CHAPTER 2

2. LITERATURE REVIEW

In this review related literature is discussed. Section one deals with the reasoning behind using music in combination with cycling training. Section two investigates the possible effects that music can have on physiological variables; particularly focusing on heart rate and change in lactate levels. Section three discusses the psychological aspects of music on cycling training. The fourth section explores which type of music is more suited to exercise training. Section five deals with which exercise type is the best to combine with music.

SECTION 1

2.1. RATIONALE FOR UTILIZING MUSIC IN CYCLING TRAINING

There are four main ways in which music is proposed to enhance exercise performance:

1) Music causes passive dissociation. Passive dissociation involves receiving information without having to make reciprocal decisions (White and Potteiger 1996). Music potentially causes a decreased psychological sensation of fatigue and uncomfortable sensations, as it helps direct focus away from aching muscles, ventilatory processes, increases in heart rate and boredom (Nethery 2002; Potteiger et al 2000; Szabo et al 1999; Szmedra and Bacharach 1998; Thornby et al 1996; Copeland and Franks 1991). People have a limited ability to focus on all the information available (Nethery 2002; Szabo et al 1999; Szmedra and

Bacharach 1998). The afferent stimuli to which we attend are dependant on a combination of the strength of the sensory signal, and the level of interest that the individual has in it (Nethery 2002). Therefore, if the athlete is focusing on the music, he is unlikely to dwell on exercise strain.

2) Music may have either a stimulatory or a relaxing effect, but that is often heavily weighed upon by what type of music is playing and the emotion that it arouses (Szabo et al 1999). Music can only temporarily increase levels of arousal (Storr 1999; Szabo et al 1999; Copeland and Franks 1991).

3) Music encourages motor co-ordination and synchronisation, especially in repetitious exercise (Storr 1999; Szabo et al 1999). Kennard (1983) described how background music with a strong rhythm assisted in a physiotherapy rehabilitative setting, by encouraging rhythmical walking and individuals to exert themselves to a greater extent.

4) Music may alter performance by affecting mood (emotion), confidence, self-esteem and motivation (Becker et al 1994). All of these are essential components to the making of a good athlete. Music can help individuals enjoy exercise and can consequently increase exercise adherence, which collectively may enhance exercise performance ((Nethery 2002; Thornby et al 1996; Copeland and Franks 1991; Boutcher and Trenske 1990).

In summary, music has the capacity to affect both physiological and psychological aspects of exercise. Because of the diverse nature of the study matter, only certain aspects have been studied so far. Consequently, not many studies have aimed their work at a particular athletic group.

SECTION 2

2.2. THE PHYSIOLOGICAL EFFECTS OF UTILIZING MUSIC

When exercise intensity is increased, the ventilatory rate and depth increases, heart rate increases, and cardiac output and muscular tension develop to overcome the external resistance (Potteiger et al 2000). This results in an individual perceiving a greater sense of effort.

Music has been shown to have a powerful coordinating effect upon bodily function (Storr 1999). For example, it can alter pulse rate and respiration (during both exercise and at rest) by reducing respiratory muscle tension (White and Potteiger 1996). The afferent receptor feedback associated with respiration can be modified by the individual's behaviour type, personality and emotional state (subjective factors). All of the previously mentioned subjective factors can be modified by music (Thornby et al 1995). A distracting stimulus prevents the attention being focused on fatigue and therefore may prevent increases in heart rate (Szabo et al 1999). Yet, by the same token it can increase the external work performed and may consequently increase heart rate (Thornby et al 1995). Music has a rhythmical basis that the heart rate often mimics (Storr 1999; Iwanaga 1995; Kennard 1983). Grant et al (1999) found that there was a high correlation between rating of perceived exertion and heart rate.

In some studies, music decreased the subject's maximal heart rate (Szmedra and Bacharach 1998; Thornby et al 1996; and Copeland and Franks 1991). While in another study, listening to music resulted in subjects exercising at a higher heart rate compared to exercising with gray noise and silence (Atkinson 2004; Thornby et al 1995). Comparatively, Nethery (2002), Potteiger et al (2000), Szabo et al (1999), White and Potteiger (1996) and Boutcher and Trenske (1990) found that the subjects had no significant difference in average heart rate, despite the work intensity being uniform during the sessions with and without music.

Nethery (2002) only used 13 subjects in his study. There is no evidence given that a power test calculation was conducted in order to establish whether 13 subjects would give meaningful results. The author does not mention what the inclusive or exclusive criteria for the subjects were and although they do say that the subjects were untrained in cycling, it is unspecified as to what their baseline fitness was and if they all had a similar baseline level. The author ensured that there was at least 48 hours separating each of the tests and that the subjects were exercised at the same time of day. This prevents the influence of some confounding variables.

A possible problem of Szmedra and Bacharach's (1998) study is that they utilized a medley of classical music. Although classical music has been shown to be effective for exercise in certain populations, it is doubtful that their subjects (who were aged 19 to 32 years old and healthy well trained men) would have been accustomed to listening to this genre of music, especially while exercising. In fact the authors did question the subjects as to their feelings about the music. They found that the subjects were indifferent to the music. Since music can be emotive (Storr 1999, Mills 1996; Thornby 1995; Becker et al 1994) using music that the subjects are indifferent to, in part, defeats the purpose of utilizing music when exercising.

Szabo et al (1999) had their subjects' cycle to exhaustion. Therefore their study entailed a combination of submaximal and maximal exercise (the latter, just before termination of the test). Other research (Nethery 2002, Pujol and Langenfeld 1999; Boutcher and Trenske 1990 and Nelson 1962) has shown that music has little effect on both psychological and physiological parameters when exercising maximally. In this particular study, at the moment of self declared point of exhaustion the subjects would have had to be exercising maximally, which in turn would have influenced their heart rates to reach maximal levels. This may be the reason that the study failed to show any significant difference with the subject's maximal heart rates, in the different exercise settings that was used in the study.

Blood lactate concentration levels are often used as stress indices (Szmedra and Bacharach 1998). Increased stress placed on the body often yields increases in blood lactate concentration levels (Szmedra and Bacharach 1998). Blood lactate concentration levels have been shown to be comparatively lower in subjects who have exercised with music at 70% of maximal oxygen consumption, compared to subjects who have exercised at the same workload without music (Szmendra and Bacharach 1998). This is thought to be due to the distracting effects of music that leads to a lower metabolic demand, especially by calming the sympathetic nervous system (Szabo et al 1999; Szmedra and Bacharach 1998) and thereby decreasing anxiety. Consequently, by combining music and endurance training, lactate concentration levels may be significantly reduced. Szmedra and Bacharach (1998) found that with music (compared to a control trial of no music) subjects had decreased lactic acid and norepinephrine levels. The average RPE for the exercise with music trial was 10% lower when compared to exercise without music.

SECTION 3

2.3. THE PSYCHOLOGICAL EFFECTS OF MUSIC ON CYCLING PERFORMANCE

Human performance is influenced by many variables for example physiological responses, but importantly are those involving the psyche (Noakes 2000; White and Potteiger 1996). Music, which forms part of an exercise setting, can influence perceptual responses to exercise and can exert a psychological influence on physiological events during continuous, moderate-intensity exercise (Nethery 2002; White and Potteiger 1996). The psychological aspect of music is thought to have a profound influence on perceived exertion. This was illustrated in the study by Szabo et al (1999), where a change from slow to fast tempo music caused a change in mental focus and resulted in subjects perceiving the exercise sessions to be easier than the sessions with no music, slow music, fast music and fast to slow music. Consequently, in the slow to fast tempo session, subjects were able to increase their work performance.

It has been shown that music, during exercise, can result in mental diversion causing an individual to concentrate on the music instead of the physical sensations that arise from exercise (Potteiger et al 2000; Szabo et al 1999; Szmedra and Bacharach 1998; White and Potteiger 1996; Thornby et al 1995; Boutcher and Trenske 1990; Nelson 1963). Mental diversion is a way of coping with the pain and discomfort that accompanies strenuous work (White and Potteiger 1996). It is difficult to focus on multiple tasks i.e. people have a limited capacity to focus on information available, as a result only a certain amount of information can be processed at any one time (Nethery 2002; Boutcher and Trenske 1990). Noakes et al (2001) suggests that there is evidence that a central governor regulates exercise performance-therefore implying that exercise is predominantly under neural control.

'Audio analgesia' has been shown to be effective in clinical medicine (Gardner et al 1960). In a study undertaken by Gardner et al (1960), music was shown to be effective as an analgesic in dental surgery. It was found that patients experienced less anxiety and discomfort during and after surgery, when accompanied by music. Music lead to an attenuation of the sympathetic response and patients tended to be more relaxed, while the audio stimulation drowned out the sound of the dental drill. The music diverted patients' attention from the operation. Music may therefore work similarly in exercise. Kennard (1983) wrote a paper (although not scientifically based), from a physiotherapist's perspective, on how music works well in conjunction with disabled patients. The author mentions that by singing in combination with tedious exercise, patients are often able to extend their concentration span.

Music has been shown by Nethery (2002), Abadie et al (1996) and White and Potteiger (1996) to be one of the most effective distraction, while exercising. Nethery (2002), Abadie et al (1996) and White and Potteiger (1996) showed that viewing music videotapes (i.e. visual stimulation, without audio) in isolation during exercise, did not have a substantial effect on RPE (Rate of Perceived Exertion) scores, when compared to a quiet environment. Interestingly, in White and Potteiger's (1996) study, there was a significant reduction of exercise RPE both when the subjects were just listening to music and when there was a combination of music and visual stimulation, but not when the subjects were just watching video tapes.

Rating of Perceived Exertion, an example being the Borg scale, represents an individual's subjective assessment of work effort during exercise (Nethery 2002; Boutcher and Trenske 1990). Potteiger et al (2000) and Boutcher and Trenske (1990), suggest that both psychological and physiological factors contribute to the determinants of RPE. Grant et al (1999) conducted a study in which they compared and assessed which subjective scale (Visual analogue, Borg scale and Likert scale) was more reproducible and sensitive to change in the assessment of symptoms of perception. This study involved each subject being tested on four occasions: two sessions with no medication and two sessions, in which propanolol or a matching placebo was administered. Propanolol was used to increase the sensation of breathlessness and general fatigue during the exercise. This was given to the subjects in order to assess the sensitivity of each scale to a change in symptom perception. All four sessions consisted of submaximal tests, on a treadmill, at 60% of the subject's maximal oxygen consumption for two minutes. Thereafter, subjects were further exercised at 70% of their maximal oxygen consumption for an additional six minutes. However, this posed a problem if the subjects were fit (it is mentioned that they are 'physically fit'), as 70% of their maximal oxygen consumption is not very physically demanding. The study concluded that the Borg scale was the most sensitive for general fatigue and as a subjective scale.

Nethery (2002), Potteiger et al (2000); Szmedra and Bacharach (1998); Thornby et al (1995) and Boutcher and Trenske (1990) all found that music resulted in lower ratings of perceived exertion during low, moderate and high intensity aerobic exercise. Interestingly, the above authors all used different subject groups. Potteiger et al (2000) and Szmendra and Bacharach (1998) studied physically active subjects between the ages of 18 to 30 years old; Boutcher and Trenske (1990) used untrained females (aged 18 to 20); Nethery (2002) used untrained male subjects, while Thornby et al (1995) utilized subjects with moderate chronic obstructive pulmonary disease (COPD), who were 54 to 71 years old. This may indicate that music had an affect on subjects of all ages and fitness levels.

Boutcher and Trenske (1990) studied the effects of sensory deprivation and music on perceived exertion during exercise. They found that music lowered RPE at light load intensity. Subjects were able to choose their own music which has an advantage, as music preference is very personalized, but in a study that measures physiological variables, it may not be suitable. This is because the rhythm and tempo of music can have an effect on physiological parameters like heart rate and intensity of exercise (Storr 1999; Szabo et al 1999). In contrast to all of the above mentioned research, Atkinson et al (2004) study showed that their subjects selected to work at a higher rate during the music time trial and therefore had a higher RPE.

Individuals have their own unique ways of responding to music (Kennard 1983). This is because music often brings about an emotional state (Storr 1999; Mills 1996; Thornby et al 1995). Music may generate positive emotional states and allow subjects to associate music with uplifting experiences (Boutcher and Trenske 1990). Conversely, by the same virtue it is possible for music to also generate negative experiences, but none of the available literature has reported on this.

Although comparative studies of males and females have tended to have shown similar ratings of perceived exertion responses, to certain work loads; the gender of a subject could potentially play a part in influencing the perceptual response (Nethery 2002). Mayfield and Moss (1989) studied the effect of music tempo on gender task performance. The task involved subjects collecting closing stock prices and calculating the percentage of change in the price from week to week. They found that women performed better on the task both with and without music compared to men. Speechly et al (1996) investigated endurance performance in male and female matched runners. It was found that although the female subjects performed as well as their male counterparts at 42.2km, the females performed significantly better for a 90km race, as they were able to work at a higher average fraction of their maximal oxygen consumption. Endurance exercise has both physiological and psychological elements. Speechly et al (1996) suggested that one of the possible explanations for this is that female athletes have a psychologically stronger disposition in endurance exercise. The authors postulated that females are more likely to be influenced from a psychological perspective than their male counterparts. It should be noted that this is just speculation and has yet to be scientifically proven. So technically, music that has an emotional psychological element is likely to affect females more than males. However, in studies that have compared female to male responses with regard to utilizing music in exercise, there seems to be no evidential difference between genders. Potteiger et al (2000) found that there were no significant differences in RPE between male and female subjects, when cycling at 70% of their $V0_2$ max with and without music.

SECTION 4

2.4. TYPE OF MUSIC MOST SUITABLE FOR EXERCISE

Music preference is both personal and subjective. Individuals will react differently to varied music (North and Hargreaves 2000). People respond best to music which they have grown up with or have become conditioned to (Gunby 1981). While children and younger adults showed consistently positive responses to the music that was used in Becker et al (1994) study, senior subjects showed no effect, possibly because the seniors were not familiar with the music that was played in the study (Becker et al 1994). Perhaps, music becomes appropriate because it is often played in given situations (North and Hargreaves 2000). Iwanaga (1995) indicated that subjects may choose music that has similar tempos to their heart rates. Iwanaga (1995), however, did not give a definitive purpose for conducting the research and mentions results in the introduction. Step by step procedures are omitted, which makes the research less repeatable. In addition, only 14 subjects were utilized (there is no mention that a power test was performed). Since all subjects were very close in age (19 to 22 years old), the findings are probably only pertinent to that particular age group.

In an exercise setting, individuals often listen to music that will optimize their mood by moderating or polarizing their level of arousal. North and Hargreaves (2000) studied musical preferences during and after exercise and relaxation. It was found that musical preference can be directly linked to the characteristics of the listening situation. The study showed that the subjects deemed high arousal music to be most suitable during exercise, while low arousal music was selected as more appropriate for relaxation. This was perhaps because high arousal music is able to evoke arousal levels that are required for exercising. The authors do not mention what type of music was selected for the study. They mentioned, however, that the same musical selections were made into high and low arousal music, by altering the tempo and volume. North and Hargreaves (2000) conducted a follow up study to their first study. In the follow up study, the examiners looked at whether music could be used to moderate arousal. It is not entirely clear, however, why they decided to do the complementary study. In the text it says that 'psychology undergraduates volunteered for the study as part of their course requirement.' This may be problematic as to whether the subjects really did volunteer if it was part of their course requirement.

Soft, slow music reduced subjects' physiological arousal during submaximal exercise and consequently resulted in an increase in treadmill endurance and a significantly longer time to exhaustion, according to Copeland and Franks et al (1991). It seems that slow music has a calming effect on an individual, therefore making the subject more relaxed and consequently less likely to become mentally and physically exhausted (Mayfield and Moss 1989).

Atkinson et al (2004) studied the effect of 'trance' (dance) music on work-rate distribution during a cycling time trial. According to a questionnaire that was given to the subjects once they had completed the music time trial, subjects indicated that the music assisted in motivating them. Generally, it was found that the 'trance' music improved the subjects' cycling speed, especially in the first few minutes of the time trial. Even though, this study was of high quality (the research was well constructed and consisted of a repeatable method as well as gave solid reasons for conducting the study) the subject population consisted of a mixture of cyclists, triathletes and runners. It is difficult to compare cyclists and runners (even though subjects acted as their own controls) in a cycling time trial. It is almost certain that the cyclists would have been more comfortable and more at ease than the runners. Consequently, the cyclists would have been more receptive to the distracting element of music, compared to the runners. This is because the cyclists wouldn't have had to concentrate, as hard as the runners, on the actual action of cycling, as they were already accustomed to it.

Potteiger et al (2000) examined the influence of different kinds of music on ratings of perceived exertion. They used four music conditions:

1) Fast upbeat music
2) Classical music
3) Self-selected music
4) No music

It was found that music (all kinds) resulted in a reduced RPE, during 20 minutes of submaximal (70% of $V0_2$ max) cycling. Becker et al (1994) had similar findings. They found that music increased the distance ridden on a stationary bicycle, although there was no significant difference between mellow and frenetic music. An advantage of the study by Potteiger et al (2000) was that the examiners were kept blinded as to whether the subjects were receiving the mellow music, frenetic music or white noise. Becker et al (1994) conducted three randomized two-minute exercise trials. Each trial was accompanied by either white noise, mellow or frenetic music. Two-minute exercise trials are a very short time period to gain accurate measures of performance. Secondly, it appears that the subjects listened to the music prior to commencing the two-minute trials and not during the actual 2 minutes of exercising. In this instance music was used for its emotive element-as a mood moderator and not as a passive distracter.

Szabo et al (1999) studied the effects of slow-and fast-rhythm classical music on progressive cycling to voluntary physical exhaustion. . The study showed that the subjects preferred either the fast or the slow-to-fast music sessions. The purpose of the research was not clearly defined. The study utilized subjects with the mean age of 20.8 years and used edited extracts from Beethoven's Symphony no. 7. It is questionable as to whether subjects of that age would choose such music to listen to. Subjects were exercised at the same time of the day, at the same time of the week, to prevent circadian rhythm variation.

Mills (1996) showed that students (in their teens) showed less assertive behaviour when they listened to slow-tempo music, while more assertive behaviour occurred when exercising to fast tempo music. The assertive behaviour was established by videotaping the students. The videotapes were then watched by the raters who recorded the total number of assertive actions. Assertive behaviour was considered to be any type of bodily contact. This may be advantageous in certain sports, like cycling for example, where assertive behaviour may be required to give an athlete a more competitive edge. A criticism of this research was that each session with the different types of music was videotaped and subsequently rated for assertive behaviour by 16 raters. There is no mention why so many raters were used, nor how they ensured consistency, nor if the exact same raters were used throughout the study.

SECTION 5

2.5. MUSIC AND EXERCISE TYPE

The rhythm of one skill differs from the rhythm of another skill (Nelson 1963). Music has been shown to influence submaximal repetitive exercise, by mainly reducing boredom and contributing to the rhythm and beat of the activity. (Szmedra and Bacharach 1998; White and Potteiger 1996 and Copeland and Franks 1991), but it becomes less effective if working at very high intensities, such as anaerobic activities and high loads (Nethery 2002; Pujol and Langenfeld 1999; Boutcher and Trenske 1990). Physiological cues (for example rapid heart-rate, increased respiration and an increase in lactate) are more predominant when individuals are working near their maximal exercise capacity, while psychological cues are more predominant during submaximal work intensities (Thornby et al 1995). During high intensity exercise (> 90% $V0_2$ max), internal cues, such as fatigue and pain, override the psychological effects of music (Szabo et al 1999; Pujol and Langenfeld 1999; Nelson 1962; Nethery 2002).

Boutcher and Trenske (1990) showed that perceived exertion was load dependant both when exercising with and without music. They found that the RPE was lower at light work intensities when accompanied by music. In this study, however, the subjects' workload was based on a submaximal fitness test. They assumed that when subjects' heart rate reached 170 beats per minute, subjects had reached their maximal oxygen consumption ($V0_2$ max). The authors assume that 170 beats per minute was the maximal heart rate of every subject, but surely, there is variability between individual's resting and maximal heart rates, even if subjects were within a similar age group.

Pujol and Langenfeld (1999) found no significant difference between the use of music and a control (i.e. no music) with regard to the anaerobic, Wingate test. Nelson (1963) had similar findings, but this particular study ,however, contained flaws. Firstly, the author used three different experiments: 1- Subjects exercised to self selected music; 2- subjects exercised to pure tones; 3- subjects exercised to varied music intensity. The authors do not mention in what order the subjects performed the experiments. If the experiments were conducted in the same order, the results may have been due to a learned response. Secondly, it is uncertain as to whether the authors got ethical clearance in order to conduct the research.

In summary, according to the literature, music (of varying tempos and styles) has been shown to have an effect on most types of exercise. Music affects mainly psychological variables, which have mostly been illustrated by rating of perceived exertion, mostly using the Borg Scale, to be significantly lower compared to exercising without music.