ABSTRACT

Van Laarhoven, R. J. (1985). The effects of a music stimulus on heart rate, blood pressure, vo2, duration, and perceived exertion of performance at submaximal. M.S. in Adult Fitness and Cardiac Rehabilitation. 51 pp. (Dr. Philip Wilson)

This study examined the effects of music on heart rate response, blood pressure response, oxygen uptake, duration, and perceived exertion of subjects during three submaximal exercise tests. A music stimulus (fast tempo and slow tempo) was implemented during two of the tests. The third test had no music stimulant. Twenty-five subjects (11 females, 14 males) participated in this study and randomly selected which order the music stimulus or no-stimulant occurred. The data were analyzed by an ANOVA with repeated measures. Significant interactions were further analyzed by a Scheffe post hoc test.

There was no significant difference ($p. < .05$) in blood pressure response between fast tempo music, slow tempo music and no-music. Significant difference was indicated for duration as determined by heart rate response, oxygen uptake with relation to duration and perceived exertion. Significance at the $p. < .05$ level showed that while subjects listened to slow tempo music, they submaximally exercised longer and used less oxygen during the test. When compared to duration, the subjects perceived the exercise test easier while listening to fast or slow tempo music.

It was concluded that slow tempo music has a physiological effect while exercising submaximally. An individual can exercise longer while using less oxygen.

THE EFFECTS OF A MUSIC STIMULUS ON HEART RATE, BLOOD PRESSURE, VO2, DURATION, AND PERCEIVED EXERTION OF PERFORMANCE AT SUBMAXIMAL

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Most of all I want to thank my special friend , Mary S. Dobeck. Who has, without a doubt, been my mentor, sounding board, and "sharer of laughter" through my adult years. Hopefully, we will continue with our friends to maintain the attitude of being a "Connoisseur of Life" 1.

1 "one who enjoys with discrimination and appreciation of subtleties in life" (definition #2 in the Webster's New Collegiate Dictionary. 1976)

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CHAPTER 1

INTRODUCTION

There has been a considerable amount of literature written and suggestions made by qualified professionals about the benefits of exercise. The physiological benefits stated include increased maximal oxygen uptake, lowered resting and submaximal heart rate and systolic blood pressure, reduced adipose tissue, increased percentage of lean body mass, favorable alterations in concentration of serum insulin, glucagon, triglycerides and a increased ratio of serum high density to low density lipoproteins. Emotional benefits include increased self-esteem, decrease in anxiety and a decrease in depression (Hall, Meyer, & Hellerstein, 1984). Through promotions of these benefits, one would presume more people would be involved in some type of exercise program. Presently, however, most of the adult population in this country (about 55%) choose to be sedentary during their leisure time. Additionally, half of these who consider themselves active, exercise only twice a week or less and for the most part the activity is walking, while participation in vigorous activities is much less common (Wilson, Fardy, & Froelicher, 1981).

Apparently a majority of the general population finds it difficult to involve themselves in an exercise program. Typically, loss of motivation is an important factor (Wilson, et al. 1981). Investigations on how to motivate individuals are presently being studied by other researchers. An attempt of this study was to make the mode of exercise more enjoyable via the stimulus of music. This may aid in motivating more indivduals in attaining or maintaining an exercise program.

Music has touched each person's life in one way or another. We have been aware of the benefits of music over the centuries and have acknowledged this by writing music to: soothe children (i.e., lullibies), motivate patriotism, "set the mood" for romantic interludes, make the environment in commercial settings relaxed and enjoyable (i.e., elevator music and department store music available from commercial vendors such as Musak), and relieve the tension of patients and friends in hospitals and physician's waiting rooms.

> "Our bodies are literally human instruments and the sounds in our environment exert a tremendous influence over our physical, psychological and spiritual state of being. Some can make us ill, some can enhance our feeling of well-being by bringing us into "tune"" (Halpren,1981).

Today, music is being used in a number of modalities. Some include, relaxing patients who are mentally handicapped (Peretti & Swenson, 1974), as an educational tool in arithmetic and grammar courses (Wolf & Weiner, 1972), to initiate rhythms and tempos for children in physical education courses, as background music in many exercsie programs, as a therapeutic device by speech therapists and for the rehabilitation of the disabled elderly (Phillips, 1980). Since music has been used for a variety of aspects in our lives, this study will attempt to examine its possible physiological benefits in exercise.

Purpose of Study

The effects of music on human behavior has been investigated by both commercial and academic institutions; however, conclusions have been somewhat inconsistent. The influence of music can be studied with numerous physiological and psychological parameters. This study examined some physiological parameters during a submaximal exercise test while listening to music with a tempo faster then 120 beats per minute, slower than 60 beats per minute or no-music.

Statement of the Problem

The problem of the study was to ascertain the effect that music with a tempo faster than 120 b.p.m. or slower than 60 b.p.m. would have on heart rate in relation to the duration of the test, blood pressure, oxygen uptake (VO2), and perceived exertion of a submaximal exercise test.

Null Hypothesis

Listening to music with either a tempo faster than 120 b.p.m. (FAST-TEMPO) or slower than 60 b.p.m. (SLOW-TEMPO) during a submaximal exercies test will not significantly (P. <. 05) affect the subjects': 1) duration of the test as determined by heart rate, 2) blood pressure, 3) VO2, or 4) perceived exertion following the test.

Assumptions of the Study

The researcher made the following assumptions;

1. The subjects sampled were representative of typical undergraduate students (i.e., non-athletes, moderately trained).
2. Subjects during each test consistently performed to the best of their ability.
3. Subjects did not vary their training regimen or life style in any way so as to influence their heart rates, blood pressures, VO2, and the duration of exercising submaximally during the period of testing.
4. Subjects were honest when giving their perceived exertion following the completion of the submaximal test.
5. Subjects had the abiltiy to listen to the music through the headphones.

Delimitations

The delimitations of this study were;

1. Subjects used for the sample were volunteers, not randomly selected.

2. So that the testing procedure was not biased, randomization was used to determine the order in which the tests were undertaken.
3. The day of the week and time was held consistent throughout the experiment for each subject.
4. Subjects were undergraduate students from the University of Wisconsin -La Crosse.

Limitations

The following are limitations for this study;

1. The subject's emotional status before and during each test was not evaluated.
2. The subject's prior music education was undetermined.
3. The subject's sensitivity to rhythm was unknown.
4. The subject's familiarity of music literature chosen was not determined.
5. The subject's dissappointment when there was no music implemented during one of the test was not evaluated.

Definitions of Terms

The defintion of terms necessary for this study are;

BLOOD PRESSURE (BP) - Pressure exerted by the blood upon the walls of the vessels and arteries varying with the muscular efficiency of the heart.

BECKMAN METABOLIC MEASUREMENT CART (MMC) - An automated machine comprised of an OM-11 oxygen sensor and LB-2 carbon dioxide sensor which have the capability to analyze air which has been expired to a mixing chamber. After the expired air has been analyzed and calculated, the metabolic data are graphically printed.

DECIBEL (dB) - A unit for expressing the relative intensity of sounds on a scale from zero (least preceptible sound) to 130 (average pain level).

ELECTROCARDIOGRAM (ECG) - A graphic record of heart contractions as recorded upon an electrocardiograph.

HEART RATE (HR) - The number of times the heart beats during a period of one minute. For the purpose of this study, heart beats were determined from a six-second electrocardiography heart rate strip.

METRONOME - The device used to set a tempo, representing the beat of music. The tempo is recorded as beats per minute (b.p.m.).

OXYGEN UPTAKE (VO2) - Amount of oxygen taken in by the body, transported and utilized in a period of time. It is expressed in milliliters per kilograms of body weight per minute (ml^kg^min - 1).

RATED PERCEIVED EXERTION (RPE) - A rated scale (7 being very, very light to 20 being very, very hard) to quantify a person's subjective estimate of work in a pyschological context (Borg, 1970).

SPL METER (Sound Pressure Level) - The device which measures the sound levels, usually described in decibels (dB). The range begins at 0 and can reach levels above 150. A whisper is measured around 60 dB, conversation at 70-80 dB, damage to the eardrum begins around 100-110 dB, and pain begins around 117 dB (ie., rock bands 110-115 dB, and jet engines 140 dB).

SUBMAXIMAL TEST - For the purpose of this study, the submaximal exercise test would mean 2 minute workloads at 3 m.p.h. at a 2.5% grade, 5.5 m.p.h. at 2.5% grade, 5.5 m.p.h. at 5.0% grade, and 6.0 m.p.h. at 5.0% grade until the subject has reached 60% of predicted maximal heart rate. Karvonen's Formula (% x (220-RHR) + RHR) was used to calculate heart rate for the termination of test (RHR = Resting Heart Rate). An example for termination of a test for a subject with a RHR = 75 b.p.m. is: (60% x (220-75) + 75) = 162 b.p.m. The subject exercised until his/her heart rate reached 162 beats per minute.

CHAPTER 2

REVIEW OF RELATED LITERATURE

Introduction

There have been a number of studies conducted on the psychological benefits of music. Research prior to this study have considered some physiological parameters (HR, BP, skin temperature), but a majority of the findings have been considered non-conclusive (Geringer & Nelson, 1979). Studies that have considered the effects of music on human behavior, psychologically and physiologcially, have been reviewed in this chapter.

Effects of Sound on the Brain and Peripheral Functions

The autonomic nervous system (ANS) aids in the control of the heart. The ANS has two separate divisions; the sympathetic and the parasympathetic. Stimulation of the sympathetic fibers causes the rate and force of contraction of the heart to increase, while stimulation of parasympathetic fibers causes the opposite to occur. When sound is transmitted through the ear (via cochlea to the auditory cortex of the brain), it travels through the bulboreticular formation (which has as one of its functions, the combination and coordination of motor information from the motor cortex). The ANS is part of the motor portion of the nervous system, and regulates many of the body's internal functions. Sound activates the bulboreticular formation and at the same time affects the ANS, which controls the heart. It has been hypothesized that music can effect the heart beat (Ruiz, 1979).

Psychological Studies

The effect of background music on human behavior has been investigated frequently. Responses to background music appear to vary according to age, behavioral characteristics such as TYPE A or B , education of the subjects, musical characteristics of the background music and difficulty of the task.

Comparisons among ages and levels of education have given inconsistent experimental results. College students, sixth graders, and individuals who were considered retarded performed more accurately on tasks in the presence of background music (Wolf & Weiner, 1972). In other studies, college students and high school students (Smith & Morris, 1976) performed no differently on tasks with music than without, while high school students (Parente, 1976) and eighth graders (Fogelson, 1973) performed more efficiently in silence.

DeJong, van Mourick, and Schellekens (1973) reported on a study, researched by Lacey (1963), and found considerable psycho-physiological evidence to support the notion that pleasant stimuli (those that the organism wants to take in from the environment) produced cardiac decelerations, whereas unpleasant stimuli (those that the organism wants to reject) produce cardiac acceleration. This study lead to their experiment of exploring the possibilities of music as an aesthetic stimuli. The subjects were presented with nine pieces of music. The time period of each piece was one minute in length. The nine pieces were split into three separate catagories of tempo (adagio, moderato, and allegro). During the presentations, recordings were made of heart rate, respiration rate, and skin conductance. The scores of these measures were compared to the subject's ratings of the music on a scale that had its extremes of "very beautiful" to "very ugly". There were three groups of 15 subjects each, both female and male. Fast music was more often rated "beautiful" than slow music, and slow music was more often rated "ugly" than fast music. "Ugly" music did not elicit a cardiac acceleration, instead it elicited a smaller deceleration than the "beautiful" music. The authors recommended that if one wants to investigate the influence of music on autonomic parameters, it is of prime importance to take the tempo of the music into consideration.

Blanchard (1979) examined the influence of background music on 254 students during a final exam period. Blanchard experimented with no-music, rock n' roll, and classical music. He concluded that the results of the study (students earned higher grades who had music as an accompaniment) suggested that music acts as a general factor in critical thinking of students. Students who had listened to classical music in the background, obtained the highest "mean" grades.

Behavioral characteristics of Type A individuals (coronary heart diseased prone - CHD) and Type B (non-CHD prone) (Jenkins, Rosenmann, & Zyzanski, 1974) have also been investigated. Type A persons exhibit an exaggerated sense of time urgency and are easily aroused, facilitating environmental control, particularly in stressful situations. Type B persons are defined by the relative absence of these characteristics (Matthews, 1982). A study done by Strube, Turner, Patrick, & Perrillo (1983), on response by Type A and Type B individuals to an aesthetic stimulus on the effects of mood and performance, found that a pleasant stimuli can have a soothing (generally slow and soft), ameliorative effect on negative mood states. If an aesthetic stimulus reduced a negative mood, the resulting state could lead to increased perceived control (Alloy, Abramson, & Viscusi, 1981) and improved performance (Seligman, Klein, & Miller, 1975). Strube et al.'s conclusions indicated that the focused attention style utilized by Type As is not completely adaptive for dealing with extraneous stimuli. Only Type Bs benefited from the presence of the music stimuli which enhanced performance.

Music has been used as a healing modality for elderly persons in nursing homes. Music, with it rhythms, was utilized by nurses as the "organizer and energizer" to help repattern altered behavior manifestations of the elderly (Phillips, 1980; Hinds, 1980). Interaction of geriatrics in nursing homes ranges from active engagement to withdrawal and isolation. Since music is considered the most social of the arts (Alvin, 1975), it fosters relationships among the elderly. One significant aging process in elderly persons is a decrease in the ability to move through space. Movement through space is enhanced through the use of the rhythms of music as evidenced by hand clapping and foot tapping of persons confined to wheelchairs and dancing movements of persons using walkers. Nurses have used these behaviors to help maintain flexibility of fingers and joints and to prevent contractures brought about by muscle disuse. Dancing to music has been used to give grace, poise, and a sense of security in walking while at the same time improves circulation and muscle tone (Phillips, 1980). Also, music through its reminising capabilities, can stimulate memory because of past associations with it (Domokos, et al. 1978).

Music is now being used in prenatal care. Marana (1981) reported that Brazelton (1981) found prenatal infants not only orient themselves to sound; they prefer the sound of a human voice, especially the high pitch of the female voice. Brazelton claimed that this is a discovery in the sense that science is beginning to recognize what sensitive mothers have suspected all along.

Physiological Studies

Coleman (1921), observing a subject, found that it was possible to alter pulse by concentrating on a metronomic beat. The subject sat erect and poised while the metronome was set at a rate 15-30 beats faster or 10-15 beats slower than the subject's pulse. The subject's pulse was taken every 15 seconds. Coleman found that the pulse rate of the subject had become the same as the rate of the metronome.

Coutts (1965) investigated the after-effect of music on pulse rates (which are affected by emotions) and work output of short duration (which is involved in some athletic contests). The subjects who participated in this study were 15 male students. Three experimental conditions were administered 1) "Stars and Stripes Forever, by Sousa, 2) "The Swan" from Carnival of the Animals, by Saint-Saens, and 3) no-music. The testing consisted of taking the resting pulse rate after the subject sat quietly for 5 min. and then introducing the experimental condition scheduled for that day. The music was played on a prerecorded tape at a constant volume each time. The pulse rate was then retested to observe any changes that may have occurred as a result of the experimental conditions. Coutts concluded that music did not have a significant after-effect on pulse rate.

Gorden, Kinney, McGinty, and McSorley (1977) measured heart rate of subjects listening to music. The subjects chose, from a list of 23 albums, the ones they felt were physically stimulating. The album classifications were; jazz, classiscal, popular, country, and rock music. The 39 volunteers were between the ages of 18 and 73. Their findings indicated that significant differences were found between baseline readings in Situation A (stimulative) and between baseline readings in Situation B (sedative). The heart rate increased to stimulative music and decreased to sedative music.

Mitkov, Moldovanska, and Roglev's (1981) study examined the effect of music on brain electrical activity and its hemodynamics. Their study incorporated two experiments; one, examining the influence of pop music and the other, classical music. Electroencephalographic (EEG) changes occurred more often in pop music while blood supply to the brain was significantly ($p.<.05$) greater by the influence of classical music. Pop music actually reduced blood supply to the brain ($p < .02$). Mitkov et al.'s concluded that the diverse nature of changes observed under the effect of music points to the participation of both autonomic nervous system portions (sympathetic and parasympathetic) in the positive emotions.

Blanchard's study (1979) on the effect of music on heart rate and blood pressure of students taking final exams, found that college students in the experimental groups, accompanied by music, displayed excellent recuperative activity of the heart.

Janiszewski (1979) studied 85 patients with primary hypertension. They were exposed to selected musical compositions (the musical pieces were not given) for 5 months. A significant decrease of arterial blood pressure was observed. The changes were more pronounced in subjects with higher levels of neuroticism and introversion. A study done by Kibler and Rider (1983) examined Progressive Muscle Relaxation (PMR) techniques with or without sedative music (M) on the influence of stress reduction, had shown increased skin temperature immediately following the treatments. The effects of combining PMR and M treatments increased the positive influence even more ($p < .0001$) while PMR alone showed a $p < .01$ and M alone indicated $p < .001$.

A more recent study was done by Miller (1984) on the effects music has while a person runs. The study measured beta endorphins (this is a chemical produced by the body and released into the blood as a natural pain killer), production of lactate in muscles, respiratory rate and heart rate. In all cases, beta endorphin was at a lower level in subjects listening to music than without. Measurements of the production of lactate, respiratory and heart rates remained unaffected, indicating that the runners worked at the same level with the music as without it. The runners claimed that the exercise was easier with music rather than without. Miller attributed this to the possiblity that listening to music prevented the runners from hearing heavy breathing or the sound of their feet hitting the ground. Miller then stated;

> "because it makes exercise seem easier, a person can do more of it and increase the training effect without feeling as tired" (Van, 1984, pg.3).

Music has been used in many clinical settings. Listening to relaxing music will decrease airway resistance (Metera, Metera, & Warwas, 1975). In emergency centers having separate "asthma rooms", relaxing or sedating music, concurrent with the adminstration of standard pharmocotherapy, has shown beneficial effects (Leonidas, 1981). In the palliative-care unit at the Royal Victoria Hospital in Montreal, selected musical pieces have improved the quality of life in patients with advanced malignant conditions. Frequently, analgesics were discontinued and patients were "treated" only with relaxation techniques and musical therapy (Munro, 1978). Gala (1976), reported on a study at Dusznkachzdoju Medical Center in Poland, where twenty sessions each day of symphonic music were played for six months. They showed a significant decrease in the amount of medication given to the patients; therefore, such therapy prevented drug abuse. Surgeons have used music while utilizing local anesthesia. Jacobs (1983) has found stereo headphones useful in augmenting patient sedation because of the relaxing effect of music and it muffles background operating room noise and comments from the surgical personnel.

Characteristics of music as a background have indicated that tempos greater than 84 MM (Richman, 1976) and intensity levels between 50 and 70 dB (Norton, 1972) appear to facilitate task performance. The complexity of an aesthetic stimuli may produce different effects on the combination of mood and performance (Geringer & Nelson, 1979). Increased volumes (above 95 dB) over time may impair performance and become even less soothing (Strube, et al. 1983).

Summary

Music has been implemented in facilitation of performances, utilized as a therapeutic tool, for modification of emotions, and incorporated in the relaxtion or sedation of patients. The effects of music physiologically, has shown changes in blood pressure, heart rate, and perceived exertion. The study on runners, with general music as a background stimulus, showed non-conclusive alterations in blood pressure and heart rate. This study will attempt to explore possible alterations by implementing different tempos (faster than 120 and slower than 60 b.p.m.) while individuals were submaximally exercise tested.

CHAPTER 3

METHODS

Introduction

This investigation was designed to evaluate physiological and perceptual responses following a submaximal exercise test while listening to music. The individuals tested had a background stimulant (music) 1) faster than 120 b.p.m., 2) slower than 60 b.p.m., and 3) no-music.

The research methods for this study consisted of Sample Selections, Music Selections, Test Mode Selections, Test Procedures, Data Collection and Statistical Treatments.

Sample Selection

1. Twenty-five volunteers were obtained from the undergraduate student body at the University of Wisconsin - La Crosse.
2. Subjects were excluded from the study if:
    a. audiological impairments existed.
    b. physical disabilities and/or deficiencies that would not allow them to exercise.
    b. audiological impairments

3. Results of the characteristics of subjects (sex, age, weight, and height) were recorded on Data Sheets (Appendix A).

Music Selection

Music was selected for each category (faster than 120 beats per minute and slower than 60 beats per minute) through the use of a metronome. Music chosen for the tempo faster than 120 b.p.m. was from a Vangelis selection: (Pulstar). Music slower than 60 b.p.m. was chosen from the Satie selection: (Gymnopedy). The decibel level was determined using a SPL meter (General Rad. #1982 #0815) on an audiometer calibrator stand (#1982) and was calibrated with a General Rad, 1562-A (sound level calibrator). The calibration was performed in the Audiological Department at Gunderson Clinic, La Crosse, Wisconsin. The right and left phone of the headphone set averaged 92 dB of music faster than 120 b.p.m. while the slower music tempo of below 60 b.p.m. had an average of 90 dB. The music was recorded on a cassette and played to the subjects on a portable cassette player with headphones while they were exercise tested.

Test Mode Selection

The treadmill was selected for this research due to studies done by Astrand (1971) and Kemper and Vershcurr (1978). Testing on the treadmill was reported to have a 5-10 % higher max V02 when compared to tests done on the bicycle ergometer. Matthews and and Fox (1976) also considered that cycling leads to localized fatigue of muscles. This involves mainly the large muscles of the thigh. Such fatique would occur prior to maximally stressing the circulatory and respiratory systems, thus leading to a smaller max V02.

Submax V02 was used to calculate percentage of performance. A study done by Costill, Thomason, and Roberts (1973) showed that there is individual variation in oxygen uptake values at a given submaximal running speed. They found submax V02 not totally related to peak performance, but if expressed as a percentage of max V02, the relationship was r=.94 . Submaximal testing also reduces the percentage of potential medical problems from occurring because it is less taxing on the cardiovascular system than maximal stress tests.

The submax walk/run protocol (Table 1) was chosen due to the speed and grade typically paced during an exercise bout at 60% or less of maximal exercise. The duration (under 8 minutes) for a submaximal exercise test is less than 8 minutes in length (Matthews & Fox, 1976).

TABLE 1

Submax Walk/Run Protocol

Stage (2 min.)	Speed	Grade
1	3.0 m.p.h.	2.5%
2	5.5 m.p.h.	2.5%
3	5.5 m.p.h.	5.0%
4	6.0 m.p.h.	5.0%

A Rated Perceived Exertion Scale was implemented in this study (Appendix C). The use of perceived exertion ratings is an additional means by which exercise intensity can be monitored and was developed by Borg (1970). One use of perceived exertion ratings is to help the participants subjectively evaluate the effort of cardiovascular endurance training during the beginning stages of an exercise program. In this way, individuals can attempt to "read" their bodies as a means for regulating intensity (Falls, Baylor, & Dishman, 1980).

Test Procedures

Equipment utilized during the submaximal test were:

Treadmill (Quinton - Model 24-72)

Beckman Metabolic Measurement Cart - (VO2)

Beckman Instruments: Head Piece - Model 219665

Danial's Two-way Valve

Large Rubber Mouth Piece

52.5 cm Corregated Tubing

Burdick Electrocardiograph - (ECG)

Blood Pressure Cuff/Stethoscope

Sanyo Cassette Player - w/Memorex dB series Cassettes

Rated Perceived Exertion Chart

An informed consent statement (Appendix D) was signed and the nature of the test was explained to each subject prior to the adminstration of the first submaximal test. Once the consent form was obtained, the weight and the resting heart rates (RHR) of subjects were recorded.

PRETEST SESSION: Each subject had a practice session on the treadmill before the testing began. A demonstration was given by the researcher and included; 1) how to get on and off the treadmill; 2) how to straddle the treadmill when the test was completed; 3) the placement of the arms and positioning of the head during the treadmill run; 4) a verbal explanation of the Borg Scale of Perceived Exertion (modified to include numbers 7 to 20) (Borg, 1970); and 5) a description of the electrode placement.

SUBJECT PREPARATION: Subjects were asked to report to the Human Performance Laboratory after at least a two hour fast. Upon arrival the subjects were asked to change into running shorts, socks and shoes, and take their weight on a Continental Health-O-Meter Scale. While the subjects were changing, the barometric pressure was recorded in millimeters of mercury (mm Hg) and the oxygen (O2) and carbon dioxide (CO2) analyzers (Beckman Instruments, Models OM 11 and LB 2 respectively) were calibrated with known gas mixtures determined by the Micro Schoelander technique.

The sujects were prepared for electrocardiographic monitoring via a three-lead arrangement (CM5). The skin was cleaned with alcohol pads before the lead electrodes were positioned in place. The leadwires were attached to the electrodes and hooked up to a Marquette Electrocardiograph. Resting heart rate was determined at this time. Heart rate was determined from the last 15 seconds of each minute while a graphic recording was taken at submaximal exercise. The method of heart rate determination was recorded from R-to-R complexes in a 6 second strip. This time was then converted to beats per minute (b.p.m.). Blood pressure (BP) was taken prior to the test in a supine position and at the termination of the test (standing).

Following RHR determination, a light weight plastic head piece (Beckman Instrument, Model 219665) was fitted on the subject's head while a noseclip was applied. This head piece supported a Danial's two-way valve and a large rubber mouth piece. The outflow port of the Danial's valve was connected to the common port of a low turbulence three way "Y" valve by 52.5 cm. of corrugated rubber tubing.

VO2 CALIBRATION: The Beckman Metabolic Measurement Cart (MMC) was used to obtained the following information: volume of expired air (Ve), volume of oxygen consumed (VO2 in L^min-1 and ml^kg^min-1), respiratory exchanged ratio (RER), fraction of expired carbon dioxide (FCO2), and fraction of expired oxygen (FO2). The Beckman MMC was programmed with the weight of each subject and adjusted ambient temperature and pressure as needed. The OM 11 and LB 2 gas analyzers were calibrated against the Scholander gas prior to and immediately following each test. The MMC was programmed to give print-outs every 60 seconds until the test had terminated.

EXPERIMENTAL PROCEDURES: Each subject randomly selected (drawing from a container) which order the test occurred between the experimental conditions. The decibel level was held constant (90 - 100 dB) during the music conditions while room noise during the no-music condition was 80 to 90 dB. This was calibrated using a SPL meter. Implementation of the conditions was done through the use of headphones attached to a Sanyo Cassette Player. The three conditions were tested over a four week period. The day of the week and time of the day of tests were held as consistent to each other, for each subject, as possible (i.e., 1st test - Monday at 6:15, 2nd test - following Monday between 6:00 to 6:30, etc.).

A 2 minute warm-up period for each subject was conducted prior to each submaximal test. This was done in order that the subject might become reacquainted with the treadmill and to allow for proper circulation of blood to their body tissue. The scale of perceived exertion was reviewed at this time and the sequence of walking and running speeds that would be utilized during the test were explained.

Subjects exercised on the treadmill at 2 minute workload intervals of 3.0 m.p.h. at 2.5% grade, 5.5 m.p.h. at 2.5% grade, 5.5 m.p.h. at 5.0% grade and 6.0 m.p.h. at 5.0% grade. The test was terminated at 60% of subjects predicted maximal heart rate. This was acquired using Karvonen's Formula (% x (220-RHR) + RHR). An example of a 20 year old with a resting heart rate (RHR) of 70 b.p.m. is: 60% x (220-70) + 70 = 160. Their blood pressure was immediately taken following the termination of the test. Upon completion, they were then asked for their subjective perceived exertion, which was obtained from the Rated Perceived Exertion Chart.

Data Collection

Data collection sheets (Appendix B) were designed to record the physical characteristics of the subjects; their heart rate, blood pressure, VO2, duration of test, perceived exertion following the tests, and if they liked or disliked the music. The data collected from each of the three tests taken by the subjects were calculated and compared to each other using a Hewlett Packard Series 11,000 access system.

Statistical Treatment

An analysis of variance with repeated measures, covariance with repeated measures, along with Scheffe's post-hoc test were used to test significance of experimental treatments on subject's performance. The level of significance was represented by a probability (p) value of .05 or less. Statistical analysis was performed on the IBM VAX system with the SMS programs available for use at the University of Wisconsin - La Crosse.

CHAPTER 4

RESULTS AND DISCUSSION

Introduction

The purpose of this study was to examine the effects of music stimuli on heart rate, blood pressure, VO2, duration, and perceived exertion of performance following a submaximal exercise test. This chapter was provided to present the research data obtained following statistical analysis, and to discuss these results.

Characteristics of Subjects

Twenty-five untrained females and males (11 females, 14 males) participated in this study. The groups mean, standard deviation, range of age, weight, and height of the subjects is provided in Table 2.

TABLE 2

SUBJECT CHARACTERISTICS (N = 25)

	MEAN	S.D.	RANGE
AGE (YR.)	19.6	1.99	18 - 28
WEIGHT (Kg)	73.9	11.94	56.8 - 102.3
HEIGHT (cm)	180.04	10.40	160.02 - 190.51

TEST RESULTS

Each subject (N = 25) completed three submaximal exercise tests, two of which were influenced by an experimental music stimuli. Information gathered from each group (fast-tempo, slow-tempo and no-music) were catagoried in group means and standard deviations of resting heart rate (RHR), resting blood pressure (RBP) (systolic & diastolic), end of test blood pressure (EBP) (systolic & diastolic), end of test oxygen uptake (VO2), duration of test (seconds), rated perceived exertion (RPE) upon completion of the test, subject's preference of music (liked (#1) or disliked (#2)), and the ratio between duration and VO2 (TABLE 3).

TABLE 3

Means and Standard Deviations for Dependent Variables

Variable	Condition	Means +/- S.D.
RHR	1 NO-MUSIC	70.04 +/- 13.62
	2 FAST-TEMPO	67.76 +/- 12.40
	3 SLOW-TEMPO	68.48 +/- 10.80
RBP (systolic)	1	120.48 +/- 11.74
	2	120.56 +/- 11.97
	3	118.64 +/- 10.64
RBP (diastolic)	1	69.36 +/- 12.51
	2	66.16 +/- 10.75
	3	61.04 +/- 13.05
EBP (systolic)	1	153.11 +/- 21.02
	2	155.04 +/- 20.31
	3	154.08 +/- 19.43

TABLE 3 is continued on next page

TABLE 3 (con't)

Means and Standard Deviations for Dependent Variables

EBP (diastolic)	1 NO-MUSIC	75.84 +/- 12.62
	2 FAST-TEMPO	73.60 +/- 11.56
	3 SLOW-TEMPO	70.16 +/- 11.42
Duration (seconds)	1	249.87 +/- 76.42
	2	244.16 +/- 71.92
	3	278.03 +/- 93.87
VO2 (ml/kg/min.)	1	31.22 +/- 7.56
	2	29.96 +/- 5.57
	3	29.66 +/- 7.18
RPE (Borg Scale)	1	11.60 +/- 2.08
	2	11.28 +/- 1.90
	3	11.60 +/- 2.22
LIKED OR DISLIKED	2	1.28 +/- .46
(1) (2)	3	1.72 +/- .46
RATIO DURATION/VO2	1	7.72 +/- 1.40
	2	7.70 +/- 1.77
	3	6.69 +/- 1.56

An analysis of variance (ANOVA) with repeated measures was performed and it showed that there were significant differences among RBP (diastolic) and EBP (diastolic), duration, subject's preference of music, and the ratio between duration and VO2 (indicated by *, next to the number in TABLE 4).

TABLE 4

ANALYSIS OF VARIANCE WITH REPEATED MEASURES
FOR DEPENDENT VARIABLES

VARIABLE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F	PROB. F EXCEEDED
(RHR)					
MEAN	358041.653	1	358041.653	980.45	
ERROR	8764.347	24	365.181		
REP. MEAS.	148.587	2	74.293	1.25	.02965
ERROR	2859.413	48	59.571		
(RBP)(systolic)					
MEAN	1078080.853	1	1078080.853	3652.2	
ERROR	7084.480	24	295.187		
REP. MEAS.	58.987	2	29.493	0.609	.5551
ERROR	2375.680	48	49.493		
(RBP)(diastolic)					
MEAN	321965.280	1	321965.280	1098.22	
ERROR	7036.053	24	293.169		
REP. MEAS.	880.640	2	440.320	* 5.89	.0051
ERROR	3586.027	48	74.709		
(EBP)(systolic)					
MEAN	1780548.480	1	1780548.480	1680.06	
ERROR	25435.520	24	1059.813		
REP. MEAS.	46.080	2	23.040	.27	.7666
ERROR	4137.920	48	16.207		
(EBP)(diastolic)					
MEAN	401868.000	1	401868.000	1519.67	
ERROR	6346.667	24	264.444		
REP. MEAS.	409.280	2	204.640	* 2.58	.0865
ERROR	3812.053	48	79.418		

* - SIGNIFICANT AT THE P. < .05 LEVEL

TABLE 4 - CONTINUED ON THE NEXT PAGE

TABLE 4 (con't)

ANALYSIS OF VARIANCE WITH REPEATED MEASURES
FOR DEPENDENT VARIABLES

VARIABLE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARES	F	PROB. F EXCEEDED
(DURATION)					
MEAN	4967356.786	1	4987356.786	304.96	
ERROR	390925.861	24	16288.578		
REP. MEAS.	16441.040	2	8220.520	* 4.65	.0143
ERROR	84866.073	48	1768.043		
(VO2)					
MEAN	68765.880	1	68765.880	764.22	
ERROR	2158.573	24	89.892		
REP. MEAS.	34.260	2	17.130	.68	.0590
ERROR	1200.407	48	25.008		
(RPE)					
MEAN	9907.253	1	9907.253	993.125	
ERROR	239.413	24	9.976		
REP. MEAS.	1.707	2	.853	.59	.5592
ERROR	69.627	48	1.450		
(LIKED OR DISLIKED)					
MEAN	112.500	1	112.500		
ERROR	0.000	24	0.000		
REP. MEAS.	2.420	2	2.420		
ERROR	10.080	48	0.420	* 5.76	.0245
(RATIO DURATION/VO2)					
MEAN	4077.079	1	4077.079	1047.73	
ERROR	93.392	24	3.891		
REP. MEAS.	17.291	2	8.646	* 4.82	.0130
ERROR	86.165	48	1.795		

* - SIGNIFICANT AT THE P. < .05 LEVEL

An analysis of covariance was performed and indicated that there was no significant difference between RBP (diastolic) and EBP (diastolic). This statisical treatment did indicate a significant difference for duration, ratio between duration and VO2 and preference of music.

Following the ANOVA, a post-hoc Scheffe's test was performed and indicated that significant differences at the p. < .05 level was found for duration between experimental conditions of No-music & Slow-tempo, and ratio between duration and VO2 of No-music & Slow-tempo, and between Fast-tempo & Slow-tempo (TABLE 5).

TABLE 5

SCHEFFE'S TEST - POST-HOC ANOVA

VARIABLE	MEAN	SQUARE	F
VO2 (ml/kg/min.)	mean (1) = 31.22 mean (2) = 29.96	25.00847	.7935340
	(1) = 31.22 (3) = 29.66	25.00447	1.2163900
	(2) = 29.96 (3) = 29.66	25.00447	.0449845
DURATION (seconds)	(1) = 249.872 (2) = 244.160	1768.04318	.2306720
	(1) = 249.872 (3) = 278.032	1768.04318	5.6063700
	(2) = 244.160 (3) = 278.032	1768.04318	*8.1114500

* - SIGNIFICANT AT THE P. < .05 LEVEL

TABLE 5 CONTINUTED ON THE NEXT PAGE

TABLE 5 (con't)

SCGEFFE'S TEST - POST-HOC ANOVA

RATIO (DURATION/VO2)	(1) = 7.7195 (2) = 7.7055	1.79511	.0036448
	(1) = 7.7195 (3) = 6.6940	1.79511	*7.7230100
	(2) = 7.7055 (3) = 6.6940	1.79511	*7.1244300

* - SIGNIFICANT AT THE P. < .05 LEVEL

Discussion

From the previous statistical treatments, significant differences ($p. < .05$) were concluded for the following variables.

DURATION RELATIVE TO HEART RATE RESPONSE

Duration relative to heart rate response between no-music and slow-tempo music indicated that subjects performed longer on a submaximal exercise test listening to slow-tempo music. No significant difference was found between no-music & fast-tempo and fast-tempo & slow-tempo music. The data indicated that the slow-tempo music has a greater impact on heart rate (while listening to slow-tempo music, the subject's heart rate progressed slower to termination of the test, thus obtaining a significant increase in duration of the exercise test). This information disagreed with the findings of Coutts (1968) and Miller (1984), that music has no effect on pulse. It does, though, agree with the findings of

Gordon, Kinney, McGinty, and McSorley (1977), that stimulative music (fast-tempo) increases heart rate while its counterpart, sedative music (slow-tempo), decreases heart rate.

RATIO OF DURATION TO VO2

Ratio of duration to VO2 between no-music and slow-tempo music indicated that subjects consumed less oxygen per time period while listening to slow-tempo music. This was also found between fast-tempo music and slow-tempo music, which indicated that while listening to slow-tempo music the subjects consumed less oxygen per time period. No significant difference was found between no-music and fast-tempo music. This information coincides with Metera, Metera, and Warwas's (1975) findings that listening to relaxing music decreases airway resistance. This may relate to the reason for less oxygen being consumed while exercising submaximally. No significance was found between fast-tempo music and no-music on these parameters.

PREFERENCE OF MUSIC

The subject's preference of music between fast-tempo music and slow-tempo music indicated that a significant number of subjects preferred fast-tempo music more than the slow-tempo music while exercising. When related to preference of music by the subjects in this study to heart rate response, the information concurs with the findings of DeJong, van Mourick, and Schellekens (1973). The subjects who found the music "Ugly" (slow-tempo) did not elicit cardiac acceleration (increase heart rate), but actually caused a deceleration in heart rate, as compared to "beautiful" music (fast-tempo).

From the previous statistical treatment, no significant difference (p. $<$ .05) was concluded for the following variables.

BLOOD PRESSURE RESPONSE

No significant difference was found between the blood pressure response pertaining to systolic and diastolic measure of each experimental condition. As a result, the data obtained in this study was supported by the findings of Miller (1984) and Blanchard (1979), that listening to music did not affect normal blood pressure response.

PERCEIVED EXERTION RESPONSE

No significant difference was found among the perceived exertion responses of all three experimental conditions. This information disagreed with Miller's (1984) study where his subjects perceived exercising easier while listening to music than without.

CHAPTER 5

SUMMARY AND CONCLUSION

SUMMARY

This study was conducted for the purpose of assessing the effects of music stimuli on heart rate, blood pressure, VO2, duration of test and perceived exertion on performance following a submaximal exercise test. The twenty-five subjects were untrained, volunteer, undergraduate students at the University of Wisconsin - La Crosse and were involved in three submaximal exercise tests, two of which were experimentally treated with a music stimuli heard through headphones. The other test was non-treated (no- music).

The two experimental conditions consisted of music with a tempo faster than 120 beats per minute and slower than 60 beats per minute. In addition, subjects were asked if they liked or disliked the music while exercising. This was done to compare if liking or disliking the music had an influence on the above physiological parameters and perceived exertion. The order of administration of the test (Labeled: No-Music #1, Fast-Tempo #2, Slow-Tempo #3) were randomly chosen by the subjects. The submaximal test consisted of a walk/run protocol with 2 minute stages of 3.0 m.p.h./2.5% grade, 5.5 m.p.h./2.5% grade, 5.5 m.p.h./ 5.0% grade, and 6.0 m.p.h./5.0% grade. The test was terminated when the subject reached 60% of predicted maximal heart rate, calculated by using the Karvonen Formula (% x (220 - RHR) + RHR = ?). Upon completion of the test, the blood pressure was taken and the perceived exertion obtained from the subjects. The oxygen and carbon dioxide content was determined using precalibrated Beckman OM-11 and LB-2 gas analyzers. Data for VO2 (ml/kg/min.) and duration (seconds) were recorded from the Beckman Metabolic Cart.

Statistical treatment on data obtained from testing the subjects included; means, standard deviations, analysis of variance with repeated measures, covariance with repeated measures, and Scheffe's Test post-hoc. These statistical treatments were performed on the following variables: Resting Heart Rate (RHR), Resting Blood Pressure (RBP, systolic and diastolic), End Blood Pressure (EBP, systolic and diastolic), Oxygen Uptake (VO2), Duration of tests, Rated Perceived Exertion (RPE), subject's musical preference (liked or disliked the music), and ratio between Duration and VO2 of the submaximal exercise test. Significant differences at the $p < .05$ level were found on the variables of duration of test, perference of music, and ratio between duration and VO2.

CONCLUSIONS

The null hypothesis of this investigation was rejected. [NULL HYPOTHESIS Statement: Listening to music with either a tempo faster than 120 b.p.m. (FAST-TEMPO) OR slower than 60 b.p.m. (SLOW-TEMPO) during a submaximal exercise test will not significantly (P. < .05) affect the subjects': 1) duration of the test as determined by heart rate, 2) blood pressure, 3) VO2, or 4) perceived exertion following the test]. The data supported that the presence of music does have an effect on some physiological parameters (heart rate and oxygen uptake), but not on blood pressure, during a submaximal exercise test.

DURATION RELATED TO HEART RATE RESPONSE

The data indicated that the slow-tempo music has a greater impact on heart rate, while listening to slow-tempo music, the subject's heart rate progressed slower to the termination of the test, thus obtaining a significant increase in duration of the exercise test. The results disagreed with the findings of Coutts (1968) and Miller (1984), that music has no effect on pulse. It did however, agree with the Gordon, Kinney, McGinty, and McSorley (1977) findings that stimulative music (fast-tempo) increases heart rate while its counterpart, sedative music (slow-tempo), decreases heart rate. The discrepancy with Miller's study may be due to the fact that he did not consider tempo as a variable in the study.

BLOOD PRESSURE RESPONSE

The results from the data accepts the null hypothesis that music would not effect blood pressure response while being submaximally exercise tested. This was supported by Miller's (1984) and Blanchard's (1979) findings that listening to music did not affect normal blood pressure response.

DURATION AND VO2 RELATIONSHIP

The data also supported the relationship between duration and oxygen consumption (less oxygen was consumed per time period while listening to slow-tempo music compared to no-music and fast-tempo music). This information coincides with the findings of Metera, Metera, and Warwas (1975) that listening to relaxing music decreases airway resistance. This may relate to the reason for less oxygen being consumed while exercising submaximally. No significance was found between fast-tempo music and no-music on any of the investigated parameters.

PERCEIVED EXERTION

Statistical treatment indicated that perceived exertion did not differ among the experimental conditions. Because the subjects exercised for a longer time period while listening to slow-tempo music, their perceived exertion would have also increased. Therefore, this researcher concluded that perceived exertion would have been lower on an equal time basis between slow-tempo music and no- music. Since the results showed no significant difference between fast-tempo music and no-music on duration, the statistical treatment performed on perceived exertion was correct. Therefore, by this interpretation, the data would coincide with Miller's (1984) findings that while listening to music (in this study - slow-tempo music), the subjects perceived the exertion of running easier than with no-music.

ADDITIONAL CONSIDERATIONS

The data on subject's preference of music (liked or disliked) indicated that while exercising they preferred fast-tempo music over slow-tempo music and either over no-music. They felt it was easier to run to the fast-tempo music and that the tempo increased there pace while running. Just the opposite was felt for slow-tempo music. The subjects felt it was more difficult to maintain a running rhythm with an increase in running pace.

When preference of music by the subjects in this study was related to heart rate response, the results concur with the findings of DeJong, van Mourick, and Schellekens (1973). Who found that "Ugly" (slow-tempo) music did not elicit cardiac acceleration (increased heart rate), but actually caused a deceleration in heart rate, as compared to "beautiful" music (fast-tempo).

RECOMMENDATIONS

The following are recommendations as a result of this study:

1. The study should be replicated with a larger sample. The experiment indicated a tendency for blood pressure responses to be lower during exercise, however with a relatively small sample.

2. Consideration to test the subjects maximally is an alternative to this study. Observing VO2, duration, and perceived exertion could provide insight for competitve runners while listening to music (ie., 10K and Marathon events).

3. Another variation that should be considered is to increase the range of subject samples in age and education. Education and maturity are linked to the increase in ability to concentrate on music stimulation (Alloy, et al. 1981).

4. The experimental design should be altered to observe other music stimuli, catagorized as; classical, country, jazz, new image (no-tempo), new wave, punk, reggae, and rock and roll. Another possibility would be to examine different tempos of the music selections offered above and/or the influence of their lyrics.

5. Future studies should research sedative music in relation to stress reduction and other therapeutic measures. Sedative music has shown a decrease in the use of pharmaceutical drugs in hospitals (Gala, 1976).

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APPENDIX A

PHYSICAL CHARACTERISTICS OF SUBJECTS

SUBJECTS #	AGE	SEX	HEIGHT	MEAN WEIGHT
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				
25.				

APPENDIX B

SUBMAXIMAL WALK/RUN PROTOCOL DATA SHEET

NAME______________________________ DATE _________ HT._________

WT._________ TEST # __________ EXPERIMENT IMPLEMENTED _______

RESTING (SUPINE) HEART RATE:________ BLOOD PRESSURE: ________

TERMINATION OF THE TEST: 60% (220 - RHR) + RHR = ______________
(KARVONEN'S FORMULA)

(2 MIN.) STAGE	(M.P.H.) SPEED	GRADE	TIME OF TEST	VO2	END BP	P.E.	MUSIC LIKE	MUSIC DISLIKE
1	3.0	2.5%						
2	5.5	2.5%						
3	5.5	5.0%						
4	6.0	5.0%						
* 5	6.5	5.0%						

* - Submaximal test should be completed prior to Stage 5 (within 8 minutes). Stage 5 was implemented only as a precautionary measure.

APPENDIX C

RATED PERCEIVED EXERTION CHART

7	VERY, VERY LIGHT
8	
9	VERY LIGHT
10	
11	FAIRLY LIGHT
12	
13	SOMEWHAT HARD
14	
15	HARD
16	
17	VERY HARD
18	
19	VERY, VERY HARD
20	

(BORG, 1970)

APPENDIX D

INFORMED CONSENT FORM

I, ____, would like to volunteer to participate in three submaximal treadmill tests. The test will be terminated when I approximately reach 60% of my Predicted Maximal Heart Rate. I agree to be evaluated for heart rate, blood pressure and submax uptake (VO2) during each test while listening to music through headphones. During all the exercise tests, heart rate will be monitored on an ECG, blood pressure taken via a blood pressure cuff and exhaled air will be collected using the Beckman Metabolic Measurement Cart each minute.

As with any exercise, there exists the possibility of adverse changes occurring during the tests such as dizziness or irregularities in heart rates. However, every effort will be made to minimize these occurrences and, if any abnormal observations are noted, the test will be terminated immediately. I also understand that I may stop at any time during any of the tests if I feel I cannot safely continue.

I consider myself to be in good health and to my knowledge I am not infected with a contagious disease or any limiting physical condition or disability, especially with respect to my heart, that would preclude such tests.

I have read the foregoing and I understand it, and any questions which may have occurred by me have been answered to my satisfaction. I, therefore, voluntarily consent to be a subject in this study.

signed: ________________________________ date: ___________