THE EFFECTS OF AN EMOTIONAL STIMULATION ON SUBMAXIMAL EXERCISE HEART RATE

by

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DEDICATION

To Billie and Barbara

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Chapter 1

INTRODUCTION

The extent to which emotional factors affect performances has been a subject of much concern by investigators. Very little of this concern, however, has been channeled into constructive, well controlled research.

The use of cardiovascular parameters such as heart rate for determining levels of physical fitness is a widely recognized practice. Several tests such as the Harvard Step Test, the Tuttle Pulse-Ratio Test, the Sjostrand-Wahlund PWC-170, and the Astrand-Ryhming prediction test for maximal oxygen uptake are being extensively employed with the lay public as instruments for the evaluation of physical fitness levels and capacities. The need for these tools has arisen from the need by clinicians for a means of determining the heart's working capacity or reserve power. The cardiologist especially, has recognized that the capacity for physical exercise is undoubtedly a valid criterion of the condition of heart efficeincy, because the capacity for exercise depends largely on the ability of the heart to increase its output (18). In these and most submaximal working capacity tests the heart rate response to a work load determines the subject's working capacity or fitness level (4, 18). While it is true that one's ability to perform work is, as a rule, determined by the functional capacity of his heart, evidence has suggested that emotional factors may increase the heart rate, thus producing an erroneously low value for the subject's fitness level.

Recent studies have also claimed that the anticipatory response or emotional stress felt by the subject prior to exercise may subsequently reflect itself in the heart rate response of the subject to the workload. (2, 4, 18, 32).

The need and importance of this study was to increase the body of knowledge concerning the response of the heart rate due to emotional factors, specifically during submaximal exercise. The actual testing was administered in a laboratory setting in a manner similar to that which many researchers utilize in the administration of various tests of cardiovascular fitness.

A careful review of the research has indicated that the validity of such tests which employ heart rate as an index of physical fitness is subject to question. The role of temperature, humidity, emotion and other factors in fitness testing has not yet been determined. Faulkner and others (12) have suggested the need for such research in clarification of the amount of variance in heart rate due to these variables.

The implications of this study for future physical fitness testing are primarily twofold. If other variables such as emotion do play a significant role during submaximal exercise tests, then physical educators need to be made aware of the fact and adjust their physical fitness evaluations accordingly. Secondly, assuming that external factors are important during physical fitness and work capacity tests, to what extent and by what means can the interplay be evaluated?

This study is intended to provide some direction for future investigators concerned with the effects of emotional factors on heart rate during exercise. This study will hopefully determine whether or not a

significant role is played by emotion during submaximal work. To what extent and by what means these effects may be measured must be left to future investigations.

STATEMENT OF THE PROBLEM

The purpose of this study was to determine the effects of an emotional stimulation on submaximal exercise heart rate. More specifically, the objectives of this study were:

1. to determine if emotional stimulation affects heart rate during submaximal exercise

2. to determine if different emotional stimuli affect heart rate during submaximal exercise, and if so, to determine the varying effects of the different treatments

3. to determine if different emotional stimuli have major effects on the heart rates of subjects exercising at low, moderate and relatively high submaximal workloads.

LIMITATIONS

1. Instructions were given in regards to the procedures to be followed in preparing for the testing sessions. Nevertheless, it was impossible to control the food intake, rest, emotional level or outside activities of the subjects.

2. A reliable and valid means of determining when a subject had reached a steady state condition was not employed by the investigator. Alteration of the subject's heart rate after application of the emotional stimulus may consequently, have been due, in part, to the physical demands of the activity.

DELIMITATIONS

1. This investigation was delimited to thirty college freshmen females aged 17 to 19, all of whom were attending Kansas State University during the Spring semester, 1974.

2. The subjects for this study were not randomly selected, but were all medically fit volunteers who were enrolled in the basic physical education classes at Kansas State University.

3. Only students who had experienced one prior exposure to the Astrand-Ryhming prediction test for maximal oxygen uptake were accepted as subjects for this study. This was an attempt by the author to reduce some of the anticipatory anxieties accompanying the testing procedures and to control for the familiarization effect. The degree to which this was accomplished could not be estimated.

4. The subjects were somewhat familiarized with the testing apparatus and procedures, although the entire extent of the investigation could not, obviously be revealed. This attempt to allay anxieties could not be reasonably measured for its success.

DEFINITIONS OF TERMS

Anticipatory Response

The difference between the resting heart rate and the heart rate immediately prior to the start of an exercise bout. This difference is due to emotional, not physical factors.

Cardiovascular Fitness

A functional response of the body which is representative of the cardiovascular system (31).

Emotional Stimulation

A stimulus characterized by a strong, generalized feeling of psychical nature which may be reflected in the appearance of physiological symptoms.

Resting Heart Rate

The 60-second sitting heart beat count taken before exercise.

Chapter 2

REVIEW OF THE LITERATURE

The review of the literature for this investigation was divided into three major categories: (1) Heart rate and exercise, (2) The anticipatory response, (3) The effects of various stimuli on heart rate during exercise.

HEART RATE AND EXERCISE

Astrand (4) has stated that "the simplest and most extensively applied way of testing the circulatory functional capacity is to determine the heart rate during or after exercise." He added that there was a greater reliability in taking the pulse rate during the exercise bout as compared to measuring it after.

Several tests have been devised within the past fifty years using the variable heart rate as an index of cardiovascular fitness. Among these, the Harvard Step Test, the maximum oxygen uptake treadmill test, and the Astrand-Ryhming prediction test for maximal oxygen uptake have become popular instruments among physical educators and physicians alike.

Karpovich (18) has determined that the frequency of the heart rate during a period of exercise, particularly if a steady state is established, is in linear relationship with the load of work. Astrand (5), in several studies with co-workers also observed this phenomenon to be true. Kozar (20) recorded the heart rate data from a highly skilled gymnast performing on several pieces of apparatus and found that the heart rate response was

apparently related to the difficulty of the routine. Turner (33) studied the heart rates due to postural changes in young women and found them to increase during prolonged standing.

The mechanisms by which heart rate is increased during exercise are many and varied. Astrand (4) has listed anaerobic power, technique and especially motivation as likely factors which may either limit or extend the working capacity of the individual.

Asmussen and Nielsen (3), in a study on cardiac output during muscular work, described the circulatory changes that occur at the transition from rest to work:

> A stimulus closely correlated to the intensity of work and possibly of peripheral nervous origin influences the circulatory centers in such a way that a relative increase in sympathetic tone is produced. As a result, the heart frequency is increased and the emptying of the heart becomes more complete. The hereby produced increase in blood flow, from the heart through the dilated vessels of working muscles, returns to the heart, assisted only by the venous pump. It seems that an emptying of venous blood depots is not necessary in order to obtain the increase in the cardiac output.

Asmussen and Nielsen's description indicates that the affecting stimulus may be of psychical nature, such as that associated with the anticipatory response. Further discussion of this phenomenon follows.

THE ANTICIPATORY RESPONSE

The anticipatory response may be defined as the difference, which is due to emotional, not physical factors, between the resting heart rate and the heart rate immediately prior to the start of an exercise bout. Several researchers who utilized heart rate as a criterion variable did not take into consideration the effects brought about by the anticipatory response. As a result, Karpovich (18) suggested that instead of resting

pulse rate, the term "start" pulse should be used when denoting pre-exercise heart rate. This "start" pulse was a combination of resting heart rate and the anticipatory response. Within recent years, considerable research concerning the anticipatory response has been conducted in the physical education setting. In an unpublished doctoral dissertation, Yarbrough (39) presented a literature review relative to the anticipatory response. For an excellent discussion of this topic, the reader is referred to this source.

In 1952, Harmon and Johnson (15) completed a study in which they measured the anticipatory responses of the 42 member 1949 Boston University football team just prior to each of its games. An average increase of 11.2 beats over the resting heart was reported, indicating that the team was measurably "up" for each game.

Brouha and Heath (7), in a study concerning the relationship between resting heart rate and physical fitness, observed that resting heart rates before a treadmill test were markedly affected by emotional factors. This observation led them to the conclusion that emotional factors are largely responsible for the high pulse rates recorded during routine medical examinations. Massey and others (21) concurred with these findings and added that through palpation a more reliable resting heart rate could be found.

Raab (22) conducted a study on 14 medical students and found that before important exams, the mean resting heart rates rose 11 beats per minute. In a study on champion weight lifters, Novesinikova (19) observed a marked increase in their pulse rates immediately before a lift. He also noted that the anticipatory response was greatest prior to a very quick lift such as the "snatch" and lowest prior to a slower lift such as the "press."

Hanson and Tabakin (14) found that skiers exhibited a most pronounced anticipatory response immediately prior to the competition. Skubic and Hodgkins (27) observed the same effects in two girls who participated in golf, tennis, archery, badminton and bowling. Anticipatory rates in this study were approximately 16 beats over the resting rates.

During World War II many volunteer applicants for the Air Force were reported to have had higher pulse rates at the beginning of a medical examination than at the end when they had regained composure. This led Karpovich (18) to the generalization that, "The subject may appear relaxed, while his pulse rate tells a different story." He also added that because emotions accelerate pulse rate, it is sometimes very difficult and even impossible to obtain a normal resting pulse rate. Rowley and others (24), after investigating heart rates during certain activities, commented that the act of taking the pulse itself may increase the resting rate.

In a study utilizing radio telemetry, Hanson (13) found that the heart rates of Little League baseball players were highest while at bat. Wallin and Schendel (35) telemetered the hearts of middle-aged joggers and observed a sharp increase from one to three minutes prior to the start of an exercise period.

Yarbrough (39) in a study on 24 male college freshmen, found no relationship between the anticipatory heart rate response and the level of anxiety or physical fitness.

As an apt conclusion to this section Wells (36) commented that any novelty, such as attaching ECG leads, causes an increased anticipatory rate.

An explanation of the effect of anticipation on the heart rate was offered by Karpovich (18). He stated that the heart is governed by two

sets of nerves from the autonomic nervous system. The sympathetic system causes acceleration of the heart beat while the parasympathetic inhibits the acceleratory effect. Anticipation disrupts the homestatic nature of the two systems, causing inhibition of the cardio-inhibitory center, increased tone of the cardio-accelerator center, or by both actions at the same time.

The rate of the heart beat varies due to many factors. Any review of these factors should take into consideration the part played by anticipation.

THE EFFECTS OF VARIOUS STIMULI ON HEART RATE DURING EXERCISE

The effects of the anticipatory response on heart rate have been clearly documented. Whether these emotional and other factors cause an increase in heart rate after exercise has begun still is not well known. More and more valuable research has been conducted in this area, however, and it appears that the solution to this problem is not far off.

Vogel and Hannon (34), in a study with dogs at high altitude found that the heart rate response to exercise was elevated above the normal level. Stenberg and others (29) concurred with these findings in an investigation of the effects of altitude on heart rate during exercise. He concluded that the excessively high heart rates could be attributed to a lower oxygen concentration in the inspired air resulting in an increased cardiac output.

Somervell (28) made several personal observations regarding cardiovascular parameters while climbing in the neighborhood of 27,000 to

28,000 feet. Among these, the heart rate during the actual motion upwards was found to be beating 160 to 180 times per minute, regular in rhythm and of good volume.

Williams and others (37) conducted an investigation of the effects of extreme heat on heart rate during submaximal exercise. He noted that "the most striking alteration in the circulatory parameters during work in heat is that of heart rate." He also reported that the major change in hemodynamics associated with an increase in heart rate was a corresponding fall in the stroke volume.

Brouha (6) studied the effects of exercise on heart rate and oxygen consumption for six male subjects at moderately high temperature and humidity. The exercise consisted of pedaling a bicycle ergometer for 30 minutes at submaximal work, followed by a 4 minute period of maximum work. Although a steady state of oxygen consumption was reached at the lower load, the heart rate continued to increase.

Horton and Gabrielson (16), in a study involving swimmers observed that exposure to cold aquatic conditions caused an increase in the pulse rate, however, this increase was not significant.

In 1932, Scott and Tuttle (26) investigated the periodic fluctuation in physical efficiency during the menstrual cycle. Menstruation was determined to cause no significant alterations in the heart rate.

Alam and Smirk (1) showed that if tourniquets are placed on the arm or leg so that blood circulation is stopped, the resultant contraction of the muscles of these limbs caused an acceleration of the heart rate.

Taylor and others (32), in a study of subjects walking on a treadmill observed that excitement caused an increase in the work pulse rate.

Taylor noticed that one subject, as he was getting off the treadmill, stumbled. When he resumed walking, his pulse had increased 40 beats per minute. The following day the subject's work pulse rate was still above normal. The theory was suggested that the subject's new fear of stumbling reflected itself in his increased work pulse rate.

Howell and Maxwell (17) investigated the influence of emotional tension on speed of reaction time and movement. One of the stressors used to create emotional tension was the administration of an electric shock. This shock caused a dramatic increase in the subject's heart rate.

Rosenblat (25) studied the electrocardiograms of basketball players during training sessions and observed that emotional factors played a significant role in the elevation of heart rates to 180 beats per minute or higher.

Ramsey and others (23), in a similiar investigation with basketball players reported that rest intervals during the game as short as 40 to 60 seconds provided opportunity for physiological recovery in terms of significant reductions in heart rate. This decrease was not observed, however, when the player was shooting a foul shot. Apparently the emotional involvement of taking the free throw, coupled with the physical stress from previous action, were such that the heart rate showed no significant reduction during this period.

In a study using radio telemetry, Stockholm and Morris (30) monitored the heart rate of a college freshman baseball pitcher. Interesting to note was the fact that the pitcher's heart rate exceeded 180 beats per minute several times throughout the game due to the combined effects of the physical and emotional stress.

Antel and Cumming (2) investigated the effects of externally administered emotional stimuli on heart rate during submaximal exercise. Nine adolescent males, aged 13 to 15 years, exercised submaximally on an electronic bicycle ergometer while their heart rates were recorded on an electrocardiograph. When a steady state was attained in the region of 110 to 130 beats per minute a stimulus was used to create a highly emotional state within the subject. One stimulus was to administer an electrical shock. Another was the threat of a blood sample as represented by a hypodermic needle on a syringe which was brought out during the test. The results of the study indicated that emotional factors significantly altered the heart rates of subjects exercising submaximally. Also indicated was the observation that heart rates of 170 beats per minute may be further increased by emotion.

As illustrated in the review of literature, with the exception of the studies by Antel and Cumming (2) and Taylor and others (32), very little research has been conducted which has considered the effects of emotional factors on heart rates at working levels. Moreover, there have been no studies reported in this area on women. This study was, therefore, designed to investigate this topic while utilizing women as subjects.

Chapter 3

METHODS AND PROCEDURES

AUTHORIZATION TO SELECT VOLUNTEERS

In order to conduct this investigation it was first necessary to submit a written proposal to the Committee on Policy and Procedures for Research with Humans at Kansas State University. This committee reviewed and subsequently approved this study.

SELECTION OF SUBJECTS

Thirty freshman college females, aged 17 to 19, served as subjects in this study. Subjects were selected through the solicitation of volunteers from several of the basic physical education classes at Kansas State University.

During these physical education classes, a description of the study was presented to the students, and the equipment to be used in the study was explained. It was particularly emphasized to the students that only those with one previous experience with the Astrand bicycle test would be eligible to participate as subjects. Following this, each student was given an informed consent form which briefly outlined the purpose, procedures, time and risk involved in the study.[1] The student then, if she wished to participate in the study, filled out the information blank located at the bottom of the form.

[1]See Appendix A.

Upon receipt of the informed consent forms, the investigator contacted each of the subjects to arrange for testing dates and times. At this time the subjects were informed that they were not to eat or participate in exercise for 1 to 2 hours prior to the testing session. They were also informed that it would be necessary for them to wear some type of clothing which allowed for placement of three electrodes to the subscapular region of the back. A bathing suit top or halter top were suggestions.

Each student provided proof of positive health or a statement of their physical limitations signed by a physician. Since all of the subjects were in positive health at this time it was deemed that physical examinations would not be necessary.

TEST ADMINISTRATION

The test was administered in the Motor Learning Laboratory located on the campus of Kansas State University. Aside from the experimental apparatus, contents of the room included several tables and chairs and two or three storage cabinets. Windows were located at the far end of the room, however, only sky and trees could be observed by peering through them. Since the laboratory was air conditioned, the temperature remained relatively constant (68-72 degrees Fahrenheit). A physiograph unit was positioned approximately equidistant from both side walls and at the end of the room opposite the windows. Immediately in front of (toward the center of the room) the physiograph, a Monark bicycle ergometer was placed. The ergometer faced away from the physiograph so that visual cues in the subject would not be triggered by its presence. Approximately 45 degrees

to the right and in front of the bicycle ergometer was placed a small 8 inch by 20 inch unmarked cabinet. The cabinet was mounted on a table for easy accessibility and was closed but not locked. The cabinet was, at all times, in full view of the subject.

Each subject was met by the investigator outside the door of the Motor Learning Laboratory. Upon entering the room the subject walked immediately to the bicycle ergometer and assumed a sitting position on it. The seat height was then adjusted so that the leg was almost at full extension when the pedal recorded the lowest point of its revolution. The subject then pedaled two or three revolutions at no resistance in order to determine whether the seat height was in a comfortable position.

The subject was told that she would receive two sets of instructions. The first was to be given immediately, and the second, once the subject had been connected, by means of three electrodes to the physiograph. The subject was informed that she was going to ride the bicycle ergometer for six minutes during which time her heart rate would be recorded on the physiograph. She was told that she would have three electrodes attached to her lower back and that she should not make unnecessary movements since these produced interference on the physiograph.

At this time the necessary connections and preparations were made including attachment of the electrodes to the subscapular and suprailiac regions of the subject's lower back.

The subject was then instructed to pedal at 20 kilometers per hour (approximately 50 revolutions per minute) for a period of 6 minutes. The investigator completed the second set of instructions by stating to the subject that she should not stop pedaling until she had been told to do so.

At this time the subject was asked if she understood all of the instructions and if she had any questions.

Prior to the beginning of the exercise bout, a resting heart rate was recorded for one minute. The subject then began pedaling at a constant rate of approximately 50 revolutions per minute. Resistance was proportioned by the investigator so that after a period of approximately four minutes of continuous exercise, the subject's heart rate had reached one of three levels (125 beats per minute, 140 beats per minute, 155 beats per minute). A read out of heart rate was easily obtained through utilization of a cardiotachometer. Once the desired heart rate level was achieved, presentation of the emotional stimulus occurred.

The subjects were randomly divided so that each subject would receive one of the two stimuli used in the study. Stimulus one involved use of the cabinet which was located diagonally in front of and to the right of the subject. The investigator approached the cabinet, opened the door of it and took out a hypodermic needle on a syringe, a small pad of cotton and a plastic bottle of isopropyl (rubbing alcohol). Also located within the cabinet, but which was not removed, was a test tube containing a substance which appeared to be blood but was really red ink. The red ink was used to increase the authenticity of the situation. The cotton pad was swabbed with the alcohol and both it and the hypodermic needle were brought to the subject's side. The subject was then informed that if her heart rate reached a certain level, the syringe would be used to obtain a sample of blood. The needle was held in full view of the subject for 15 seconds. During this time the subject's arm, in the region of the brachial artery, was cleaned with the small cotton pad. Upon completion of the 15 second time period the investigator told the subject that her heart rate

had not reached the desired level and that a blood sample would not be necessary. The hypodermic needle and cotton pad were returned to the cabinet and the door of the cabinet was closed. Shortly thereafter, the resistance on the bicycle ergometer was removed and the subject "cooled down" by pedaling slowly for 1 minute in order to promote venous blood return to the heart.

The presentation of stimulus two involved mainly a verbal attempt at creating a stressful situation. When the desired level of heart rate was reached the investigator exclaimed, "Something is wrong here, your heart rate shouldn't be that high." Auditory cues were then stimulated as several switches and buttons on the physiograph were pushed as if to suggest that the error may have been mechanical. Following this, the subject was asked if she felt alright or if she felt dizzy or nauseous. The investigator turned back to the physiograph and stated "Everything's alright now, the cardiotachometer was not recording properly; I have your right heart rate now." Approximately one minute following this statement, the resistance on the bicycle ergometer was removed and the subject "cooled down" for another minute before she was allowed to descend from the ergometer.

During the subsequent unhooking of electrodes the subject was informed of the true nature of the study. She was asked not to discuss the events of the study with anyone so that successive responses by subjects would be spontaneous.

INSTRUMENTATION

Heart rates before and during the 6 minute bicycle ergometer ride were recorded on the physiograph. This device has made it possible to transmit electrocardiogram signals from electrodes taped to the subject's back. One electrode site was approximately 2 inches below the inferior ridge of the scapula and 3 to 4 inches to the left of the vertebral column. The second site was 3 to 4 inches to the right of the vertebral column and in the same position relative to the inferior scapula as the first electrode site. The third site was slightly superior to the iliac crest of the hip and about 6 to 7 inches to the left of the vertebral column. Before attaching the electrodes, the skin was cleaned with alcohol and was as dry as possible. Electrode paste was used to improve contact and create greater conductivity. A 24 inch elastic band was used to hold the electrodes in place throughout the ride. Lead wires were then attached and taped down at various points to reduce any possible interference.

The electrodes picked up the electrical signal of the heart and converted it to a normal electrocardiogram which was printed on paper with a paper recorder in the form of R waves. Thus, it was possible to count the R waves to determine the subject's heart rate response to the various physical and emotional stimuli. A cardiotachometer was used in the physiograph so that the experimenter could determine when the heart rate level required for presentation of the stimulus was reached.

INVESTIGATION PROCEDURES

This investigation was conducted between April 8 and April 26, 1974 at times which were arranged with the subject. Each subject was contacted by the investigator approximately 1 week prior to the subject's actual participation in the study. At this time the clothing to be worn and the necessary preparations to be made were discussed.

The subjects were randomly divided into 6 groups with each cell containing 5 subjects. The experimental format for this study included a treatment by levels design. Three levels of heart rate were used, all of which required submaximal effort to elicit. The three levels were 125 beats per minute, 140 beats per minute, and 155 beats per minute.

As each subject entered the testing area, she was asked to take a seat on the bicycle ergometer. The experimenter attempted to make the subject feel at ease as much as possible by commenting about the weather and school events. This was done to reduce the anticipatory response for the actual bicycle ergometer ride. The subject and the experimenter were the only persons present during the testing session and only one subject was tested at a time.

Once the necessary instructions and placement of electrodes were completed, the subject's resting heart rate was recorded for approximately 1 minute. The subject then began pedaling at about 20 kilometers per hour (50 revolutions per minute). The resistance was adjusted by the investigator so that the subject's heart rate would reach the desired level after about 4 minutes of exercise. For most of the subjects the workload on the bicycle ergometer ranged from 300 to 600 KPM. Once the desired level of heart rate was obtained, introduction of either stimulus one or

stimulus two occurred. Approximately 1 minute later the resistance was removed and the subject cooled down for another minute before descending from the apparatus.

Heart rates in the subject were recorded at rest, immediately prior to presentation of the stimulus, the five seconds immediately after application of the stimulus, from 5 to 10 seconds after stimulus injection, and from 10 to 15 seconds after introduction of the stimulus.

STATISTICAL ANALYSIS

A completely randomised 2x3 factorial analysis of variance design was used to analyse the following variables:

1. resting heart rate
2. differences between heart rate 5 to 10 seconds after stimulus presentation and heart rates immediately prior to stinulus presentation
3. differences between heart rates 10 to 15 seconds after stimulus presentation and heart rates immediately prior to stimulus presentation
4. differences between highest heart rates after stimulus presentation and heart rates immediately prior to stimulus presentation

To determine whether the mean differences between the heart rates before and after introduction of the stimulus were significant, the standard error for each mean difference was multiplied by a constant and the resultant value compared to the mean difference to determine its significance at the .05 level. The constant value used was students t (24 df) = 2.064.

Chapter 4

ANALYSIS OF THE DATA

Data from this investigation are presented in the following section. In addition to presentation of statistical analysis, data are presented graphically and are discussed in order to allow conclusions to be drawn.

PRESENTATION OF THE DATA

Resting Heart Rate Response

Each subject's resting heart rate was recorded on the physiograph prior to performance of the exercise bout. To determine statistically whether, among the cells, there was a significant difference in mean resting rates, an analysis of variance was applied to the data. Table 4.1 contains the results of this computation.

Table 4.1

Analysis of Variance Table
for Resting Heart Rates

Source of Variance	df	SS	MS	F
Treatment	1	235.20	235.20	1.13
Level	2	9.60	4.80	0.02
Treatment by Level	2	124.80	62.40	0.30
Error	24	5011.27	208.80	

[a]Significant at the .05 level.

Results of the analysis of variance for resting heart rates as presented in Table 4.1 indicate that the F ratios for treatment, level, and treatment by level were not significant at the .05 level. For the benefit of the reader, the means for resting heart rate are illustrated graphically in Figure 4.1.

A study of Figure 4.1 reaffirms the lack of significance of the differences between resting heart rates with respect to the treatment applied, the level of heart rate at which the stimulus was presented, and the treatment by level interaction. The fact that the lines diverge only to a small extent suggests that the differences are not significant. For the information of the reader, the mean scores for resting heart rates are presented in Table 4.2.

Table 4.2

Mean Scores Table for
Resting Heart Rates

	T_1	T_2	Level Totals
L_1	91.20	84.00	87.60
L_2	86.40	86.40	86.40
L_3	91.20	81.60	86.40
Treatment Totals	89.60	84.00	86.80
			Grand Mean

Table 4.2 indicates that, as expected, there were no significant differences between the resting heart rates of the various groups.

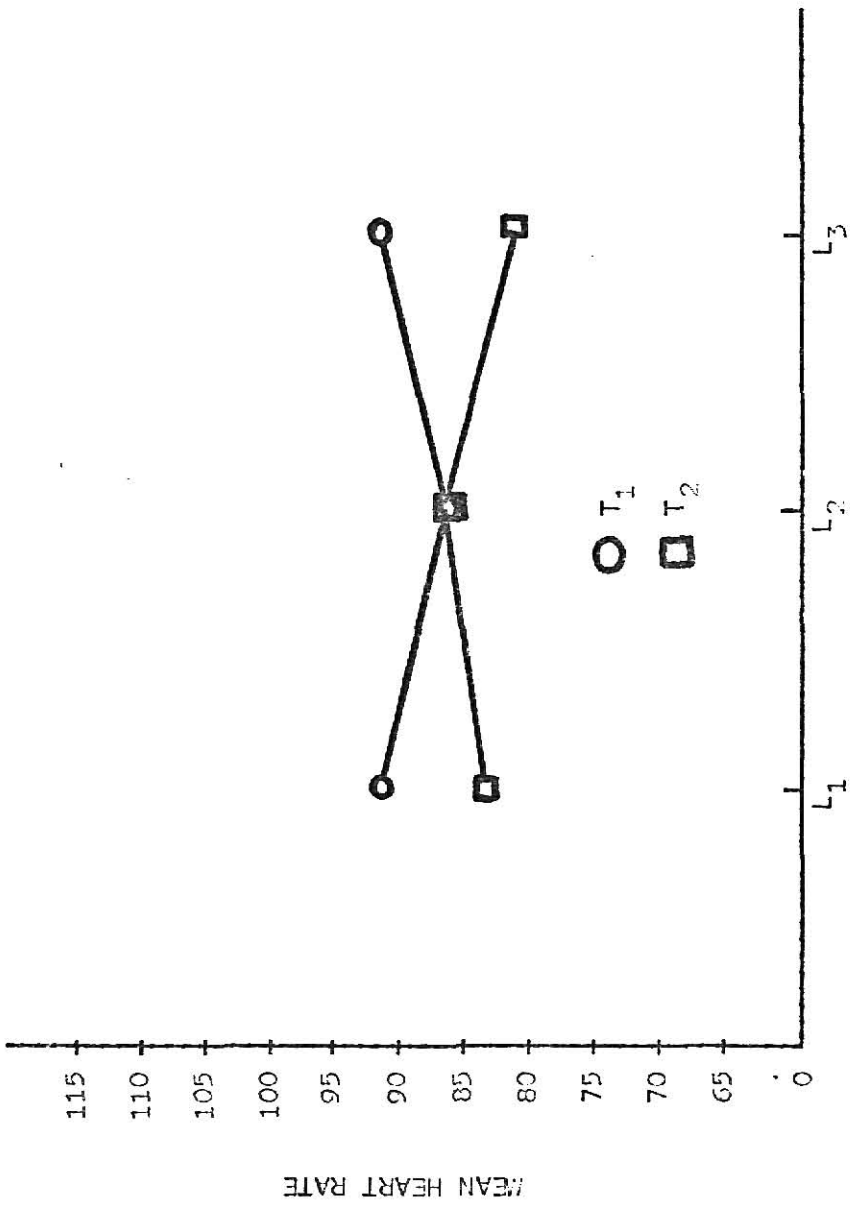

Figure 4.1

Mean Resting Heart Rate Responses

Differences Between Heart Rates 0 to 5 Seconds After Stimulus Presentation and Heart Rates Immediately Prior to Stimulus Presentation

Due to lack of variability in heart rate responses at this level, no analysis of variance was performed. The data relating to this portion of the study will, consequently, not be presented.

Differences Between Heart Rates 5 to 10 Seconds After Stimulus Presentation and Heart Rates Immediately Prior to Stimulus Presentation

The results of the analysis of variance for the differences between heart rates 5 to 10 seconds after stimulus presentation and heart rates immediately prior to stimulus presentation are displayed in Table 4.3.

Table 4.3

Analysis of Variance Table for Differences Between Heart Rates 5 to 10 Seconds After Stimulus Presentation and Heart Rates Immediately Prior to Stimulus Presentation

Source of Variance	df	SS	MS	F
Treatment	1	76.80	76.80	2.00
Level	2	355.20	177.60	4.63[a]
Treatment by Level	2	297.60	148.80	3.88[a]
Error	24	921.60	38.40	

[a]Significant at the .05 level.

Table 4.3 indicates that the differences between heart rate responses among the three levels of application are significant. A Duncan's multiple range test was administered to determine where these differences exist. The results are shown in Table 4.4.

Table 4.4

Duncan's Multiple Range Test for the Differences Between Levels of Heart Rates (5 to 10 Seconds After Stimulus Presentation)

	Levels of Heart Rate		
	L_1	L_3	L_2
.05 level of significance	10.80	6.00	2.40

An observation of Table 4.4 reveals a significant difference occurred between the mean difference totals for levels one and two. Thus, the emotional stimulus had a greater effect of elevating heart rate when applied at level one than at level two. There was no significant difference between levels one and three, or between levels two and three.

Also significant at the .05 level was the treatment by level interaction. Worthy of notice then, is the interpretation that subjects with heart rates at one particular level, using one type of treatment, showed significantly greater increases in heart rates over subjects exercising at another heart rate level, using the same or a different type of treatment. A study of Figure 4.2 illustrates where these differences lie.

Observation of Figure 4.2 reveals that treatment one, injected at the lowest level of heart rate, was more effective in elevating heart rate than treatment two. This inference is supported by the large variability between the mean scores of both treatments at level one. This variability was not present at either level two or three. The mean scores for the

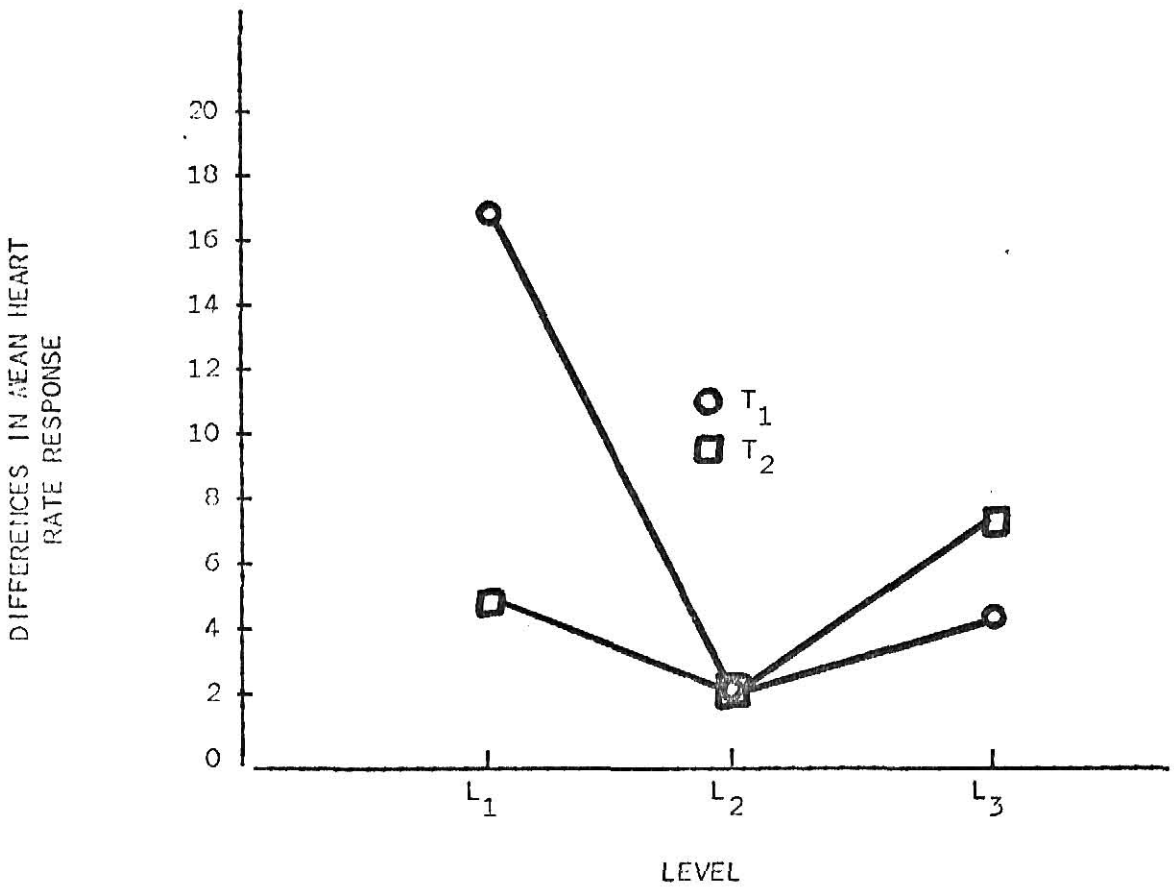

Figure 4.2

Mean Scores for Differences Between Heart Rates 5 to 10 Seconds After Stimulus Presentation and Heart Rates Immediately Prior to Stimulus Presentation

differences between heart rate at 5 to 10 seconds after stimulus presentation and heart rates immediately prior to stimulus presentation are given in Table 4.5.

Table 4.5

Mean Scores Table for Differences Between Heart Rates 5 to 10 Seconds After Stimulus Presentation and Heart Rates Immediately Prior to Stimulus Presentation

	T_1	T_2	Level Totals
L_1	16.80[a]	4.80	10.80[a]
L_2	2.40	2.40	2.40
L_3	4.80	7.20[a]	6.00[a]
Treatment Totals	8.00[a]	4.80[a]	6.40

[a]Significantly different from 0 at the .05 level.

Grand Mean

Table 4.5 shows large differences between the mean scores for treatments one and two, injected at level one. This accounts for the significance of the treatment by level interaction observed in the data.

Several of the mean differences in heart rates presented in Table 4.5 represent significant increases due to the introduction of an emotional stimulus. Both treatments one and two elicited significant increases from the prior state. In the case of treatment one, application of this stimulus at level one was responsible for the overall significance of the mean increase since at no other level did a significant difference from the

prior state exist. Thus, at the lowest level of heart rate, the injection of treatment one produced a significant elevation in heart rate.

In reference to treatment two, a somewhat different phenomenon was observed. Once again, the overall effect of the treatment caused a significant increase in heart rate from the prior condition. In this case, however, the increase must be attributed to the change in heart rate as a result of the stimulus being presented at level three. In other words, at the highest level of heart rate, injection of treatment two produced a significant elevation in the heart rate response. This difference was not nearly as great as the increase observed for treatment one at level one, however, it was significant at the .05 level.

Differences Between Heart Rates 10 to 15 Seconds After Stimulus Presentation and Heart Rates Immediately Prior to Stimulus Presentation

The analysis of variance statistical technique was employed to determine the differences between heart rate responses 10 to 15 seconds after stimulus presentation and heart rates immediately prior to stimulus presentation. The results of this analysis are shown in Table 4.6.

Table 4.6

Analysis of Variance Table for Differences Between Heart Rates 10 to 15 Seconds After Stimulus Presentation and Heart Rates Immediately Prior to Stimulus Presentation

Source of Variance	df	SS	MS	F
Treatment	1	120.00	120.00	2.38
Level	2	240.00	120.00	2.38
Treatment by Level	2	355.20	177.60	3.52[a]
Error	24	1209.60	50.40	

[a]Significant at the .05 level.

An examination of Table 4.6 reveals that there was a significant treatment by levels interaction for the data. Figure 4.3 graphically illustrates where this significant difference exists.

The fact that the lines in Figure 4.3 diverge greatly at the low level of heart rate suggests that a significant difference exists at that point. For the information of the reader, the mean scores for the differences between heart rates 10 to 15 seconds after stimulus presentation and heart rates immediately prior to stimulus presentation are shown in Table 4.7.

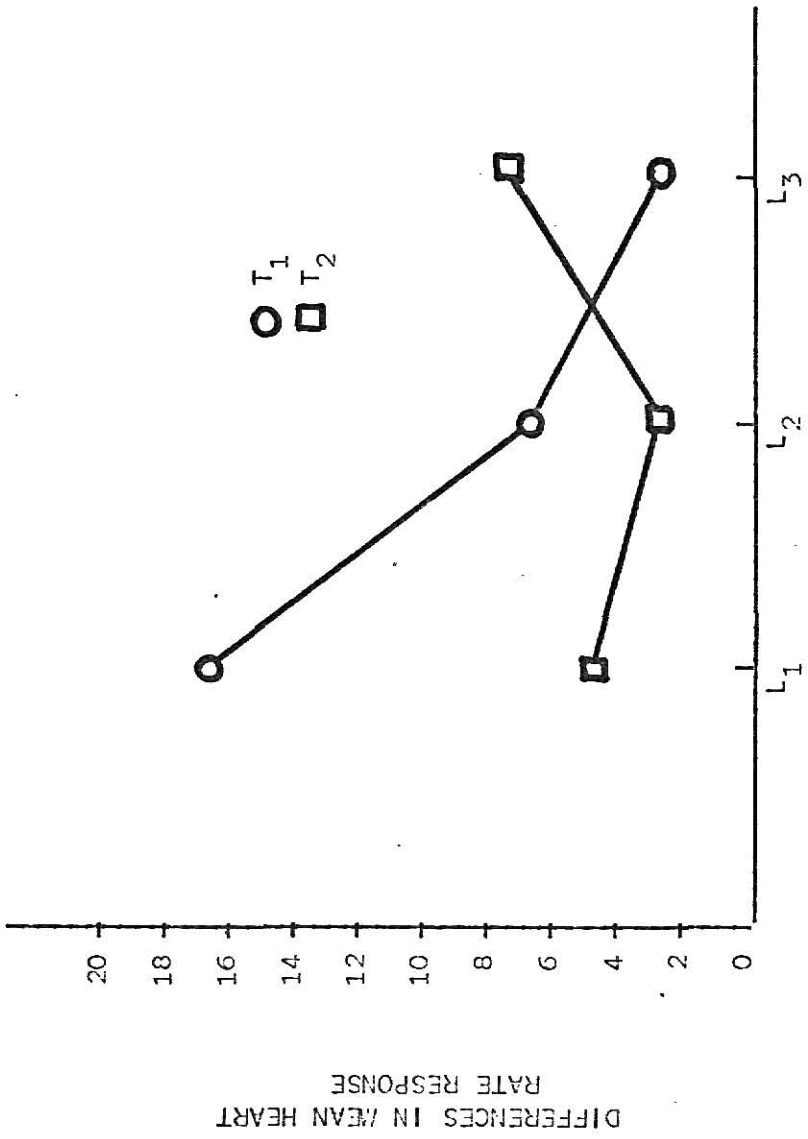

Figure 4.3

Mean Scores for Differences Between Heart Rates 10 to 15 Seconds After Stimulus Presentation and Heart Rates Immediately Prior to Stimulus Presentation

Table 4.7

Mean Scores Table for Differences Between Heart Rates 10 to 15 Seconds After Stimulus Presentation and Heart Rates Immediately Prior to Stimulus Presentation

	T_1	T_2	Level Totals
L_1	16.80[a]	4.80	10.80[a]
L_2	7.20[a]	2.40	4.80
L_3	2.40	7.20[a]	4.80
Treatment Totals	8.80[a]	4.80[a]	6.80

[a]Significantly different from 0 at the .05 level.

Grand Mean

A significant difference in the treatment utilized at level one is clearly reflected in the large differences in the mean scores as presented in Table 4.7. That is, treatment one was more effective in producing an elevation in heart rate when used at the lowest level of heart rate than was treatment two. This effect was not observed at other levels of heart rate.

Table 4.7 also illustrates that both treatments one and two were effective in causing significant elevations in heart rates from the prior state. With respect to treatment one, these significant increases occurred at low and intermediate heart rate levels. There was no appreciable increase at high heart rates as a result of the application of treatment one. Treatment two, on the other hand, was effective in producing significant elevations in heart rate only at high heart rate levels.

Once again the greatest increases in heart rates were caused by the application of treatment one at low levels of heart rate.

Differences Between Highest Heart Rates After Stimulus Presentation and Heart Rates Immediately Prior to Stimulus Presentation

An analysis of variance was used to statistically determine the differences between the highest heart rates obtained after stimulus presentation and heart rates immediately prior to stimulus presentation. The results are summarized in Table 4.8.

Table 4.8

Analysis of Variance Table for Differences Between Highest Heart Rates After Stimulus Presentation and Heart Rates Immediately Prior to Stimulus Presentation

Source of Variance	df	SS	MS	F
Treatment	1	76.80	76.80	1.88
Level	2	297.60	148.80	3.65[a]
Treatment by Level	2	355.20	177.60	4.35[a]
Error	24	979.20	40.80	

[a]Significant at the .05 level.

A significant levels difference was observed for the data presented in Table 4.8. A Duncan's multiple range test was employed to determine where these differences exist. The results are displayed in Table 4.9.

Table 4.9

Duncan's Multiple Range Test for the Differences Between Levels of Heart Rates (Highest Heart Rates After Stimulus Presentation)

	Levels of Heart Rate		
	L_1	L_2	L_3
.05 level of significance	13.20	7.20	6.00

A study of Table 4.9 reaffirms that at lower levels of heart rate a greater increase resulted from the application of the stimulus. This is illustrated in the significance of the differences between the mean difference totals for level one as compared with levels two and three.

Also significant at the .05 level was a treatment by levels interaction. The construction of Figure 4.4 was done in order to determine where these differences existed.

A study of Figure 4.4 reveals an obvious difference between treatments at level one. Treatment one was observed to elicit a much greater effect on heart rate at this level than treatment two. In other words, the injection of treatment one at a low level of working heart rate produced a greater elevation than the injection of treatment two at the same level. For the information of the reader, the mean scores for the differences between the highest heart rates after stimulus presentation and heart rates immediately prior to stimulus presentation are displayed in Table 4.10.

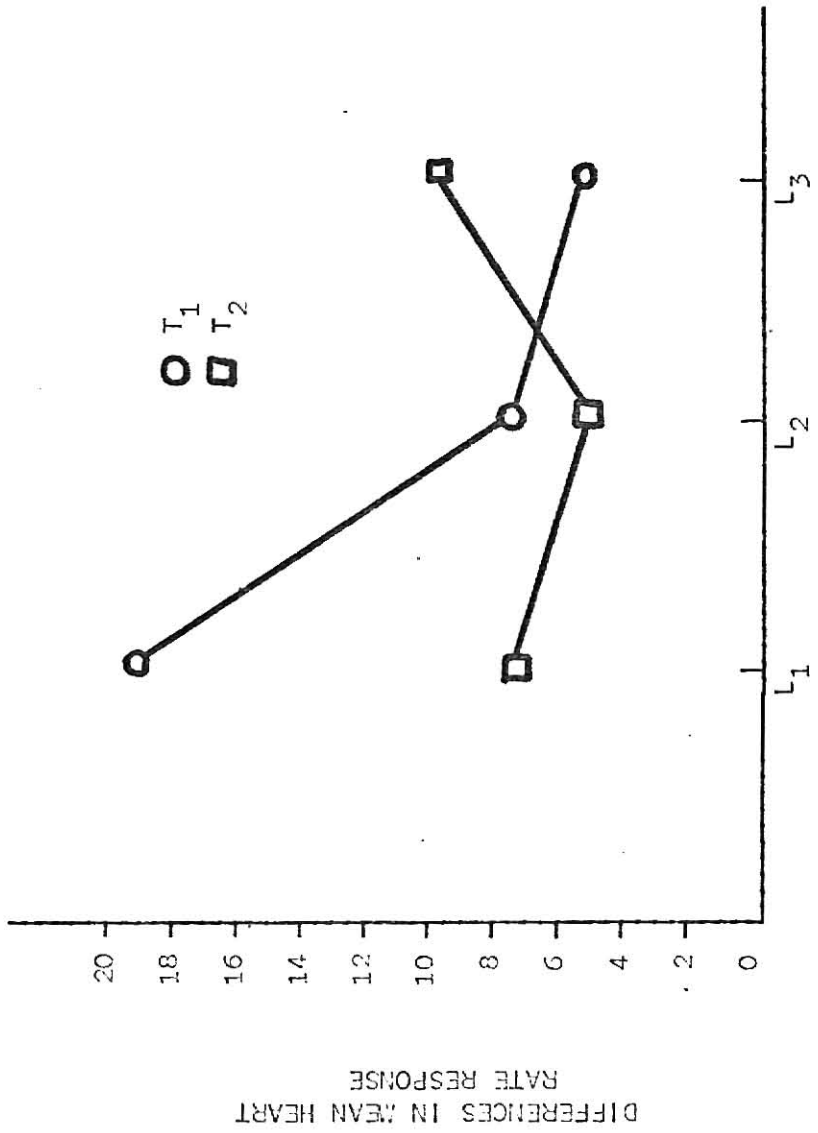

Figure 4.4

Mean Scores for Differences Between Highest Heart Rates After Stimulus Presentation and Heart Rates Immediately Prior to Stimulus Presentation

Table 4.10

Mean Scores Table for Differences Between Highest Heart Rates After Stimulus Presentation and Heart Rates Immediately Prior to Stimulus Presentation

	T_1	T_2	Level Totals
L_1	19.20^a	7.20^a	13.20^a
L_2	7.20^a	4.80	6.00^a
L_3	4.80	9.60^a	7.20^a
Treatment Totals	10.40^a	7.20^a	8.80

Grand Mean

[a]Significantly different from 0 at the .05 level.

The large differences in mean scores as presented in Table 4.10 indicates that there is a significant difference between treatments when employed at low levels of heart rate. No differences in treatments were observed for other levels of heart rate.

Several of the mean scores presented in Table 4.10 represented significant increases in heart responses from the prior condition. Generally, both treatments produced significant elevations in heart rates. Treatment one caused increases at low and intermediate levels of heart rate but not at high levels. Treatment two, on the other hand, produced significant alterations at low and high levels of heart rate but not in the intermediate range.

DISCUSSION

On the basis of results as previously presented, discussion and some interpretation of data seemed pertinent. Comments relating to the specific objectives of the investigation are presented in the following section.

Specific Objective One

The first specific objective of this investigation was to determine if emotional stimulation effects heart rate during submaximal exercise.

Results of the data indicate that at the .05 level, the injection of either treatment one or two resulted in an increase in heart rate which was significantly different from the heart rate level immediately prior to stimulus presentation. That is, both types of treatments elicited significant increases in heart rate during submaximal exercise.

The reason for this increase may have been due to the mechanism described by Karpovich (18). Reception of the emotional stimulation produced a disruption of the normal homeostatic balance of the autonomic nervous system. Either or both of two effects may have resulted. The sympathetic or cardio-accelerator system may have increased its tone or the parasympathetic or cardio-inhibitory center may have been inhibited. As stated, both actions may have occurred simultaneously to produce an increased heart rate.

This increase is in accord with the findings of Antel and Cumming (2) who showed that the presence of emotional stimuli significantly altered the heart rates of subjects exercising submaximally.

Specific Objective Two

The second specific objective of this study was to determine if different emotional stimuli affect heart rate during submaximal exercise, and if so, to determine the varying effects of the different treatments.

The data indicate that both types of treatments were effective in producing significant elevations in heart rate during the exercise state. The significance may be attributed, in the case of treatment one, to the profound effect of this stimulus on heart rate when injected at level one. In reference to treatment two, the application of this stimulus at high levels of heart rate was responsible for the overall significance.

Although the difference was not significant at the .05 level, it was observed from the data that treatment one was more effective in elevating heart rate than treatment two. This was likely due to the relative intensity of the two treatments. Treatment one appeared to be of greater severity in the fact that not only auditory but visual cues were stimulated by its presence. The sight of a hypodermic needle on a syringe was apparently more frightening than verbalization by the investigator as to the subject's abnormally high heart rate response.

Specific Objective Three

The third specific objective of this investigation was to determine if different emotional stimuli have major effects on the heart rates of subjects exercising at low, moderate and relatively high submaximal workloads.

Observation of the data clearly indicates that emotional factors may cause significant elevations in heart rate responses while working at low levels of heart rate. This is illustrated in the large differences in

heart rates between the prior state and the post-stimulus condition at working level one. Primary responsibility for the variability must be given to the effects of treatment one on heart rate responses at this level since it was this type of stimulus which markedly influenced the overall significance of the heart rate differences.

Furthermore, there is some evidence, on the basis of the data obtained, to suggest that high working heart rates were increased by the introduction of emotional stimuli. These findings are in support of the observation of Antel and Cunning (2) who noted that heart rates of 170 beats and higher were further stimulated by emotional factors. A study of Tables 4.5 and 4.10 reveals the significance of the increases in heart rates from the prior condition. Once again, the overall significance of the increases may be attributed to the injection of one particular type of treatment. In this case, the application of treatment two resulted in the elevation of the heart rate responses.

Results of the data also indicate that a significant treatment by levels interaction occurred at the .05 level. An observation of Figures 4.2, 4.3 and 4.4 reveals that the part played by treatment one, injected at level one, in determining the overall significance of the interaction was of major proportions. In other words, the differences between the effects of the two types of treatments were quite significant when the treatments were used at low levels of heart rate. Treatment one was observed to elicit a much greater effect on the heart rate response when utilized at level one. It appears that the combined effects of two theories may explain this phenomenon. Treatment one was observed to be, by its nature, of greater severity than treatment two. Secondly, at low levels of heart

rate, there is a larger capacity for an increase in heart rate to occur than at higher levels. It is hypothesized that the interaction of these two factors was responsible for the significant variability in heart rates between treatments one and two, when used at low heart rate levels. The effects of the employment of treatment one, presented at level one appeared to greatly influence the overall significance of the interaction between the treatment used and the level of heart rate at which the treatment was applied.

The effects of treatment one, when injected at low levels of heart rate, were such that significant increases in heart rates from the prior condition resulted.

Also significantly effective in elevating heart rates from the prior state was the presentation of treatment two at high levels of heart rate. The reason for this increase is not clear, and it appears that more research in the area of heart rate responses to emotional stimuli during exercise at similar levels of heart rate is needed before reliable conclusions may be drawn. With reference to this investigation, it may be hypothesized that subjects with heart rates at this level experienced the sensation of having to work against a high resistance, finding the task somewhat difficult. When the investigator then stated that the subject's heart rate was abnormally high, she consequently became quite concerned about the situation, which reflected itself in the elevated heart rate.

A study of the data indicates that treatment one was somewhat effective in elevating heart rates when injected at level two. From 0 to 10 seconds after stimulus presentation, no significant increases in heart rates from the prior state occurred. During the next 5 seconds following

the presentation of the stimulus, however, significant elevations from the prior condition became apparent. In other words, the effects of the stimulus in elevating heart rate were somewhat latent in their appearance.

Further observation reveals that significant differences in heart rates from the prior state existed for treatment one injected at level two and for treatment two injected at level one. This may be explained in the fact that when the highest heart rate responses were employed, significant differences became apparent. These differences did not, in some cases, exist during the 15 second time interval after presentation of the stimulus. No other significant differences in heart rates from the prior condition were observed.

Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

SUMMARY

The purpose of this investigation was to determine the effects of an emotional stimulation on submaximal exercise heart rate. More specifically, the objectives of this study were:

1. to determine if emotional stimulation affects heart rate during submaximal exercise

2. to determine if different emotional stimuli affect heart rate during submaximal exercise, and if so, to determine the varying effects of the different treatments

3. to determine if different emotional stimuli have major effects on the heart rates of subjects exercising at low, moderate and relatively high submaximal workloads.

Thirty freshman college females, aged 17 to 19 served as subjects in this study. The subjects were selected through the solicitation of volunteers from the basic physical education classes at Kansas State University. Only students with one previous experience with the Astrand-Ryhming bicycle test were accepted as participants in this study. All subjects were in positive health as determined by a medical examination administered at the beginning of the academic session.

The subjects were randomly divided into the following groups with each group containing five subjects:

1. treatment one - heart rate level one
2. treatment one - heart rate level two
3. treatment one - heart rate level three
4. treatment two - heart rate level one
5. treatment two - heart rate level two
6. treatment two - heart rate level three

Each subject performed a single ride on the bicycle ergometer at a resistance which produced the desired heart rate level. Upon attaining this desirable level, the subject was then administered an emotional stimulation. The levels of heart rate employed and the types of treatments administered are shown in Appendix D. Subjects were told the purpose of the test was to observe the effects of varying workloads on heart rate.

Heart rate was monitored on the physiograph throughout testing and recorded on an electrocardiogram. Resting heart rates which included the anticipatory response were recorded immediately prior to the actual exercise bout. Heart rate responses immediately prior to stimulus presentation, from 0 to 5 seconds after stimulus presentation, from 5 to 10 seconds after stimulus presentation and from 10 to 15 seconds after stimulus presentation were calculated. Differences between heart rates after stimulus presentation and prior to stimulus presentation were determined for each of the five second intervals. Differences between the subject's highest heart rate responses and rates immediately prior to stimulus presentation were also computed.

Results were analyzed by a completely randomized 2x3 factorial analysis of variance. To determine whether the mean differences between the heart rates before and after introduction of the stimulus were significant, the standard error for each mean difference was multiplied by a constant and the resultant value was compared to the mean difference to determine its significance at the .05 level.

Statistical analysis revealed a significant difference in heart rate responses between heart rates immediately prior to stimulus presentation and heart rates after introduction of the stimulus. Emotional factors should, therefore, be taken into consideration in tests where heart rate is used as the criterion. Results of the analysis of variance performed on the data indicated a significant treatment by level interaction at the .05 level. The significance was attributed mainly to the effects of the introduction of stimulus one at heart rate level one and treatment two presented at level three. Thus, at low and high heart rates the introduction of particular types of emotional stimuli have significant effects on increasing the heart rate.

CONCLUSIONS

On the basis of data obtained and within the limitations of this study the following conclusions appear warranted:

1. Working heart rates are significantly increased by the introduction of emotional stimuli.

2. Emotional factors cause greater increases in working heart rates when applied at lower levels of heart rate.

3. The presentation of a hypodermic needle on a syringe to subjects working at low levels of heart rate causes significant increases in heart rates.

4. Further significant increases in high working heart rates are caused by verbalization to subjects as to their abnormally high heart rates during submaximal exercise.

RECOMMENDATIONS

Results and discussion of this study indicate the need for further investigation in the following areas:

1. It is recommended that a means be developed to assess the extent to which emotional factors effect heart rates during submaximal exercise.

2. It is recommended that further investigation be conducted involving the application of one type of stimulus at one particular level of heart rate.

3. It is recommended that further studies be conducted investigating the effects of emotional stimuli on the heart rates of various age levels during exercise.

4. It is recommended that further studies be conducted investigating the effects of the introduction of emotional stimuli on heart rate response of subjects exercising near maximally.

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APPENDIX A

INFORMED CONSENT OF SUBJECTS

My name is Jack Rutherford and I am a graduate student in Physical Education at Kansas State University. I am presently working on my Master's Thesis and require the assistance of several students in order to complete my research. Your help would be greatly appreciated.

Purpose:

The purpose of my study is to determine the effects of varying work loads on exercise heart rates of college freshman females.

Procedures:

Each subject will ride the bicycle ergometer for six minutes during which time her heart rate will be monitored by means of an electrocardiogram.

Time Involved:

Each subject who volunteers for this study will be required to attend only one testing session which should last approximately 20-30 minutes.

Risk Involved:

No subject will suffer physical, psychological or other injury as a result of participating in this study. It is to be understood by all persons volunteering for this study that participation may be terminated at any time if so desired by the subject.

Compensation:

No compensation will be afforded the subject other than the satisfaction of knowing that she has contributed to the body of knowledge in Physical Education.

Fill out the information blank below if you would like to participate in this study. PLEASE PRINT!

NAME_____ AGE_____

ADDRESS_____ PHONE_____

APPENDIX B

RANDOMIZATION OF TREATMENT AND LEVEL ADMINISTRATION

Subject	Treatment	Level of Heart Rate
1	2	1
2	2	2
3	2	2
4	2	3
5	1	1
6	1	2
7	2	3
8	2	3
9	2	3
10	2	3
11	2	2
12	2	2
13	2	1
14	2	1
15	2	1
16	1	3
17	1	3
18	1	3
19	1	2
20	1	2
21	1	2
22	1	2
23	1	1
24	1	1
25	1	1
26	1	1
27	2	2
28	2	1
29	1	3
30	1	3

APPENDIX C

SUBJECT HEART RATES AT REST, PRIOR TO STIMULUS PRESENTATION, 0 TO 5 SECONDS (A_1), 5 TO 10 SECONDS (A_2), 10 TO 15 SECONDS (A_3), AND HIGHEST AFTER STIMULUS PRESENTATION

Subject	Resting	Prior	A_1	A_2	A_3	Highest
1	108	132	132	132	144	144
2	84	144	156	144	144	156
3	84	144	144	132	132	144
4	72	156	168	168	168	168
5	84	120	120	132	132	132
6	72	144	156	156	156	156
7	84	156	156	156	156	156
8	84	156	168	168	168	168
9	72	156	156	168	156	168
10	96	156	156	156	168	168
11	84	144	144	144	144	144
12	72	144	144	144	144	144
13	72	120	120	120	120	120
14	72	132	144	144	132	144
15	72	132	132	132	132	132
16	84	156	156	156	156	156
17	72	156	156	156	156	156
18	120	156	168	168	168	168
19	108	144	144	144	144	144
20	84	144	144	144	156	156
21	72	144	144	144	144	144
22	96	144	144	144	156	156
23	108	120	132	132	144	144
24	96	120	132	144	144	144
25	84	120	132	144	144	144
26	84	120	132	132	120	132
27	108	132	144	144	144	144
28	96	120	132	132	132	132
29	96	156	156	156	156	156
30	84	156	156	168	156	168

APPENDIX D

LEVELS OF HEART RATES EMPLOYED AND
TYPES OF TREATMENTS ADMINISTERED

Levels of Heart Rate

Level One - 125 beats per minute

Level Two - 140 beats per minute

Level Three - 155 beats per minute

Types of Treatments

Stimulus One - A hypodermic needle on a syringe was produced and the subject was informed that if her heart rate reached a certain level the needle would be used to obtain a sample of blood.

Stimulus Two - The investigator informed the subject that her heart rate was abnormally high for the given work-load. The subject was then asked if she felt either dizzy or nauseous.

THE EFFECTS OF AN EMOTIONAL STIMULATION ON SUBMAXIMAL EXERCISE HEART RATE

by

WILLIAM JOHN RUTHERFORD

B. P. E., The University of Manitoba, 1973

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Health, Physical Education and Recreation

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1974

Abstract

The Effects of Emotional Stimulation on Submaximal Exercise Heart Rate. (August 1974)

William John Rutherford, B.P.E., The University of Manitoba;

Directed by: Dr. Charles B. Corbin

Purpose

The purpose of this investigation was to determine the effects of an emotional stimulation on submaximal exercise heart rate. More specifically, the objectives of this study were:

1. to determine if emotional stimulation affects heart rate during submaximal exercise

2. to determine if different emotional stimuli affect heart rate during submaximal exercise, and if so, to determine the varying effects of the different treatments

3. to determine if different emotional stimuli have major effects on the heart rates of subjects exercising at low, moderate and relatively high submaximal workloads

Procedure

Thirty freshman college females, aged 17 to 19, served as subjects in this study. The subjects were selected through the solicitation of volunteers from the basic physical education classes at Kansas State University. Only students with one previous experience with the Astrand-Ryhming bicycle test were accepted as participants in this study. The subjects were randomly divided into the following groups with each group containing five subjects:

1. treatment one-heart rate level one
2. treatment one-heart rate level two
3. treatment one-heart rate level three
4. treatment two-heart rate level one
5. treatment two-heart rate level two
6. treatment two-heart rate level three

Each subject performed a single ride on the bicycle ergometer at a resistance which produced the desired heart rate level. Upon attaining this desirable level, the subject was then administered an emotional stimulation. Heart rate was monitored throughout testing and recorded on an electrocardiogram. Resting heart rates which included the anticipatory response were recorded immediately prior to the actual exercise bout. Heart rate responses immediately prior to stimulus presentation, from 0 to 5 seconds after stimulus presentation, from 5 to 10 seconds after stimulus presentation, and from 10 to 15 seconds after stimulus presentation were calculated. The differences between heart rates after stimulus presentation and prior to stimulus presentation were determined for each of the five second intervals. Differences between the subjects' highest heart rate responses and rates immediately prior to stimulus presentation were also computed.

Results

A completely randomized 2 x 3 factorial analysis of variance design was used to analyze the following variables:

1. resting heart rate
2. differences between heart rates 5 to 10 seconds after stimulus presentation and heart rates immediately prior to stimulus presentation
3. differences between heart rates 10 to 15 seconds after stimulus presentation and heart rates immediately prior to stimulus presentation
4. differences between highest heart rates after stimulus presentation and heart rates immediately prior to stimulus presentation

Statistical analysis revealed a significant difference in heart rate responses between heart rates immediately prior to stimulus presentation and heart rates after introduction of the stimulus. Emotional factors should, therefore, be taken into consideration in tests where heart rate is used as the criterion. Further analysis showed no statistical significance between the types of treatments (emotional stimuli) used, although both treatments produced significant elevations in heart rates from the time immediately prior to the presentation of the stimulus throughout the 15 second interval following the introduction of the stimulus. Results of the analysis of variance performed on the data indicated a significant treatment by level interaction at the .05 level. The significance was attributed mainly to the effects of the introduction of stimulus one at heart rate level one. Thus, at low heart rates the presentation of an emotional stimulus has a significant effect on the heart rate.

Conclusions

Based on the conditions of this study, it was concluded that working heart rates are significantly increased by the introduction of emotional stimuli. Emotional factors produced greater increases in heart rates when applied at lower levels of heart rate. Unique combinations of treatments and levels of heart rate have significant effects on submaximal exercise heart rates.