D. G 1991, *Practical Statistics for Medical Research*. London: Chapman and Hall.

Atkinson, G, Wilson, D & Eubank, M 2004, 'Effects of music on work-rate distribution during a cycle time trial'. *International Journal of Sports Medicine,* vol. 25, no. 8, pp. 611-615.

Bernardi, L, Porta, C, & Sleight, P 2006, 'Cardiovascular, cereberovascular, and respiratory changes induced by different types of music in musicians and non-musicians: the importance of silence'. *Heart*, vol. 92, pp. 445-452. doi: 10.1136/hrt.2005.064600

Biagini, M.S, Brown, L.E, Coburn, J.W, Judelson, D.A, Staler T.A, Bottaro, M, Tran, T.T, Longo, N.A 2012, 'Effects of self-selected music on strength, explosivness, and mood'. *Journal of Strength and Conditioning.* Vol. 26, no. 7, pp. 1934-1938. doi: 10.1519/JSC.0b013e318237e7b3

Bishop, D. T, Karageorghis, C. I, & Kinrade, N. P 2009. 'Effects of musically-induced emotions on choice reaction time performance'. *The Sport Psychologist*, vol. *23*, pp. 59-76.

Borg, G 1998, *Borg's perceived exertion and pain scales.* Champaign, IL: Human Kinetics

Brewer, B. W, & Buman, M. P 2006, 'Attentional focus and endurance performance: Review and theoretical integration'. *Kinesiologia Slovenica*, vol. 12 no. 2, pp. 82-97.

Brownley, K., McMurray, R., & Hackney, A. (1995). 'Effects of music on physiological and affective responses to graded treadmill exercise in trained and untrained runners'. *International Journal of Psychophysiology*, vol. 19, pp. 193-201. doi: 10.1016/0167-8760(95)00007-F

Currell, K, & Jeukendrup, A. E 2008, 'Validity, reliability and sensitivity of measures of sporting performance'. *Sports Med*icine, vol. 38, pp. 297–316.

Elliot, D 2007, ‘Music during exercise: Does tempo influence psychophysical responses?’. *Philica.com*, article number 110. Retrieved from http://philica.com/display_article.php?article_id=110.

Elliot, D, Carr, S, & Orme, D 2005, ‘The effect motivational music on sub-maximal exercise’. *European Journal of Sports Sciences,* vol. 5, pp. 97-106.

Elliot, D, Carr, S, & Savage 2004, ‘Effects of motivational music on work output and affective responses during sub-maximal cycling of a standardised perceived intensity’. *Journal of Sport Behaviour,* vol. 27, pp. 134-147.

Foster, C, Hendrickson, K, Peyer K, Reiner, B, deKoning, J. J, Lucia, A, Battista, R. A, Hettinga, F. J, Porcari, J. P, & Wright, G 2009, ‘Pattern of developing the performance template’. *British Journal of Sports Medicine,* vol. 43, pp. 765-769.

Harris, B. A 2010, ‘iPods—A surrogate coach for junior and subelite athletes: New ideas based on a review of the literature’. *Journal of Strength and Conditioning Research*, vol. 24, no. 12, pp. 3507-3519.

Hagen, J, Foster, C, Rodriguez-Marroyo, J, de Koning, J. J, Mikat, R.P, Hendrix, C. R, Porcari, J. P, 2013, ‘The effect of music on 10-km cycle time-trial performance’. *International Journal of Sports Physiology and Performance*, vol. 8, pp. 104-106.

Hutchinson, J. C, Sherman, T, Davis, L. K, Cawthon, D, Reeder, N. B, & Tenebaum, G 2011, ‘The influence of asynchronous motivational music on a supramaximal exercise bout’. *International Journal of Sports Psychology*, vol. 42, pp. 1-14.

Hutchinson, J. C, & Tenenbaum, G 2007, ‘Attention focus during physical effort: The mediating role of task intensity’. *Psychology of Sport and Exercise,* vol. 8, pp. 233-245.

Husain, G, Thompson, W. F, & Schellenberg, E. G 2002, ‘Effects of musical tempo and mode on arousal, mood, and spatial abilities’. *Music Perception*, vol. 20, pp. 151–171.

Iwanaga, M, Kobayashi, A, & Kawasaki, C 2005, ‘Heart rate variability with repetitive exposure to music’. *Biological Psychology*, vol. 70, pp. 61-66.

Jeukendrup, A. E., Craig, N. P., & Hawley, J. A. (2000). ‘The bioenergetics of world class cycling’. *Journal of Science and Medicine in Sport*, vol. 3, no. 4, pp. 414-433.

Juslin, P. N, & Vastfjall, D 2008, ‘Emotional responses to music: The need to consider underlying mechanisms’. *Behavioral and Brain Sciences,* vol. 31, pp. 559-621. doi:10.1017/S0140525X08005293

Karageorghis, C. I, Jones, L, & Low, D. C 2006. ‘Relationship between exercise and heart rate and music tempo preference’. *Research Quarterly for Exercise and Sport*, vol. 77, no. 2, pp. 240-250.

Karageorghis, C. I, Jones, L, Priest, D. L, Akers, R. I, Clarke, A, Perry, J, Reddick, B, Bishop, D, & Lim, H. B. T 2011, ‘Revisiting the relationship between exercise heart rate and music tempo preference’. *Research Quarterly for Exercise and Sport*, vol. 82, no. 2, pp. 274-284.

Karageorghis, C. I, Jones, L, & Stuart, D. P 2007, ‘Psychological effects of music tempi during exercise’. *International Journal of Sports Medicine*, vol. 28, pp. 1-7.

Karageorghis, C. I, Mouzourides, D, Priest, D. L, Sasso, T, Morrish, D, & Walley, C 2009, ‘Psychophysical and ergogenic effects of synchronous music during treadmill walking’. *Journal of Sport and Exercise Psychology*, vol. 31, pp. 18-36.

Karageorghis, C. I, & Priest, D. L 2012, ‘Music in the exercise domain: a review and synthesis (Part I)’. *International Review of Sport and Exercise Psychology*, vol. 5, no. 1, pp. 44-66.

Karageorghis, C. I, & Priest, D. L 2012, ‘Music in the exercise domain: a review and synthesis (Part II)’. *International Review of Sport and Exercise Psychology*, vol. 5, no. 1, pp. 67-84.

Karageorghis, C. I, Priest, D. L, Williams, L. S, Hirani, R. M, Lannon, K. M, & Bates, B. J 2010, ‘Ergogenic and psychological effects of synchronous music during circuit-type exercise’. *Psychology of Sport and Exercise*, vol. 11, pp. 551-559.

Karageorghis, C.I, Terry, P.C, & Lane, A.M 1999, ‘Development and initial validation of an instrument to assess the motivational qualities of music in exercise and sport: The Brunel Music Rating Inventory’. *Journal of Sports Sciences*, vol. 17, pp. 713_724.

Khalfa, S, Roy, M, Rainville, P, Dalla Bella, S, Peretz, I 2008, ‘Role of tempo entrainment in psychophysiological differentiation of happy and sad music?’. *International Journal of Psychophysiology*, vol. 68, pp. 17–26.

Leunes, A, & Burger, J 2000, ‘Profile of Mood States research in sport and exercise psychology: Past, present and future’. *Journal of Applied Sport Psychology*, vol. 12, no. 1, pp. 5-15.

Lim, H.B.T, Atkinson, G, Karageorghis, C.I, & Eubank, M 2009, ‘Effects of differentiated music exposure during a 10-km cycling time trial’. *International Journal of Sports Medicine*, vol. 30, pp. 435_442.

MacDougall, H. G, & Moore, S. T 2005, ‘Marching to the beat of the same drummer: The spontaneous tempo of human locomotion’. *Journal of Applied Physiology*, vol. 99, pp. 1164–1173.

McNair, D, Lorr, M, & Droppleman, L. 1971, *Manual for the Profile of Mood States*. San Diego, CA.: Educational and Industrial Testing Service.

Milliman, R. E 1982, ‘Using Background Music to Affect the Behavior of Supermarket Shoppers’," *Journal of Marketing*, vol. 46, pp. 86-91.

Mohammadzadeh, H, Tartibiyan, B, & Ahmadi, A 2008, ‘The effects of music on the perceived exertion rate and performance of trained and untrained individuals during progressive exercise’. *Facta Universitatis: Series Physical Education and Sport*, vol. 6, pp. 67-74.

Morgan, W. P, & Pollock, L 1977, ‘Psychological characterization of the elite distance runner’. *Annals of the New York Academy of Science*, vol. 301, pp. 382-403.

Nethery, V. M 2002, ‘Competition between internal and external sources of information during exercise: Influence on RPE and the impact of the exercise load’. *Journal of Sports Medicine and Physical Fitness*, vol. 42, pp. 172_178.

North, A.C, Hargreaves, D.J, 1997, ‘Liking, arousal potential, and the emotions expressed by music’. *Scandinavian Journal of Psychology*. Vol. 38, pp. 45–53.

Palmer, G. S, Dennis, S. C, Noakes, T. D, and Hawley, J. A 1996, ‘Assessment of the reproducibility of performance testing on an air-braked cycle ergometer’. *International Journal of Sports Medicine*, vol. 17, pp. 293–298.

Paton, C. D, & Hopkins, W. G 2001, ‘Tests of cycling performance’. *Sports Medicine,* vol. 31, pp. 489–496.

Paton, C. D, & Hopkins, W. G 2005, ‘Combining explosive and high resistance training improves performance in competitive cyclists’. Journal of Strength Conditioning Research, vol. 19, pp. 826–830.

Potteiger, J. A, Schroeder, J. M, & Goff, K. L 2000, ‘Influence of music on ratings of perceived exertion during 20 minutes of moderate intensity exercise’. *Perceptual and Motor Skill*s, vol. 91, pp. 848-854.

Priest, D. L, & Karageorghis, C. I 2008, 'A qualitative investigation into the characteristics and effects of music accompanying exercise'. *European Physical Education Review*, vol. 14, no. 3, pp. 351-371.

Pujol, T. J, & Langenfeld, M. E 1999, 'Influence of music on Wingate Anaerobic Test performance'. *Perceptual and Motor Skills*, vol. 88, pp. 292-296.

Safranek, M. G, Koshland, G. F, & Raymond, G 1982, 'Effect of Auditory Rhythm on Muscle Activity'. *Journal of Physical Therapy*, vol. 62, no. 2, pp. 161-168.

Scherer, K. R 2004, 'Which emotions can be induced by music? What are the underlying mechanisms? And how can we measure them?'. *Journal of New Music Research*, vol. 33, pp. 239_251.

Schie, N. A, Stewart, A, Becker, P, & Rogers, G 2008, 'Effect of music on submaximal cycling'. *South African Journal of Sports Medicine*, vol. 20, no. 1, pp. 28-31.

Simpson, S. D, & Karageorghis, C. I 2006, 'The effects of synchronous music on 400-m sprint performance'. *Journal of Sports Sciences*, vol. 24, pp. 1095_1102.

Stevens, M. J, & Lane, A. M 2001, 'Mood-regulating strategies used by athletes'. *Online Journal of Sports Psychology*, vol. 3, no. 3.

Stevinson, C. D, & Biddle, S. J 1998, 'Cognitive orientations in marathon running and "hitting the wall"'. *British Journal of Sports Medicine,* vol. 32, no. 3, pp. 229-234.

Swart, J., Lamberts, R.P., Lambert, M.I., Lambert, E.V., Woolrich, R.W., Johnston, S. et al. (2009). 'Exercising with reserve: exercise regulation by perceived exertion in relation to duration of exercise and knowledge of endpoint'. *British Journal of Sports Medicine*, *43*, 775-781

Swart, J, Tucker, R, Lamberts, R. P, Albertus-Kajee, Y, Lambert, M. I 2008, ‘Potential cause of chronic knee anterior knee pain in a former winner of the Tour de France’. *International SportMed Journal,* vol. 8, no. 4, pp. 162-171.

Szabo, A, Small, A, & Leigh, M 1999, ‘The effects of slow- and fast-rhythm classical music on progressive cycling to voluntary physical volitional exhaustion’. *Journal of Sports Medicine and Physical Fitness*, vol. 39, pp. 220-225.

Tenenbaum, G, Lidor, R, Lavyan, N, Morrow, K, Tonnel, S, Gershgoren, A, Meis, J, Johnson, M 2004, ‘The effect of music type on running perseverence and coping with effort sensations’. *Psychology of Sport and Exercise*, vol. 5, pp. 89 - 109.

Terry, P. C, & Karageorghis, C. I 2006. Psychophysical effects of music in sport and exercise: An update on theory, research and application. In M. Katsikitis (Ed.), *Psychology bridging the Tasman: Science, culture and practice – Proceedings of the 2006 Joint Conference of the Australian Psychological Society and the New Zealand Psychological Society* (415-419). Melbourne, VIC: Australian Psychological Society.

Terry, P.C, Karageorghis, C.I, MecozziSaha, A, & D’Auria, S 2012, ‘Effects of synchronous music on treadmill running among elite triathletes’. *Journal of Science and Medicine in Sport*, vol. 15, pp. 52-57.

Thornby, M. A, Haas, F, & Axen, K 1995, ‘Effect of Distractive Auditory Stimuli on Exercise Tolerance in Patients with COPD’. *Chest*, vol. 107**,** pp. 1213-1217.

Van Laetham, C, Van De Veire, N, De Sutter, J, Bartunek, J, De Backer, G, Goethals, M, & Vanderheyden, M 2006, ‘Prospective evaluation of the oxygen uptake efficiency slope as a submaximal predictor of peak oxygen uptake in aged patients with ischemic heart disease’. *American Heart Journal*, vol. 152, no. 2, pp. 297.e299 - 297e215.

Waterhouse, J, Hudson, P, & Edwards, B 2009, 'Effects of music tempo on submaximal cycling performance'. *Scandinavian Journal of Medicine and Science in Sports*, vol. 20, no. 4, pp. 662-669.

Yamamoto, T, Ohkuwa, T, Itoh, H, Kitoh, M, Terasawa, J, Tsuda, T, Kitagawa, S, Sato, Y 2003, 'Effects of pre-exercise listening to slow and fast rhythm music on supramaximal cycle performance and selected metabolic variables'. *Archives of Physiology and Biochemistry,* vol. 111, no. 3, pp. 211-214.

Yamashita, S, Iwai, K, Akimoto, T, Sugawara, J, & Kono, I. 2006, 'Effects of music during exercise on RPE, heart rate and the autonomic nervous system'. *Journal of Sports Medicine and Physical Fitness, vol.* 46, pp. 425-443.

Zehr, E. P 2005, 'Neural Control of Rhythmic Human Movement: The common core hypothesis'. *Exercise and Sport Science Reviews*, vol. 33**,** pp. 54-60.

Appendix A: Information Sheet for Participants

Dear ____

Thank you for showing an interest in this project. Please read this information sheet carefully before deciding whether or not to participate. If you decide to participate we thank you. If you decide not to take part there will be no disadvantage to you of any kind and we thank you for considering our request.

What is the aim of the project?

This project is being undertaken as part of the requirements for a postgraduate degree in Sports Science. The aim is to evaluate the effect of music of varying tempos on physiological markers of performance and pacing strategy during a 40km cycling time trial.

What type of participants are needed?

This study requires participants aged 21 to 25years. Volunteers will need to have at least three years competitive road cycling experience and be training for a minimum of 6 hours per week. Volunteers will be excluded if they have any form of hearing disability or have been recently injured. Presence of conditions such as diabetes, respiratory complications, heart disease, recent heart attack will also result in exclusion from the study.

What will participants be asked to do?

Should you agree to take part in this project, you will be asked to fill out forms and be involved in a testing protocol. Written informed consent will be obtained from all participants, and the study will be approved by the University of KwaZulu-Natal Research Ethics Committee.

We will examine participants in the Human Performance Laboratory situated in the Discipline of Sport Science at the University of KwaZulu-Natal. You will need to attend four times over the course of a month (once a week). These visits will be approximately one hour in length during the same time of day and on the same day of the week as the previous trial.

The following tests and evaluations will be performed:

a) **Personal/Medical History Form:** You will be required to complete the enclosed personal/medical history form. The purpose of completing this form is to ensure that you meet the requirements to be included in the study, and that the researcher obtains necessary information about your lifestyle (including physical activity history)and dietary habits leading up to the test.

b) **Testing Protocol:** You will be asked to perform one 40 km time trial every week for a month whilst listening to playlist of music that has either a fast, slow or varying tempo. The fourth trial will be done without listening to music. These trials will be performed in the Human Performance Laboratory at the UKZN (Westville Campus) Sports Science Department. Each trial will be performed on your own road bicycle which will be mounted on the Computrainer™ Pro 3D ergometer. The Computrainer™ is specifically designed for this function. Your bicycle will be firmly bolted to the machine thus ensuring your stability at all times.

The order in which you complete each trial will be randomized. For each relevant trial you will be provided with a list of possible songs from which you can construct your own playlist. You will be expected to maintain the same dietary and training habits for 24 hours leading up to each trial throughout the course of the study. This will be confirmed through a pre-trial interview. Resting measurements will be taken for heart rate, blood pressure, body temperature, blood lactate and bodyweight before the start of each trial. During each trial measurements will be taken for heart rate, blood pressure, body temperature, oxygen consumption, rating of perceived exertion, blood lactate and power output. You will have access to water during each of the time trials.

Possible risks and discomforts:

Measuring blood lactate requires that we obtain a small amount of blood from the tip of the finger or ear lobe with the use of a needle to prick the area. This may result in slight bruising or discomfort of the affected area. During each trial you will be required to wear a mouthpiece which will be strapped to you face in order for us to measure your oxygen consumption during the trials. There is a 6 in 10000 chance of a cardiac event such as heart attack occurring during the trial but this risk is lower in healthy individuals and every effort will be made to minimize the risks of such an event. You may also experience some muscle soreness or fatigue as a result of the exercise you will have to perform.

Potential benefits of this study:

This study will provide information as to the effects of music on physiology and pacing strategy during cycling performance and determine which types of music are most beneficial in improving or regulating exercise performance.

Can participants change their mind and withdraw from the project?

You may withdraw from participation in the project at any time and without any disadvantage to yourself of any kind.

What data or information will be collected and what use will be made of it?

Results of this project may be published but any data included will in no way be linked to any specific participant. At the end of the project any personal information will be destroyed immediately except that, as required by the University's research policy, any raw data on which the results of the project depend will be retained in secure storage for five years, after which it will be destroyed. The data collected will be securely stored in such a way that only the researchers will be able to gain access to it. You are most welcome to enquire as to the result of the project should you wish.

What do participants have to avoid prior to testing?

You will be asked to avoid caffeine, heavy physical activity, smoking, and alcohol intake for the 10 hours preceding each laboratory visit. You will also have to maintain similar routines, dietary/hydration habits and training schedules throughout the course of the study, especially on the mornings of the tests.

What if participants have any questions?

If you have any questions about our project, either now or in the future, please feel free to contact either:-

Barry Dyer or Professor Andrew McKune

Department of Sport Science Department of Sport Science

Telephone Number: 0823642923 University Telephone Number: 031 2607985

This project has been reviewed and approved by the Faculty Ethics Committee

of the UNIVERSITY OF KWAZULU-NATAL

<u>Appendix B : Informed Consent Document</u>

Consent to Participate in Research

Dear _______________

You have been invited by Masters Candidate Barry Dyer and Associate Professor Andrew McKune from the Discipline of Sport Science, University of KwaZulu-Natal, to participate in a study investigating the effects of music-listening on physiological response and pacing strategy during 40km cycle time trial performance.

<u>PLAN AND PROCEDURES</u>:

Data

(a) <u>Contact Details:</u> I agree to give basic information and contact details about myself to the researcher including my name, age (date of birth), address and phone number.

(b) <u>Medical History/Physical Activity Form:</u> I agree to give information about my medical history, physical activity and dietary habits. The purpose of completing this form is to ensure that I meet the medical requirements to be included in this study and that the researcher obtains information to declare me "apparently healthy" for inclusion as a participant.

<u>RISKS AND DISCOMFORTS</u>

<u>Finger Prick:</u> I understand that I will need to have blood taken from either my finger tip or ear lobe before and after each trial for blood lactate measurement and that this may cause slight bruising to the affected area.

<u>Mouth Piece:</u> I understand that I will be required to wear the breathing apparatus from the Cosmed system during each trial in order for the researchers to measure my oxygen consumption and that this may be uncomfortable.

<u>Dietary Habits:</u> I understand that I will be expected to control my dietary and training habits during the course of the study.

<u>Cardiac Event:</u> I understand that there is a 6 in 10000 chance that I may suffer a cardiac complication such as heart attack during testing. However I also understand that this chance is lower for healthy individuals and that the researchers will do everything possible to protect me from such harm.

<u>POTENTIAL BENEFITS</u>

This study will provide information as to the effects of music on physiology and pacing strategy during cycling performance and determine which types of music are most beneficial in improving or regulating exercise performance.

TERMINATION OF PARTICIPATION

I understand that if the screening and data collection procedures provide evidence that the tests or activities cannot be safely performed , or if I have a pre-existing condition which will not allow me to participate in the study, I will be informed at that time and will not be included in the study. I understand that the investigator will explain the reason for the exclusion to me.

COSTS/COMPENSTAION

The policy of the University of Kwa-Zulu Natal does not provide for compensation or medical treatment to participants who are injured as a result of this research study. However, every effort will be made to make the tests and activities as safe as possible, with little risk of injury.

CONFIDENTIALITY

All data and information collected in this study will be maintained in complete confidence and privacy will be protected. I will not be identified in any report or presentation by name as a result of this study.

You have been informed about the study in detail by__________________________.

You may contact the investigators in this study Masters candidate Barry Dyer (0823642923), Associate Prof Andrew McKune (031-260-7985), any time if you have questions about the research or if you are injured as a result of the research.

You may contact the **Biomedical Research Ethics Office** on **031-260 4769 or 260 1074** if you have questions about your rights as a research participant.

Your participation in this research is voluntary, and you will not be penalized or lose benefits if you refuse to participate or decide to stop at any time.

If you agree to participate, you will be given a signed copy of this document and the participant information sheet which is a written summary of the research.

The research study, including the above information, has been described to me orally. I have been given an opportunity to ask any questions that I might have about participation in the study. I understand what my involvement in the study means and I voluntarily agree to participate.

______________________ ______________________

Signature of Participant **Date**

______________________ ______________________

Signature of Witness **Date**

Appendix C: Physical Activity Readiness Questionnaire (PAR-Q)

PAR-Q is designed to help you help yourself. Many health benefits are associated with regular exercise, and the completion of PAR-Q is a sensible first step to take if you are planning to increase the amount of physical activity in your life.

For most people, physical activity should not pose any problems or hazard. PAR-Q has been designed to identify the small number of adults for whom physical activity might be inappropriate or those who should have medical advice concerning the type of activity most suitable for them.

Common sense is your best guide in answering these few questions. Please read the carefully and check **YES** or **NO** opposite the question if it applies to you. If yes, please explain.

YES **NO**

____ ____ 1. Has your doctor ever said you have heart trouble?

Yes, ____

____ ____ 2. Do you frequently have pains in your heart and chest?

Yes, ____

____ ____ 3. Do you often feel fain or have spells of severe dizziness?

Yes, ____

____ ____ 4. Has a doctor ever said your blood pressure was too high?

Yes, ____

____ ____ 5. Has your doctor ever told you that you have a bone or joint problem(s), such as arthritis that has been aggravated by exercise, or might be made worse with exercise?

Yes, ____

____ ____ 6. Is there a good physical reason, not mentioned here, why you should not follow an activity program even if you wanted to?

Yes, ____

____ ____ 7. Do you suffer from any problems of the lower back, i.e.,chronic pain, or numbness?

Yes, ____

____ ____ 8. Are you currently taking any medications? If YES, please specify.

Yes, ____

____ ____ 9. Do you currently have a disability or a communicable disease?

YES, Please specify,

____

If you answered NO to all questions above, it gives a general indication that you may participate in physical and aerobic fitness activities and/or fitness evaluation testing. The fact that you answered NO to the above questions, is no guarantee that you will have a normal response to exercise. If you answered Yes to any of the above questions, then you may need written permission from a physician before participating in physical and aerobic fitness activities and/or fitness evaluation testing.

______________________ ______________________ ______________________

Print Name Signature Date

Appendix D: Cycling Questionnaire and Medical History

Instructions

Please complete sections A, B, C and D.

Section A: Personal details			
Surname			
First Name			
Postal Address		Postal/ Zip Code	
E-mail address		Phone (day time)	code number
Date of birth	Y Y Y Y / M M / D D	Cell	
Height (cm)		Gender	Male ☐ Female ☐
Weight (kg)		Age	
Ethnic group (Only Required and Used for Research Purposes)	Black/African ☐ White Indian ☐ Mixed Ancestry (Coloured) ☐ Asian ☐ Other ☐		
Ancestry: Tribal or national background (eg Xhosa, Dutch, Zulu, German, Italian)	Father: Unknown ☐ Mother: Unknown ☐		
Country of Birth			
Dominant Hand	Left ☐ Right ☐ Both ☐	Dominant Leg	Left ☐ Right ☐ Both ☐
Occupation			

Section B. Racing and training history			
Year of first event			

How many events have you **<u>ever</u>** participated in?			
Personal best time	hrs min	hrs min	
What is your best average cycling speed (km/h) in a race during the **last 16 weeks**?	Average speed: km/h; Distance: km		

Please answer the following questions, with your answers reflecting your average in the **most recent 16 weeks i.e. beginning April 2010 to August, 2010.**	
How many days a week did you train during the **<u>last 16 weeks</u>**?	days/week
What distances did you train in an average week during the **<u>last 16 weeks</u>**?	Cycle: km/week
How many hours a week did you train in an average week during the **<u>last 16 weeks</u>**?	Cycle: hrs/week
What **<u>distances</u>** did you train in the last **<u>week before</u>** testing?	Cycle: km
How many **<u>hours</u>** did you train in the last **<u>week before</u>** testing?	Cycle: hours

Equipment use history	
Please indicate which type of saddle do you use?	
Please indicate which type of cycling shorts you use?	
Please indicate which type of cycling shoes you use?	
Do you often listen to music while you train? If so, what type of music do you prefer to listen to?	

Section C. History of medication and supplement use

What medication, if any, are you currently using? (please list)		
Have you ever used anabolic steroids? (If yes, how long ago?)	Yes ☐ No ☐	☐ 3 months ☐ 6 months ☐ 12 months ☐ 24 or more months
Are you currently taking dietary supplements/vitamins?		Yes ☐ No ☐
If yes, please list names of dietary or vitamin supplements.	Name of supplement	Years taken

Lifestyle and habits history			
Please indicate your smoking status	Current smoker ☐	Ex smoker ☐	Never smoked ☐
If you answered yes, (past or current smoker) please complete the section on the right	Number of years of smoking:	If stopped, how many years ago:	
	What is (was) the average number of cigarettes per day:		
On average, how much alcohol do you drink per week (tots, glasses) of spirits, wine or beer?	glasses beer per week glasses wine per week tots of spirits per week		

Personal/ Family Medical History:

Name________________________Sex_______Age______Date of Birth_________________
Sport(s)__________________Phone_______________E-mail Address____________________
In case of emergency, contact
Name_______________Relationship_________Phone(H)_____________(W)______________

Explain "Yes" answers on second page	Y	N		Y	N
1. Has a doctor even denied or restricted your participation in sports for any reason?	☐	☐	17. Have you ever used an inhaler or taken asthma medicine?	☐	☐
2. Do you have an ongoing medical condition (like diabetes or asthma)?	☐	☐	18. Were you born without or are you missing a kidney, an eye, a testicle, or any other organ?	☐	☐
3. Are you currently taking any prescription or nonprescription (over-the-counter) medicines or pills?	☐	☐	19. Have you had infectious mononucleosis (mono) within the last month?	☐	☐
4. Do you have allergies to medicines, pollens, foods, or stinging insects?	☐	☐	20. Do you have any rashes, pressure sores, or other skin problems?	☐	☐
5. Have you ever passed out or nearly passed out DURING exercise?	☐	☐	21. Have you had a herpes skin infection?	☐	☐
6. Have you ever passed out or nearly passed out AFTER exercise?	☐	☐	22. Have you ever had a head injury or concussion?	☐	☐
7. Have you ever had discomfort, pain, or pressure in your chest during exercise?	☐	☐	23. Have you been hit in the head or been confused or lost your memory?	☐	☐
8. Does your heart race or skip beats during exercise?	☐	☐	24. Have you ever had a seizure?	☐	☐
9. Has a doctor ever told you that you have (check all that applies)? ☐ High Blood Pressure ☐ High Cholesterol ☐ A heart murmur ☐ A heart infection	☐	☐	25. Do you have headaches with exercise?	☐	☐
10. Has a doctor ever ordered a test for your heart? (for example, ECG, echocardiogram)	☐	☐	26. Have you ever had numbness, tingling, or weakness in your arms or legs after being hit or falling?	☐	☐
11. Has anyone in your family died for no apparent reason?	☐	☐	27. Have you ever been unable to move your arms or legs after being hit or falling?	☐	☐
12. Does anyone in your family have a heart problem?	☐	☐	28. When exercising in the heat do you have severe muscle cramps or become ill?	☐	☐
13. Has any family member or relative died of heart problems or of sudden death before age 50?	☐	☐	29. Has a doctor told you that you or someone in your family has sickle trait or sickle cell disease?	☐	☐
14. Does anyone in your family have Marfan's syndrome?	☐	☐	30. Have you had any problems with your eyes or vision?	☐	☐
15. Have you ever spent the night in a hospital?	☐	☐	31. Do you wear glasses or contact lenses?	☐	☐
16. Have you ever had surgery?	☐	☐	32. Do you wear protective eyewear, such as goggles or a face shield?	☐	☐
			33. Are you happy with your weight?	☐	☐
			34. Are you trying to gain or lose weight?	☐	☐
			35. Has anyone recommended you change your weight or eating habits?	☐	☐

36. Have you ever had a stress fracture?	☐ ☐	42. Do you limit or carefully control what you eat?	☐ ☐
37. Have you been told that you have or have you had an x-ray for atlantoaxial (neck)?	☐ ☐	43. Do you have any concerns that you would like to discuss with a doctor?	☐ ☐
38. Do you regularly use a brace or assistive device?	☐ ☐	**FEMALES ONLY**	
39. Has a doctor ever told you that you have asthma or allergies?	☐ ☐	44. Have you ever had a menstrual period?	☐ ☐
40. Do you cough, wheeze, or have difficulty breathing during or after exercise?	☐ ☐	45. How old were you when you had your first menstrual period?	_____
41. Is there anyone in your family who has asthma?	☐ ☐	46. How many periods have you had in the last year?	_____

Explain "Yes" answers from previous page here:____________________________________
____
____
____
____
____

List all *previous injuries* and *approximate dates.* Check N/A if not applicable

N/A ☐ Shoulder/Elbow (dislocation, rotator cuff, AC separation):________________Date:_________
N/A ☐ Arm/Wrist/Hand (fractures):____________________________________ Date:_________
N/A ☐ Neck (burners, pinched nerve):__________________________________ Date:_________
N/A ☐ Ribs/Abdomen:____ Date:_________
N/A ☐ Low back pan (herniated disc):__________________________________ Date:_________
N/A ☐ Leg (quadriceps, hamstring strain):_______________________________ Date:_________
N/A ☐ Knee (ligament, meniscus, patella):_______________________________ Date:_________
N/A ☐ Lower leg (shin splints, calf strain):_____________________________ Date:_________
N/A ☐ Ankle/Calf/Foot (sprain, Achilles):______________________________ Date:_________
N/A ☐ Stress Fractures:____ Date:_________
N/A ☐ Concussions:____ Date:_________

If yes, have you ever been knocked out (unconscious)? Yes: ☐ No: ☐
How many times?_____________________________
How long were you unconscious?____
Have you ever lost your memory? Yes: ☐ No: ☐
How many times?_____________________________
Did you have problems in the days afterward (confusion, headache, concentration)?
Yes: ☐ No: ☐
How long did it take you to recover?______________
Are you still having problems? Yes: ☐ No: ☐

Do you have any unhealed or chronic injuries? Yes: ☐ No: ☐
Please list:____
____
____

I hereby state that, to the best of my knowledge, my answers to the above questions are complete and correct.
Signature of athlete____ Date____________

Signature of parent/guardian____Date_____________

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE

Appendix E: Pre-trial questionnaire

Date:________________________

STUDY ID#:________________

1. Bodyweight:__________Kg
   Temperature:__________ ^{O}C

   Heart Rate:____________(bpm)

   Blood Pressure_________(mmHg)

2. How many hours did you spend training last week?
   ____
____

3. How many kilometers did you cycle last week?
   ____
____

4. Please provide the details as to what physical activity you have performed over the last 48 hours?

____
____
____
____
____
____
____

5. Please provide a re-call of your dietary intake over the last 12 hours

6. Have you consumed any alcohol or medication in the last 12 hours? If yes please specify.

7. Have you consumed any caffeine containing substances (e.g.: Red Bull, coffee, tea, chocolate) in the last 3 hours? If yes please specify.

8. How many hours of sleep did you get last night?

Appendix F: Confirmation of manuscript submission to "Perceptual and Motor Skills"

Dear Dr. McKune,

We are pleased to acknowledge receipt of your manuscript, "Music during 20km time trial cycling alters mood state but not performance or physiological parameters in well-trained cyclists," which has been submitted to *Perceptual & Motor Skills* for possible publication. Your submission will be given a manuscript number once an Editor has been assigned.

You will be able to check on the progress of your paper by logging on to Editorial Manager as an author. The URL is http://amsci.edmgr.com/.

Ordinarily, we require two to four months to process reviewers' comments. If there are any special considerations or problems, you may e-mail us by logging in to your manuscript and selecting "Send E-mail" from the Action List. The review process will take longer if our search on CrossCheck (http://www.crossref.org/crosscheck.html) identifies problems with plagiarism, or if the English expression in the manuscript is poor.

If you have any comments or suggestions, please feel free to send them along. Our goal is to help researchers find materials easily.

Sincerely,
The Editors
Ammons Scientific
PERCEPTUAL AND MOTOR SKILLS
PSYCHOLOGICAL REPORTS
COMPREHENSIVE PSYCHOLOGY
INNOVATIVE TEACHING

Appendix G: Ethical Approval

UNIVERSITY OF
KWAZULU-NATAL
INYUVESI
YAKWAZULU-NATALI

RESEARCH OFFICE
Biomedical Research Ethics Administration
Westville Campus, Govan Mbeki Building
Private Bag X 54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604769 - Fax: 27 31 2604609
Email: BREC@ukzn.ac.za
Website: http://research.ukzn.ac.za/ResearchEthics/BiomedicalResearchEthics.aspx

18 January 2011

Mr B Dyer
Discipline of Sport Science
Westville Campus
University of KwaZulu-Natal

PROTOCOL: The effect of music on physiological response and pacing strategy during time-trial cycling performance. REF:BE113/010

EXPEDITED APPLICATION

A sub-committee of the Biomedical Research Ethics Committee has considered and noted your application dated 22 July 2010.

The study was provisionally approved pending appropriate responses to queries raised. Your responses dated 11 November 2010 to queries raised on 30 September 2010 have been noted by a sub-committee of the Biomedical Research Ethics Committee. The conditions have now been met and the study is given full ethics approval and may begin as from 18 January 2011.

This approval is valid for one year from **18 January 2011.** To ensure uninterrupted approval of this study beyond the approval expiry date, an application for recertification must be submitted to BREC on the appropriate BREC form 2-3 months before the expiry date.

Any amendments to this study, unless urgently required to ensure safety of participants, must be approved by BREC prior to implementation.

Your acceptance of this approval denotes your compliance with South African National Research Ethics Guidelines (2004), South African National Good Clinical Practice Guidelines (2006) (if applicable) and with UKZN BREC ethics requirements as contained in the UKZN BREC Terms of Reference and Standard Operating Procedures, all available at http://research.ukzn.ac.za/ResearchEthics11415.aspx.

BREC is registered with the South African National Health Research Ethics Council (REC-290408-009). BREC has US Office for Human Research Protections (OHRP) Federal-wide Assurance (FWA 678).

The sub-committee's decision will be **RATIFIED** at a full sitting of the Biomedical Research Ethics Committee meeting to be held on **08 February 2011.**

We wish you well with this study. We would appreciate receiving copies of all publications arising out of this study.

Yours sincerely

Professor D.R Wassenaar
Chair: Biomedical Research Ethics Committee