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Physiological and psychological responses to preferred auditory stimulation during submaximal exercise

Susan Carol Stohrer
Ithaca College

PHYSIOLOGICAL AND PSYCHOLOGICAL RESPONSES TO PREFERRED AUDITORY STIMULATION DURING SUBMAXIMAL EXERCISE

by

Susan Carol Stohrer

An Abstract

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Thesis Advisor: Dr. Gary A. Sforzo

ABSTRACT

The purpose of this study was to investigate physiological and psychological responses to preferred auditory stimulation during submaximal exercise. Nineteen aerobically trained individuals of two age groups (10 college students and 9 adults over 35 years of age) were each given a graded exercise test to determine their maximum oxygen consumption (VO_2 max) prior to the random assignment of music and no music trials. For the music trial, subjects listened through portable cassette/headphones to a tape with selections from the music style category (rock, easy listening, classical, and country) they selected. The exercise trials were performed at 75% VO_2 max, until volitional fatigue. A 2 x 2 x 2 (Age by Time by Music) multivariate analysis of variance (MANOVA) revealed no significant interactions. According to the analysis, music had no effect upon variables examined, and there was little difference between the age groups studied. However, though no statistically significant findings were observed, the means for the college-aged group revealed that college students tended to run longer, with lower heart rates, when music accompanied exercise. The large variability in training status of

the subjects within each group may have obscured the small but consistent changes in HR (8 of 10 subjects) and exercise endurance (7 of 10 subjects) experienced during the music trial. These trends support the need for further investigation.

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A Thesis Presented to the Faculty of
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Requirements for the Degree
Master of Science

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by
Susan Carol Stohrer

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Ithaca College

School of Health, Physical Education, and Recreation

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CERTIFICATE OF APPROVAL

MASTER OF SCIENCE THESIS

This is to certify that the Master of Science Thesis of

Susan Carol Stohrer

submitted in partial fulfillment of the requirements for the degree of Master of Science in the School of Health, Physical Education, and Recreation at Ithaca College has been approved.

Thesis Advisor:

Committee Member:

Candidate:

Chairman, Graduate Programs in Physical Education:

Dean of Graduate Studies:

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Chapter 1

INTRODUCTION

In 1960, only 24% of the American population exercised regularly (Reed, 1981). Improving physical fitness has since become a national obsession, and a recent national survey estimated that approximately 60% of the populace were practicing some form of physical self-betterment (Rosenzweig, 1982). Considerable interest has been shown by coaches and researchers in finding aids to improve physical performance (i.e., an ergogenic aid). Music is one medium that has been studied as a possible tool to enhance or motivate physical performance.

According to Anshel (1976), music and rhythm have been used by educators in other parts of the world to promote physical fitness and to create a pleasing environment for participants. Music is now commonly played through sound systems as an exercise adjunct in private homes, fitness centers, gymnasiums, and other recreational facilities. In addition, technological advances in sound equipment allow music to constantly accompany activity enthusiasts with the use of portable stereo headphones.

From this, one might postulate that music listening is pleasant and the addition of music to programs of physical activity may provide incentive to participants. This may result in a more positive attitude toward exercise and increase the individual's willingness to engage in exercise. Little research exists regarding the psychological or physiological responses to music during exercise performance. What little information exists is equivocal. The purpose of this study was to investigate if preferred music accompaniment alters physiological and/or psychological responses to exercise.

Statement of the Problem

Does preferred music influence physiological and/or psychological responses to treadmill exercise in aerobically trained individuals of two age groups (college students and adults over 35 years of age)? Specifically, heart rate (HR), oxygen consumption (VO_2), ventilatory frequency (Vf), endurance time (ET), and perceived exertion (RPE) were the independent variables examined.

Null Hypotheses

1. Listening to preferred music during treadmill exercise will have no effect on physiological parameters (HR, Vf, VO_2, ET) or a psychological parameter (RPE) of aerobically trained individuals.

2. Listening to preferred music during treadmill exercise will have no effect on the physiological and

psychological variables described above for aerobically trained individuals of different age levels.

<u>Assumptions</u>

This investigation was conducted with the following assumptions:

1. Subjects were motivated and voluntarily gave a maximum effort and honest ratings of perceived exertion (RPE) during music and no music conditions.

2. Each subject maintained his/her same conditioning level from the time the study began until all trials had been completed.

<u>Definition of Terms</u>

In this investigation, these terms were defined as follows:

<u>Volitional fatigue</u> - The point at which the subject feels tired and can no longer continue running on the treadmill.

<u>Endurance time</u> - Time (min) from the start of treadmill running at 75% of maximal oxygen uptake (VO_2 max) until volitional fatigue.

<u>Rating of perceived exertion</u> - A 15-point scale, from 6 to 20, with every other number assigned a description of work intensity (Borg, 1973). Word descriptions ranged from "very, very light" to "very, very hard" (see Appendix A).

Preferred music - A music selection that was the preferred choice of the listener. Music selections were developed and categorized into specific types (rock, easy listening, country, and classical) according to subjects' replies to a questionnaire (see Appendices B and C).

Aerobically trained - Person who performs some form of aerobic exercise a minimum of 30 min, three times a week, for at least 3 months prior to the testing.

Delimitations

The design of this investigation had the following delimitations:

1. Subjects were 19 aerobically trained individuals (10 college students and 9 adults over 35 years of age) from the Ithaca, New York vicinity.

2. All testing took place in the Exercise Physiology Laboratory at Ithaca College.

3. Subjects were tested on a motor-driven treadmill.

4. Subjects chose their own musical selections and controlled the volume of the music while being tested. No attempt was made by the investigator to control tempo, rhythm, style, or volume.

Limitations

The investigation was conducted with the following limitations:

1. The results can only be generalized to the populations tested.

2. Other modes of exercise may yield different results.

3. Results may be affected by the different tempos, styles, rhythm, and music volumes used.

4. No control was exerted over the subjects' diet, sleep, daily training, and/or other factors that may affect performance.

5. If sex differences exist in exercise response to preferred music, these differences would not be observed in the present study due to pooling of both male and female subjects in each age group.

6. Results may be affected by the use of volunteer subjects whose interest in a music study may have provided additional motivation during the music trials.

7. Results may be affected by the use of subjects with a wide range of training states (i.e., some were competitive athletes while others only exercised recreationally or to maintain their health).

Chapter 2

REVIEW OF LITERATURE

In this chapter the topic of music accompaniment during exercise is examined by presenting literature that addresses the following: (a) effects of music on physical performance, (b) effects of music on physiological parameters, and (c) effects of music on psychological parameters.

Effects of Music on Physical Performance

Several studies have reported that music affects various types of physical performances. Pearce (1981) investigated how different types of music affected strength as measured by a hand dynamometer in 33 male and 16 female undergraduate students. Following an initial trial to test grip strength, the subjects listened to 2 min of stimulative music, sedative music, or silence depending on the assigned order condition. After 2 min another strength measure was recorded on the dynamometer, and the process continued until the three conditions were completed. The results indicated that grip strength with sedative music was significantly lower than with silence and stimulative music. Contrary to what might be expected, stimulative music did not result in significantly higher grip strength than with silence. Pearce (1981) concluded that "music has charms to soothe the savage beast" (p.

352). This particular study investigated the effect of music on a physical task of short duration. Other studies have examined music's effect on physical tasks of longer duration in which performance tends to decrease over time (Corhan & Gounard, 1976; Fontaine & Schwalm, 1979). Ways to delay this decrease in performance are of concern, because decrements in vigilance may have serious implications for some physical tasks (e.g., long-term driving). Corhan and Gounard (1976) researched the effects of different types of music on visual vigilance performance. Subjects responded as quickly as possible when they detected a signal (i.e., a change in the amplitude of a static sine wave pattern presented on an oscilloscope). Half the subjects heard rock music and half heard easy listening music for a total time of 60 min. Results showed performance was significantly better with rock than with easy listening music, $F(1,10) = 10.29$, $p < .01$. They concluded that vigilance performance was improved when background stimulation was discontinuous and contained elements of uncertainty, as in rock music, which is more diversified, vigorous, and changeable than easy listening music.

Fontaine and Schwalm (1979) did a similar study on the effect of music on vigilance performance, but found results that questioned Corhan and Gounard's (1976) conclusions. They used 27 male and 8 female college-aged subjects, who were assigned to either "familiar rock," "unfamiliar rock," "familiar easy listening," "unfamiliar easy listening," or "no music" conditions. Music was played during the last 45 min of a 55-min signal detection session. Results showed that the different music styles did not cause a significant change in level of arousal (as measured by heart rate) or performance. However, the study did reveal that familiar music significantly increased overall performance and arousal when compared to unfamiliar music, $F(4,30) = 27.04$, $p < .001$. They suggested that pleasurable music, regardless of its type, has the potential to improve performance on vigilance tasks more than unfamiliar music and no music.

In studying vigilance tasks the concern has been to discover ways of improving performance by delaying the onset of fatigue. Other types of performances, such as running, could be considered vigilant in nature and would also benefit if the onset of fatigue were delayed. However, controversial results on the effect of music upon endurance performance exist in the literature. Some reported that music had no effect on endurance time (Brownlow, 1985), while others found that music accompaniment tended to increase exercise endurance time significantly (Anshel, 1976; Makowicki, 1982).

Anshel (1976) studied 16 male and 16 female undergraduate physical education students. Subjects rode the bicycle ergometer at the same relative submaximal workload until they could no longer maintain the 50-revolutions-per-minute pace. Each subject repeated the procedure under three different stimulus conditions (i.e., synchronized [rock] music, asynchronized [background] music, and no music). Analysis indicated that the endurance time for subjects was significantly different across conditions, $F(1,30) = 9.84$, $p < .01$. Scheffe's post hoc analysis indicated that subjects performed longer in synchronization with music, that is, movement which was rhythmically coordinated with the musical stimulus, than asynchronously to music ($p < .05$) or with no music ($p < .01$). Significant differences were not evident when comparing endurance time for the no music and asynchronized music conditions ($p > .05$). The author suggested that physical endurance may be enhanced if movement is synchronized with a musical stimulus.

Brownlow (1985) investigated the effects of music on 20 sedentary college-aged males during submaximal treadmill exercise. The subjects exercised at 70% of predicted maximal heart rate (HR) until volitional fatigue. Each subject participated in two treatments (music and no music). The music used was preselected by the subjects. The results revealed that subjects listening to music while exercising did not show significantly higher endurance time, suggesting that music has little effect on endurance performance.

Makowicki (1982) performed a similar study with 24 college males, however, his subjects performed a maximal graded exercise test to fatigue. Subjects participated in two trials (individualized music and no music). Results indicated that music significantly lengthened time to fatigue in the running activity ($p < .05$), implying that music has the ability to enhance endurance performance. According to the studies mentioned above, music of certain types has shown possibilities of improving performance of vigilance tasks. However, the findings are inconclusive as to the actual effect of music upon endurance performance. Upon studying exercise performance, endurance time should not be the sole determinant as to the influence of music upon exercise, other physiological parameters need consideration.

<u>Effects of Music on Physiological Parameters</u>

Controversial evidence exists regarding the effect of music on physiological functions. The physiological parameters emphasized in the literature are oxygen consumption (VO_2), ventilatory frequency (Vf), and heart rate (HR). Some investigators revealed that certain types of music tend to increase HR significantly (Corhan & Gounard, 1976; Fontaine & Schwalm, 1979), while others found no significant change (Brownlow, 1985; Haverly, Smith, & Otto, 1985).

Corhan and Gounard (1976) studied the effect of music on HR and arousal. They discovered that rock music produced higher HR and higher levels of arousal than did easy listening music during a visual vigilance task. Fontaine and Schwalm (1979) found similar results with music, however, they specified that the presence of familiar music resulted in heart rates that were significantly higher than in the presence of unfamiliar music. They also revealed that heart rates were significantly higher with unfamiliar music than with no music conditions. This indicated that music, regardless of its type, tended to increase HR significantly.

Haverly et al. (1985) studied eight subjects who each performed two treadmill graded exercise trials (control or music treatment). The music treatment was supplied by a portable cassette player with headphones and consisted of four 2-min tapes, which were of increasing tempos, synchronous to running pace. Statistical analysis revealed no significant difference between the control and music trials for HR, VO_2, and Vf ($p > .05$). In Brownlow's (1985) study, which was described above, music did not significantly alter HR, however, there was a significant increase in (Vf) during the music condition.

From these studies, it has been shown that the influence of rate (rock, easy listening) of auditory stimuli on various physiological parameters (i.e., HR, Vf, and VO_2) have revealed uncertain outcomes. In addition, it was suggested in Brownlow's (1985) study that enjoyable music may diminish an individual's perception of physical work effort.

Effects of Music on Psychological Parameters

Music has a potentially motivating influence on humans. From a neurophysiological standpoint it has been argued that the amount of information the waking brain can deploy at any given moment is restricted. As a result, sensory stimuli may facilitate activity in one sensory pathway while inhibiting transmission of stimuli in other afferent pathways (Hernandez-Peon, 1961). If a sensory stimulus was pleasant, the brain may use one sensory pathway to transmit the pleasurable input, while inhibiting the transmission of unpleasant stimuli. One could postulate that music as a sensory input may have the ability to prolong physical activity by inhibiting unpleasant feedback associated with fatigue. In this regard, Colbert (1963) reported that music could provide a welcomed distraction. He found that music narrowed the focus of attention, alleviated boredom and fatigue, and consequently increased worker productivity. Gardner and Licklider (1960) studied the effects of music and noise in suppressing pain in 5,000 dental operations. They found that pain was reduced directly by auditory stimulation suppressing the pain system. Asmussen and Mazin (1978) thought muscular fatigue may be caused by central inhibition of the output of motor impulses. They found that this inhibition could be diminished by diverting activities, which change the balance between the outflow of inhibitory impulses from the central nervous system. They suggested from their findings that any type of diverting activity (e.g., pleasurable music) may have the ability to prolong physical performance by blocking the physiological and psychological feedback associated with exertion and fatigue. The specific way in which music alters human perception is unknown, but it may affect one's ability to perceive fatigue and prolong certain performances.

Researchers have studied this phenomenon during vigilance (Fontaine & Schwalm, 1979), cognitive (Hilliard & Tolin, 1979), and physical tasks (Brownlow, 1985; Haverly et al., 1985; Makowicki, 1982). Fontaine and Schwalm (1979) studied the effect of familiar music on arousal and vigilance performance. They hypothesized that familiarity of music may increase arousal and slow decrement of performance regardless of the type of music played. Their results showed that familiar music did indeed reveal significantly higher heart rate ($p < .001$) and percentage of detection of important signals ($p < .01$) than did unfamiliar music. It was concluded that psychological properties (familiarity) of music are as important as its physical properties in determining the effect of music on performance of vigilance tasks.

Hilliard and Tolin (1979) investigated the effects of familiarity with background music on performance of simple and difficult reading comprehension tasks. They used 64 undergraduate volunteers, who were instructed to listen to music for 15 min. Subjects then listened through headphones to one of two music selections while taking a comprehensive reading test. The researchers used a systematic manipulation method to control for familiarity. In the familiar condition, subjects heard the selection that was presented to them initially, while in the unfamiliar condition, subjects heard a different selection. Although all subjects reported a lack of familiarity with music selections, the brief exposure to the music was sufficient to influence performance. Specifically, scores were significantly higher in the presence of familiar background music than in the presence of unfamiliar music ($p < .025$).

Upon investigating perceived exertion (RPE) during physical performance, it was discovered that evidence existed to suggest a music effect (Brownlow, 1985; Haverly et al., 1985; Makowicki, 1982). Brownlow (1985) recently completed a study on sedentary college males. He found that the presence of music during submaximal treadmill exercise did not significantly alter RPE. However, he did find that music decreased RPE during the recovery phase. He suggested that music provided a positive environment for recovery. On the other hand, Haverly et al. (1985) found that music tended to decrease RPE during treadmill running. They tested eight subjects during two graded exercise tests, one with music and one without. Results showed a significant decrease in RPE values during the music trial ($p < .05$). Makowicki (1982) also found that music significantly lowered RPE values. He investigated 24 college males during graded exercise treadmill tests. The results indicated that, during the music condition, subjects perceived the same workload to be less strenuous than during the no music condition ($p < .05$).

Franks and Myers (1984) conducted a study that took a different approach to testing the competing stimuli theory. They looked at the effect of talking on exercise tolerance. Eight male and eight female college students were tested twice on a graded treadmill test to exhaustion. During one test session, the subject was asked for a general reaction to the exercise at the end of each 2-min stage. The reaction consisted of selecting a rating on Borg's RPE scale to represent how the subject felt. During the other test session, the subject was asked at least three questions about his/her personal physical activity habits as well as general well-being and RPE. Questions were asked in such a manner that conversation developed between tester and subject. The results showed that talking to subjects during light work seemed to help them relax and lessen their anxiety (lowering HR and RPE) about the test. On the other hand, trying to answer questions when working near maximal effort tended to interfere with breathing and resulted in subjects stopping sooner. Franks and Myers (1984) pointed to an explanation supporting the competing stimuli theory. They stated that response to exercise may actually be a response to a combination of mental and emotional factors associated with testing. This was suggested because test situations are usually given to subjects who are not well acquainted with the test or the tester. This uneasiness could possibly lead to psychological stress on the subject that could hinder performance. Thus, conversation may have similar effects in inhibiting unpleasant stimuli that could lessen anxiety and improve performance.

In conclusion, music may have the potential effect of increasing exercise performance, while decreasing RPE. However, in reviewing the literature, it is evident that available results are equivocal, leaving the true effects of music on physiological and psychological parameters during exercise undetermined. Further research on the effects of music during exercise is needed, because many people exercise daily and strive to improve their performance.

Summary

The effect of music on performance is a research topic of growing interest. Investigators have tested the effects of music on cognitive, vigilance, and physical tasks, but their results have been equivocal. Some researchers not only studied the effect of different types of music (rock, easy listening) upon performance, but also tested the effect of subjects' familiarity with the music. It was suggested that familiar music might have some positive influence on exercise performance. Studies revealed that music tended to increase HR and arousal during vigilance tasks but not during exercise. According to some investigators, music may also have the potential to block physiological and psychological feedback associated with physical exertion and fatigue. They rationalized that pleasurable sensory stimuli could facilitate activity in one sensory pathway while inhibiting the transmission of negative stimuli, boredom, and fatigue in other afferent pathways. As a result, music may be considered a potential ergogenic aid that can enhance physical or athletic performance, while decreasing perceived exertion during exercise.

Chapter 3

METHODS

This chapter explains the procedures used to investigate the effects of preferred music on responses to exercise. Both physiological and psychological responses were examined in aerobically trained individuals of two age groups. The methods of subject selection, graded exercise testing, treatments, and data analysis are outlined in the following sections.

Subject Selection

The subjects for this study were 10 aerobically trained college students (3 males and 7 females), and 9 aerobically trained adults over 35 years of age (7 males and 2 females). All subjects were volunteers recruited from the Ithaca, New York vicinity. Interested subjects were asked to complete a questionnaire supplying the history of their training (see Appendices B and C). Most subjects had no previous experience running on a treadmill, and all were required to complete two experimental exercise trials: preferred music trial and control (no music) trial. The subjects were each exposed to a graded exercise test prior to the randomly assigned music or no music trials to find their maximum oxygen consumption (VO_2 max).

Graded Exercise Test

Prior to the graded exercise test, subjects were given a medical questionnaire (see Appendix D), an informed consent form for the study (see Appendix E), and an information sheet including the instructions to be carried out prior to each experimental trial (see Appendix F). Verbal explanation of the following points was also given to each subject prior to each trial:

1. Subjects were instructed not to smoke on the day of the test. Ekblom and Huot (1972) reported that smoking impairs performance due to an accumulation of carbon monoxide in the bloodstream. Furthermore, DeSilva and Hamosh (1973) found that smoking increases airway resistance, which hinders performance.

2. Subjects were instructed not to eat for 3 hr prior to testing. McArdle, Katch, and Katch (1981) suggested that 3 hr should be sufficient to provide adequate digestion and absorption of a pre-event meal.

3. Subjects were instructed not to engage in intense exercise the day before the test, or in moderate to intense exercise on test day. Gollnick (1974) stated that the glycogen depletion from intense exercise on the day prior to an event could affect subsequent performance.

4. Subjects were instructed not to drink alcohol the night before the testing. Blomqvist, Saltin, and Mitchell (1970) stated that large doses of alcohol could impair subsequent exercise performance.

5. Subjects were instructed not to drink coffee or tea on the day of the test. Costill, Dalsky, and Fink (1978) reported that caffeine is a stimulant that could diminish the sense of fatigue. They also stated that large doses can increase cardiac output, stimulate skeletal muscle metabolism, increase fatty acid metabolism, and spare muscle glycogen, all of which may affect performance.

6. Subjects were instructed to meet in the Exercise Physiology Laboratory at Ithaca College for testing and to bring proper running clothes and shoes to each trial.

7. Subjects were instructed to stop at any time during testing if they felt abnormal discomfort.

All subjects performed a graded exercise test prior to the music and no music trials. The exercise test was given to determine each subject's VO_2 max. Information obtained from the graded exercise test was used to determine the exercise intensity for the two subsequent trials. Graded exercise test procedures were as follows:

1. Subjects signed a graded exercise test informed consent form (see Appendix G) and completed a 24-hour history questionnaire (see Appendix H).

2. Resting heart rate (HR), resting blood pressure (BP), supine 12-lead electrocardiogram (ECG), standing HR, standing BP, standing ECG, and posthyperventilation ECG were obtained prior to the graded exercise test. BP and HR were obtained by ausculation and palpation, respectively. The ECG tracings were recorded on a Medical Systems electrocardiogram (Model #MSC-7111).

3. Subjects were asked to run to volitional fatigue.

4. Subjects were instructed as to proper starting and stopping procedures when running on the MacLevy-Cardio Fitness Testing treadmill (Model #192E-13).

5. Subjects then performed a modified version of Lamb's (1984) graded exercise test designed for athletes (see Appendix I). Starting at 3 METS, intensity increased 1-2 METS every 2 min until subjects reached maximum work level.

6. Oxygen consumption (VO_2), BP, HR, and ECG tracing (V5 only) were obtained throughout the graded exercise test. VO_2 was measured at 30s intervals by rapid gas analyzers (Applied Electrochemistry S-3A

Oxygen Analyzer, Beckman LB-2 Carbon Dioxide Analyzer) and a Rayfield RAM-9200 gas meter interfaced with an Apple IIe computer system. Exercise ECG was recorded each min, and HR was provided by an electrically coupled Exersentry unit. Continuous oscilloscope monitoring of the ECG occurred throughout the graded exercise test. Blood pressures were recorded by ausculation at the end of each exercise stage.

7. Test termination occurred when subjects reached their perceived maximal work rate. Upon completion of the graded exercise test and prior to leaving the laboratory, subjects' HR, BP, and ECG were monitored until these parameters returned to near resting values.

Following the graded exercise test, subjects were randomly assigned to preferred music or no music condition for their first trial.

Treatments

For the preferred music trial, subjects selected a 90-min tape from the listening style category (rock, easy listening, country, and classical) they preferred. The four tapes were prepared by the investigator according to song and artist preferences determined by the questionnaire given to each subject prior to testing. Random trial assignment resulted in 9 subjects being assigned to the preferred music condition and 10 subjects being assigned to the no music condition for the first trial. These trials were performed at 75% of VO_2 max as determined by the graded exercise test, until volitional fatigue. The following parameters were measured throughout these trials:

1. Ratings of perceived exertion (RPE) were measured every 5 min using Borg's rating scale (Borg, 1973).

2. HR was recorded every 2 min by an Exersentry (electronic HR monitor).

3. VO_2 was measured for a 5-min period every 10 min.

4. Vf was measured during the same time periods as VO_2.

5. Endurance time was recorded when subjects reached volitional fatigue.

During the music trial subjects wore a portable Sanyo M-G27 cassette player with headphones, and their preferred music selection was played for the entire length of the test. These subjects controlled the music volume (decibel level) and set it at a desirable level. During the control trial subjects wore no headphones and were asked not to converse with the test administrator. Subjects were not made aware of the length of time they were on the treadmill. The second trial took place at least 3 days after the first trial.

Data Analysis

During the music and control trials information regarding HR, VO_2, Vf, and RPE were recorded according to the procedures stated above. Values collected for HR, VO_2, Vf, and RPE at two time periods (beginning-exercise [BE], end-exercise [EE]) were used to obtain two sets of scores for each variable in the music and no music conditions. BE values for both trials were taken from min 10 to min 15 of exercise. EE values were taken during the 5-min data collection period prior to volitional fatigue. If a subject exercised considerably longer during one treatment condition than the other, EE values for the longer run were obtained from an identical time period as the final 5-min data collection period for the shorter run. For example, if a subject exercised 45 min during the music trial and 30 min during the control trial, the EE values for HR, VO_2, Vf, and RPE would be obtained from min 25 to min 30 for both trials. This was done so that each subject would have a pair of identical time periods in which to compare the trials. HR, VO_2, Vf, RPE, and endurance time (ET) values were calculated as follows:

1. HR scores were derived by taking the average of three HR recordings obtained during either the BE or EE periods.

2. The VO_2 and Vf scores were averages derived from eight data recordings acquired during either the BE or EE 5-min collection periods. The computer printouts were at 30s intervals, with the 1st min of information not used because subjects were adjusting to the mouthpiece during this time.

3. The RPE scores were derived from the average of two RPE values taken immediately prior to and following the data collection period.

4. ET was recorded, in min, from the beginning of treadmill running until volitional fatigue.

A 2 x 2 x 2 (Age by Time [i.e., BE or EE] by Music) multivariate analysis of variance (MANOVA) was used to analyze these data. If no significant three-way interaction was found, the two-way interactions were analyzed. If no significant two-way interaction was found, the main effects were analyzed. The dependent variable ET was analyzed separately by a 2 x 2 (Age by Music) analysis of variance (ANOVA). A significance level of .05 was used as the criterion for rejection of the null hypotheses.

Chapter 4

RESULTS

This study was conducted to investigate physiological and psychological responses to auditory stimulation during treadmill running for 19 aerobically trained individuals of two age groups. Specific physiological variables examined were heart rate (HR), oxygen consumption (VO_2), ventilatory frequency (Vf), and endurance time (ET). The psychological variable examined was perceived exertion (RPE). In this chapter the results of data analyzed by a multivariate analysis of variance (MANOVA) and by an analysis of variance (ANOVA) are presented.

Means and standard deviations for all data collected can be seen in Table 1 for the college-aged group and Table 2 for the adult group. The data of one subject in the adult group were eliminated because she did not exercise long enough to obtain all necessary information. The means for the college students' beginning-exercise (BE) HR and end-exercise (EE) HR were lower during the music trial than during the no music trial (control). The BE heart rates were 157.03 $\pm$ 20.90 and 166.33 $\pm$ 25.76 beats per minute (bpm) for music and control trials, respectively. The EE heart rates were 176.19 $\pm$ 19.80 and 187.11 $\pm$ 16.70 bpm for the music and no music trials, respectively. The

Table 1

College Students' Responses to Treadmill Running

	Music		No Music	
Variable	*M*	*SD*	*M*	*SD*
BE HR	157.03	$\pm$ 20.90	166.33	$\pm$ 25.76
EE HR	176.19	$\pm$ 19.80	187.11	$\pm$ 16.70
BE VO_2	42.65	$\pm$ 8.62	42.04	$\pm$ 9.61
EE VO_2	43.80	$\pm$ 9.05	44.50	$\pm$ 9.13
BE Vf	36.37	$\pm$ 5.59	36.22	$\pm$ 7.89
EE Vf	42.44	$\pm$ 6.48	39.47	$\pm$ 7.00
BE RPE	11.45	$\pm$ 1.96	11.80	$\pm$ 1.64
EE RPE	16.45	$\pm$ 1.94	17.00	$\pm$ 1.27
ET	51.17	$\pm$ 15.38	47.87	$\pm$ 12.63

Note. BE = beginning-exercise; EE = end-exercise; ET = endurance time (min); HR = heart rate (bpm); VO_2 = oxygen consumption (ml/kg/min); Vf = ventilatory frequency; RPE = rating of perceived exertion.

Table 2

Adults' Responses to Treadmill Running

	Music		No Music	
Variable	M	SD	M	SD
BE HR	162.70 ±	18.05	159.84 ±	18.79
EE HR	174.84 ±	16.47	176.16 ±	18.11
BE VO_2	40.28 ±	4.81	41.36 ±	5.31
EE VO_2	41.09 ±	5.50	42.12 ±	5.04
BE Vf	32.81 ±	7.34	32.36 ±	7.52
EE Vf	35.60 ±	4.42	34.71 ±	6.26
BE RPE	12.56 ±	1.47	12.17 ±	2.21
EE RPE	16.94 ±	1.31	16.56 ±	1.91
ET	56.60 ±	18.57	56.69 ±	21.92

Note. See Table 1 for abbreviations.

endurance time (ET) mean for the college students was greater for the music trial than for the no music trial, with means of 51.17 $\pm$ 15.38 and 47.87 $\pm$ 12.63, respectively. However, statistical analysis by MANOVA did not reveal significant differences for any of the examined variables.

The results of the three-way MANOVA (Age by Time [i.e., BE and EE] by Music) can be seen in Table 3. There was no significant three-way interaction found, $F(4,14) = .67$, $p > .05$, so the two-way interactions were examined. There was no significant Age by Music interaction, $F(4,14) = 1.72$, $p > .05$, suggesting that both age groups reacted to music in the same manner. The two-way interactions of Age by Time and Time by Music were also not significant, with $F(4,14) = 1.87$, $p > .05$ and $F(4,14) = 1.53$, $p > .05$, respectively. This indicated that age groups reacted in the same manner over time and that the music condition had the same pattern of change over time as the no music condition. Because no two-way interactions were significant the main effects were analyzed.

The main effect of Age was not significant, $F(4,14) = 1.62$, $p > .05$, suggesting that the selected responses to exercise of trained college students and adults were not different. There was also no significant Music main effect, $F(4,14) = 1.77$, $p > .05$,

Table 3

Abbreviated MANOVA Summary Table of Physiological and Psychological Responses to Treadmill Running

Source	Hotelling's T^{2a}	F^b
Age	0.463	1.62
Music	0.506	1.77
Time	8.844	30.95*
Age by Music	0.330	1.72
Age by Time	0.534	1.87
Time by Music	0.437	1.53
Age by Time by Music	0.191	0.67

[a] *df* = 1, 1, 6.

[b] Approximate *F* with *df* = 4, 14 from Hotelling's T^2.

*p < .05.

indicating that the physiological responses under the two treatment conditions were not significantly different. As expected, the Time main effect was significant, $F(4,14) = 30.95$, $p < .05$, simply indicating that significant changes took place from the beginning of exercise to volitional fatigue in the variables measured.

The results of the ANOVA (Age by Music) for the dependent variable endurance time (ET) can be seen in Table 4. There was no significant interaction, $F(1,17) = .36$, $p > .05$. Because the two-way interaction was not significant the main effects were analyzed. The main effect for Age was not significant, $F(1,17) = .92$, $p > .05$, suggesting that there was no significant difference in ET for the two age groups of trained individuals. The main effect for Music was also not significant, $F(1,17) = .32$, $p > .05$, indicating that there was no significant difference in ET for the two exercise conditions.

Table 4

ANOVA Summary Table for Endurance Time

Source	*df*	*MS*	*F*
Age	1	481.79	0.92
S Within Age	17	521.90	
Music	1	24.37	0.32
Age by Music	1	27.25	0.36
S Within Age by Music	17	76.08	

Note. S = Subjects.

Chapter 5

DISCUSSION OF RESULTS

This investigation studied the physiological and psychological responses to preferred auditory stimulation during submaximal treadmill running. It was conducted to investigate music as a potential aid to physical or athletic performance. The results of this investigation are discussed in this chapter. The variables measured were endurance time (ET), heart rate (HR), oxygen consumption (VO_2), ventilatory frequency (Vf), and perceived exertion (RPE).

Previous research revealed that listening to music during exercise has uncertain outcomes on endurance time in physical tasks such as running and biking. Some investigators found that listening to music during exercise resulted in greater endurance performance (Anshel, 1976; Makowicki, 1982), but another found no significant difference (Brownlow, 1985). It was postulated that music may have the potential to prolong physical activity by inhibiting unpleasant neural input associated with fatigue. The present investigation found that ET was not significantly ($p > .05$) different for the music and no music conditions during treadmill running. These results supported Brownlow's work, yet they did not agree with the findings of Anshel or Makowicki. A possible reason for these contradictory findings may be related to the exercise performed. Anshel studied subjects during a submaximal bicycle exercise, and Makowicki tested his subjects during a maximal graded exercise test. In Brownlow's study and in the present study, subjects were tested on a treadmill at a submaximal workload. It should be mentioned that in the present study, although no statistically significant differences were found in ET, college students ran longer with music than with no music. There was little difference seen in ET for the adult group. A possible explanation for these findings may be the large variability within the small groups tested (10 college students and 9 adults over 35). This large variability between subjects may have been a result of the recruitment of subjects possessing different levels of fitness. Some of the subjects in this study were serious athletes (marathon runners), while others exercised occasionally to maintain their health. Had more homogeneous subjects been tested, within group variance could have been lessened, to possibly reveal greater ET with music for the college students. Endurance time may have also been affected by subjects performing intense exercise the day prior to testing. No attempt was made in the present investigation to control the amount of exercise performed in the 24 hr prior to testing. Upon questioning subjects, it was discovered that 9 of the 19 subjects performed at least one of their exercise trials less than 12 hr after an intense exercise bout. According to Gollnick (1974), this does not allow for adequate rest or glycogen repletion, and may negatively affect performance. As a result, subjects may not have run as long on the treadmill as they might have with adequate rest.

The effects of music on HR have been studied during physical exercise and visual vigilance tasks. Previous investigations have found that music tended to increase HR (arousal) during visual vigilance tasks, yet it had no effect on HR during physical exercise. The present investigation supported the results of Haverly, Smith, and Otto (1985) and Brownlow (1985) in that exercise HRs were not significantly different in the music versus no music trials. Once again, although no statistically significant difference was found, the college students did show a trend toward lower HRs during the music trial as compared to the no music trial. Accordingly, music may have the ability to lower HR in college students during submaximal treadmill running, but further investigation is needed to clearly establish this possibility.

Oxygen consumption (VO_2) was measured previously in only one similar music study (Haverly et al., 1985).

The results of the present study were in agreement with those of that previous study, indicating that music has little effect on VO_2 during exercise. This was expected, because in both the music and no music conditions nearly identical workloads were performed.

There were no statistically significant differences between the two conditions for Vf. This finding is supported by the work of Haverly et al. (1985), but disagreed with Brownlow (1985). One possible explanation for contradictory findings may have to do with the physical condition of the subjects tested. The present investigation studied aerobically trained individuals, whereas Brownlow investigated a sedentary population. The aerobic capacity of individuals may influence the effect of music upon physiological responses to exercise. On the other hand, small sample size may have been a limiting factor in both the Haverly et al. study and the present study. Brownlow found significant differences in Vf after testing 20 subjects. Haverly et al. studied eight subjects, and the present investigation studied 10 subjects in each of two separate age groups. Therefore, music may have the potential to increase Vf, but sample size and large variability may have obscured this finding in the present study.

Some researchers have speculated that music may have the ability to inhibit the negative sensations associated with exertion and fatigue, thereby lowering ratings of perceived exertion during exercise. In the present study, no statistical change in RPE was observed during the music trial. Similar results were found previously by Brownlow (1985), who also investigated subjects during a submaximal workload. Haverly et al. (1985) and Makowicki (1982) found a significant decrease in RPE, however the latter investigator tested subjects during a maximal graded exercise. Therefore, music may have the ability to block the negative feedback associated with exertion and fatigue when exercise is performed at maximal levels, but this phenomenon was not evident at submaximal exercise levels in the present study. However, upon questioning the subjects it was found that they believed music helped them run longer than they ran with no music. Even though statistical results do not support these beliefs, subjective reports claimed music has the potential to improve endurance performance.

Summary

In the present investigation it was found that preferred music had no statistically significant effect on the physiological (HR, VO_2, Vf, and ET) and psychological (RPE) variables tested during treadmill running. Moreover, there was little difference between the responses of the two age groups studied. Although no statistically significant differences were found, the means indicated that college students tended to run longer and with lower HRs with music than without music. Therefore, preferred music may have the ability to increase endurance performance and lower exercise HR during submaximal treadmill running for college-aged individuals, but further study is needed to confirm this possibility.

Chapter 6

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter gives an overview of the entire experiment. The chapter is divided into three sections: (a) summary, (b) conclusions, and (c) recommendations.

Summary

A total of 19 aerobically trained individuals, aged 18-51 years, participated in this investigation designed to study physiological and psychological effects of preferred music accompaniment during submaximal treadmill running. Specific physiological variables measured were heart rate (HR), oxygen consumption (VO_2), ventilatory frequency (Vf), and endurance time (ET). The psychological parameter examined was perceived exertion (RPE).

All subjects performed a graded exercise test on a motor-driven treadmill to determine maximal oxygen uptake (VO_2 max). Following the graded exercise test, subjects were randomly assigned to preferred music or no music condition for the first of two trials. The trials were performed at 75% of VO_2 max as determined by the graded exercise test, until volitional fatigue. During the music condition, subjects listened to preferred music through a portable cassette player with headphone attachments. Subjects had control over the volume and were told to set it at a desirable level. During the no music condition, subjects wore no headphones and were asked not to converse with the tester. The second trial took place at least 3 days after the first trial.

During the two submaximal trials, information concerning HR, VO_2, Vf, and RPE were recorded. ET was recorded, in min, from the beginning of treadmill running until volitional fatigue. Values collected for HR, VO_2, Vf, and RPE at two periods (beginning-exercise [BE] and end-exercise [EE]) were used to obtain two sets of scores for each variable in the music and no music conditions.

A 2 x 2 x 2 (Age by Time [BE or EE] by Music) multivariate analysis of variance (MANOVA) was used to analyze all data except ET. There was no significant three-way interaction ($p > .05$). The results of the two-way interaction tests, Age by Music, Age by Time, and Time by Music, were also not significant ($p > .05$). In analyzing the main effects, it was found that the main effects for Age and Music were not significant ($p > .05$). As expected, the main effect for Time was significant ($p < .05$), simply indicating that significant changes in the variables measured took place from the beginning of exercise to volitional fatigue. The results of the ANOVA for endurance time were also not significant ($p > .05$).

According to the analyses, preferred music accompaniment during exercise has little effect on physiological and psychological variables for aerobically trained individuals. The results indicated no significant difference between college students and adults over 35 years of age for the music and no music conditions. In examining the group means, it was found that college students tended to have lower HRs during the music condition and they tended to exercise longer with music than without music. However, these findings were not statistically significant, possibly because of the large variability in training status among subjects within each group.

Conclusions

1. The differences in ET between the preferred music and no music trials were not statistically significant for either age group. However, the means indicated a tendency for college students to perform longer with music than without music.

2. HR was not significantly different between the preferred music trial and no music trial. However, the absolute means displayed a nonsignificant trend that indicated college students had lower heart rates during the music trial than during the no music trial.

3. VO_2 was not significantly different between the music and no music trials for either age group.

4. Vf was not significantly different between the music and no music trials.

5. RPE was not significantly different between the music and no music trial for either age group.

Recommendations

The following recommendations are being made for further research on this topic:

1. A study similar to the present one should be conducted using sedentary individuals who might benefit more from an auditory stimulus that promotes dissociation from physical stress. It may be beneficial to screen individuals for tendencies to be associators or dissociators.

2. A study similar to the present one should be conducted that controls the amount of activity performed by subjects the day before testing.

3. A study similar to the present one should be conducted investigating subjects with similar levels of fitness in order to decrease the amount of variability among subjects within a group.

Appendix A

RATING OF PERCEIVED EXERTION[a]

Rating	Descriptor
6	
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	

[a]Reprinted from Borg (1973).

Appendix B

QUESTIONNAIRE FOR AEROBICALLY TRAINED COLLEGE STUDENTS

History of training

Name:____________________ Phone #:____________________

1. The number of times you exercise per week.
2. The amount of time you exercise per day.
3. The type of exercise you do (including examples as to the intensity of your training).
4. Do you exercise alone or with others?
5. Do you know of any medical problems that may preclude your participation in an exercise study?
6. Indicate the type of music you prefer (choose one) and give examples of specific artists and titles of that music.

   Rock____ Easy listening____ Classical____

   Country____ Jazz____
7. Do you presently train with musical accompaniment?
8. The average amount of time you spend listening to music per day.
9. Indicate the degree to which you enjoy music.

   I enjoy music...

   (Not at all) A B C D E (Very much)

Appendix C

QUESTIONNAIRE FOR AEROBICALLY TRAINED ADULTS 35 AND OVER

<u>History of training</u>

Name:______________________ Phone #:____________________

1. Have you had a medical exam in the last year?
2. Are you presently aerobically training at least three times a week for a minimum of 30 min a day?
3. Do you know of any medical problems that may preclude your participation in an exercise study?
4. The number of times you exercise per week.
5. The amount of time you exercise per day.
6. The type of exercise you do (including examples as to the intensity of your training).
7. Do you exercise alone or with others?
8. Indicate the type of music you prefer (choose one) and give examples of specific artists and titles of that music.

   Rock____ Easy listening____ Classical____

   Country____ Jazz____
9. Do you presently train with musical accompaniment?
10. The average amount of time you spend listening to music per day.

Appendix C (continued)

11. Indicate the degree to which you enjoy music.

I enjoy music...

(Not at all) A B C D E (Very much)

Appendix D

MEDICAL QUESTIONNAIRE[a]

Name:________________ Age:___ Sex:___ Date:________

Check If <u>YES</u>

<u>PAST HISTORY</u> (In the past have you ever had...?)

Rheumatic Fever	( )	Heart Murmur	( )
High Blood Pressure	( )	Rhythm Abnormalities	( )
Disease of Arteries	( )	Varicose Veins	( )
Lung Disease	( )	Injury to Back	( )
Epilepsy	( )	Diabetes	( )
Stroke/Heart Attack	( )	How long ago?____________	
Operations	( )	What kinds?______________	
Other	( )		

If other is checked explain here:_____________________

<u>FAMILY HISTORY</u> (Have any blood relatives had...?)

Heart Attacks	( )	Heart Operations	( )
High Blood Pressure	( )	High Cholesterol	( )
Diabetes	( )	Congenital Heart Disease	( )
Other	( )		

If other is checked explain here:_____________________

Appendix D (continued)

PRESENT SYMPTOMS (Have you recently had...?)

Chest Pain	( )	Shortness of Breath	( )
Heart Palpitations	( )	Lightheadedness	( )
Cough on Exertion	( )	Coughing up Blood	( )
Back Pain	( )	Arthritis	( )
Swollen Legs	( )	Loss of Consciousness	( )
Awaken Short of Breath	( )		

RISK FACTORS

1. Smoking--Do you smoke? Yes ( ) No ( ) Quit ( )

   Cigarettes ( ) Cigars ( ) Pipe ( )

   How long have you been smoking?____________________

   How many do you smoke a day?______________________

   If quit, how many did you used to smoke a day?_____

   For how many years did you smoke?__________________

2. Have you gained ( ) or lost ( ) weight in the last two months? Yes___ No___ How much?____________

3. Do you presently engage in physical activity?______

   What kind?____

   How often?____

4. How far do you walk each day?______________________

5. Is your occupation--Sedentary ( ) Active ( )

   Explain your occupation:___________________________

Appendix D (continued)

6. Do you have discomfort, shortness of breath, or pain with exercise? Yes___ No___

   If yes, what type of exercise:________________________

7. Are you taking any medications:________________________

   ____

   ____

[a]Reprinted from Wilson, Fardy, & Froelicher (1981).

Appendix E

INFORMED CONSENT FORM FOR STUDY

1. a) Purpose of the Study. The purpose of this study is to investigate physiological and psychological responses of auditory stimulation during exercise.

b) Benefits. Through participation in this study subjects may discover a motivating adjunct to training. For their cooperation in the study, subjects will receive a free exercise stress test (valued at $125.00) and an evaluation of cardiovascular fitness.

2. Methods. Subjects will be asked to give a history of their training and specific examples of the music they prefer (artists and titles). Subjects will report to the Exercise Physiology Laboratory three times: graded exercise test, listening to preferred music, control (no music). During the first trial, subjects will be given a graded exercise test on a motor-driven treadmill to determine maximal oxygen uptake (VO_2 max). This test will be administered according to the American College of Sports Medicine Guidelines for Graded Exercise Testing, and will be supervised by a certified Exercise Test Technologist. Two subsequent trials will be performed on the treadmill set at a 0% grade. Subjects will be exercising at 75% of their VO_2

Appendix E (continued)

max, determined by the graded exercise evaluation, until volitional fatigue. Physiological (oxygen consumption, heart rate, ventilatory frequency, endurance time) and psychological (perceived exertion) variables will be measured throughout each trial. The auditory stimuli will be listened to through portable stereo headphone sets. Subjects will be allowed to adjust the volume (decibel level) of the headphones to personal comfort levels.

3. Will this hurt? Some muscular fatigue may arise as a result of the experiment, but no lasting physical or psychological pain are expected to result from this study.

4. Need more information? Additional information may be obtained from Susan Stohrer (272-3595) or Dr. Gary Sforzo (274-3359). All questions are welcomed and will be answered.

5. Withdrawal from the Study. Participation is voluntary. Subjects are free to withdraw from this study at any time without prejudice of any kind.

Appendix E (continued)

6. Will data be maintained in confidence? Only the above named researchers will have access to these data. Complete anonymity will be maintained, and once the data are collected, names will be replaced by coded numbers. These numbers will be used instead of individual names for subsequent reports.

7. I have read the above, I understand its contents, and I agree to participate in the study. I acknowledge I am 18 years of age and older. I have had a physical in the last year and do not know of any medical problems that may preclude participation in the exercise study.

Signature Date

Appendix F

INSTRUCTIONS PRIOR TO EACH TRIAL

1. Bring with you to the Exercise Physiology Laboratory proper running clothes and shoes.
2. Do not smoke on the day of the test.
3. Do not eat within 3 hr prior to testing. During those 3 hr only water is permitted.
4. Do not drink coffee or tea on the day of the test.
5. Do not consume alcohol the night prior to testing.
6. Do not engage in moderate to intense exercise on the day of the test, or intense exercise on the day before the test.
7. Get adequate sleep (8 hr).

Appendix G

INFORMED CONSENT FOR GRADED EXERCISE TEST[a]

1. Explanation of the Graded Exercise Test. You will perform a graded exercise test on a motor-driven treadmill. The work levels will begin at a level you can easily accomplish and will be advanced in stages, depending on your work capacity. We may stop the test at any time because of signs of fatigue, or you may stop when you wish to because of personal feelings of fatigue or discomfort. We do not wish you to exercise at a level which is uncomfortable for you, however, for maximal benefit from the test, exercise as long as is comfortable.

2. Risks and Discomforts. There exists the possibility of certain changes occurring during the test. They include abnormal blood pressure, fainting, disorders of heart beat, and very rare instances of heart attack. Every effort will be made to minimize them by the preliminary examination and by observation during testing. Emergency equipment and trained personnel are available to deal with unusual situations which may arise.

Appendix G (continued)

3. Benefits to be Expected. The results obtained from the exercise test will assist in the evaluation of cardiovascular fitness.

4. Inquiries. Any questions about the procedures used in the graded exercise test or in the evaluation of functional capacity are welcome. If you have any doubts or questions, please ask us for further explanations.

5. Freedom of Consent. Your permission to perform this graded exercise test is voluntary. You are free to deny consent if you so desire.

I have read this form and I understand the test procedures that I will perform. I consent to participate in this test.

____

Signature   Date

[a]Modified from American College of Sports Medicine (1980).

Appendix H

24-HOUR HISTORY

Name: ______________________________ Date: ________________________

Time: ______________________________

How much sleep did you get last night? (circle one)

1 2 3 4 5 6 7 8 9 10 11 12 13 14 (hours)

How much sleep do you normally get? (circle one)

1 2 3 4 5 6 7 8 9 10 11 12 13 14 (hours)

How long has it been since your last meal or snack?

1 2 3 4 5 6 7 8 9 10 11 12 13 14 (hours)

List the items eaten below:

____

When did you last:

Have a cup of coffee or tea ____________________________

Smoke a cigarette, cigar, or pipe ______________________

Take drugs (including aspirin) _________________________

Drink alcohol ____

Give blood ____

Have an illness ____

Suffer from respiratory problems _______________________

What sort of physical exercise did you perform yesterday?

What sort of exercise did you perform today?

Appendix H (continued)

Describe your general feelings by checking one of the following:

___Very Good	___Bad
___Good	___Very Bad
___Neither Bad nor Good	___Terrible

Appendix I

MODIFIED LAMB PROTOCOL FOR ATHLETES[a]

Stage	Speed (mph)	Grade (%)	Length (min)	VO_2 (ml/kg)	METS
I	3	0.0	2	11.54	3.3
II	3	5.0	2	15.16	5.4
III	5	5.0	2	36.00	10.3
IV	5	7.5	2	39.20	11.2
V	6	5.0	2	43.00	12.3
VI	6	7.5	2	46.60	13.3
VII	7	5.0	2	49.40	14.1
VIII	7	7.5	2	53.60	15.3
IX	8	5.0	2	56.40	16.1
X	8	7.5	2	60.90	17.4
XI	8	10.0	1	65.80	18.8
XII	8	12.5	1	70.70	20.2
XIII	9	10.0	1	73.50	21.0

[a]Modified from Lamb (1984).

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