AEROBIC POWER AND RESPONSES TO PSYCHOSOCIAL STRESSORS

BY

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ABSTRACT

It has been demonstrated previously that after being exposed to psychosocial stressors the heart rates of high aerobic power people decrease more quickly than do the heart rates of low aerobic power people. The purpose of the present study was to determine whether this quicker recovery in heart rate would be reflected in affect or performance. Competing on a digit-letter task was the stressor used in the present study. Changes in heart rate were used as the physiological measure of stress, changes in perceived pleasantness as the affective measure of stress, and changes in performance as the behavioural measure of stress. The subjects were forty female and forty male volunteers from an introductory psychology course. The basic design was a 2 X 2 X 2 factorial with the first factor being sex (female, male), the second aerobic power (low, high), and the third competition (absent, present). The difference in heart rate recovery between low and high aerobic power people after being stressed was replicated. However, no differences in recovery rate of affect or performance were demonstrated. Various reasons for the occurrence of these results are discussed.

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INTRODUCTION

Stress has become a topic of great interest in recent years. Both scientific and popular literature abound with articles on stress and stress management. The need to reduce the risk of stress related diseases and improve the quality of life is most appealing and is reflected in a growing trend towards a more complete life-style of physical and mental well-being. Clinical research and popular 'how-to' books offer programmes ranging from cognitive restructuring of coping styles to simple relaxation techniques. Among these, physical fitness appears to be one variable that can improve the quality of life while increasing the ability to deal more effectively with daily stressful situations (Ardell, 1976; Cooper, 1978; Harris, 1963; Morgan, 1968). The present study investigates the possibility that a high level of physical fitness enables individuals to cope more effectively with stress.

Although the notion of stress has received much investigative attention, its actual nature is not as well understood as one might assume. Definitions and explanations abound throughout the literature and the study of stress has been the interest of many individuals representing a variety of disciplines. One of the most well known researchers in the area of stress is Hans Sèlye, an endocrinologist who has a medical degree as well as a Ph.D. in organic chemistry. Selye (1976) defines stress as the "non-specific response of the body to any demand" (p. 1). Explaining that stress can be perceived positively or negatively, Selye distinguishes between eustress and distress. Eustress refers to stress that is perceived as pleasant whereas distress refers to stress that is perceived as unpleasant. Selye states that "during both eustress and distress the body undergoes virtually the same non-specific responses to various positive or negative stimuli acting upon it" (p. 74). Stress can be viewed as the resulting condition following a demand. This demand has been termed the 'stressor'.

A number of researchers have referred to stress and stressors in somewhat less medical or biological terms. McGrath (1970) proposed that "stress occurs when there is a substantial imbalance between environmental demand and the response capability of the focal organism" (p. 17). It is not only the demand that arouses the individual but also the anticipation of that demand. "In this view stress exists...in an imbalance between perceived or subjective demand and the perceived response capability" (p. 17). Epstein (1975) maintains that stress reactions are best understood as responses to ego threats. If the individual perceives the future to be threatening, anticipates attacks on his self-esteem, or cannot clearly interpret his immediate environment, that person will feel uncomfortable, unpleasantly aroused, and anxious. A similar description is given by Cofer and Appley (1964), where stress is "the state of an organism where he perceives that his well being (or integrity) is endangered and that he must divert all his energies to its protection" (p. 453). Pointing out the diversity of literature focusing on stress, Appley and Trumbull (1967) write that the word stress "has been used as a substitute for what might otherwise have been called anxiety, conflict, emotional distress, extreme environmental conditions, ego-threat, frustration, threat to security, tension, or arousal" (p. 1). These present a primarily negative connotation that would refer to distress. Epstein (1975) points out that a stressor need not necessarily create spontaneous disorganization within the individual for it may well be met with adequate coping mechanisms. In this sense, stress may be understood as a beneficial state where the individual is being conditioned for subsequent, perhaps more stressful situations.

The knowledge of how one might best cope with distress has been the underlying purpose of the investigation of stress, knowledge that might be readily applied to the day to day activities of individuals. It has become evident that there are individual differences that influence, if not determine, the ability of some people and the inability of others to cope with given amounts of stress. Selye (1976) states that "...each individual, indeed every organ in his body, again goes through innumerable adaptive reactions to develop those characteristics which distinguish him from other individuals" (p. 434). Each individual perceives stressors differently and adapts to them in different ways. It is this varying adaptation resulting in different coping mechanisms that enables individuals to react uniquely to a stressor. When faced with a given stressor, one individual may react maximally while another may react minimally. One individual's reaction may result in a performance increase while the other's may result in a performance decrease. Selye believes that although inherent personality factors predispose individuals to certain coping abilities, "the manifest features of a person are largely the result of the stresses to which (this) adaptability is then exposed during the individual's own lifetime" (p. 435). Stressors and the adaptation to them become the coping mechanisms for subsequent stressors. Epstein (1975) suggested four factors that influence the individual's response to a stressor: "1) the current level of arousal, 2) the stability and flexibility of the individual's self-theory,

3) past training and habits in coping with stress and, 4) the rate and amount of stimulation expected" (p. 192). Sells (1970) offered additional variables to be considered. The individual is stressed when he is lacking in adequate responses for a given situation. "The unavailability of an adequate response may be due to the individual's response repertoire, lack of training, equipment, or opportunity to prepare" (p. 138).

Realizing that individuals differ in coping with stress and recovering from stress, a number of studies have investigated relationships between stress and various individual variables. Lefcourt (1976) dealt with locus of control (whether the individual perceives himself to be in control of or controlled by his immediate environment). Houston (1972) studied control over stress and response to stress in terms of this locus of control. Friedman and Rosenman (1974) devised a basic life-style measure, Type A or non-Type A, largely determined by how the individual dealt with daily stressors. Lazarus (1966) pointed out that "the appraisal of a threat is not a simple perception of the elements of the situation, but a judgment, an inference in which the data are assembled to a constellation of ideas and expectations" (p. 44). Past experience and general life-attitudes will influence how one approaches problems and stressors from day to day.

Another variable that has received some investigation is physical fitness. It has been demonstrated that when asked to perform a complex task while being subjected to a physical stressor, fit people perform better than do unfit people (Weingarten, 1973). Physically fit people report a 'general feeling of well-being' (Morgan, 1968), and this has instigated much investigation. If physically fit people actually do feel better, then perhaps physical fitness is an individual difference somehow related to an over-all personality profile. Harris (1963) reports that "there is a tendency for the 'fit' individuals to appear more stable in certain psychological traits and to appear less anxious in others" (p. 293). Physically fit children appear superior on measures of dominance, extroversion, social orientation and group interaction (Tillman, 1965). Rarick and McKee (1949) reported that those children scoring high on motor proficiency tests also demonstrated less nervous tension and were more socially adjusted than children who scored low on the same physical measure.

The present study looks at physical fitness as being one variable influencing individual coping and recovery from stress. Although strength, muscular endurance, and flexibility are important, it is generally accepted by exercise physiologists that the best measure of an individual's physical condition is his or her cardio-vascular-respiratory fitness. Glassford, Baycroft, Sedgwick and MacNab (1965) state that "...the ability to perform hard physical work is related to the maximal capacity of the cardio-vascular-respiratory system to take up, transport, and give off the oxygen" (p. 509). Cooper (1978) states that oxygen consumption is the key to fitness and the amount of oxygen that the body can utilize is the best measure of physical fitness. This is a measure of the individual's maximum oxygen uptake or the amount of oxygen utilized by the body while at a maximum workload, and is a comment on the efficiency of the lungs, the heart, and the blood vessels in transporting oxygen from the environment and utilizing it within the body. This is the aerobic power of the individual. Measuring physical fitness in this way has been used effectively by a number of researchers (Åstrand & Rodahl, 1977; Cooper, 1978; Taylor & Buskirk, 1955). Aerobic power is adjusted according to individual body differences, age and sex, and is measured in milliliters of oxygen consumed per kilogram of body weight per minute (ml/kg/min).

One study dealing with physical fitness and stress monitored the heart rates of subjects exposed to a psycho-social stressor (Cox, Evans, & Jamieson, 1979). The initial response to the stressor and then the recovery following the removal of the stressor were measured. Subjects had been previously tested to determine level of physical fitness (aerobic power) and it was reported that high aerobic power individuals recovered more quickly from the effects of the stressor than did low aerobic power individuals. The psychosocial stressor was such that subjects were led to believe that their level of performance on some tests was far below average. The experimenter became quite agitated and ended the session by storming out of the room. Following perceived failure, where all subjects' heart rates reacted similarly, heart rate recovery was quicker for high aerobic power individuals compared to low aerobic power individuals. Similar results were reported by Sellick (1977).

Stressors, those things which cause stress, are many and varied. Research has studied environmental factors such as extreme temperatures (Weybrew, 1967), noise (Glass & Singer, 1972), density (Freedman, 1973), and sensory deprivation (Zubek, 1969). Of increasing interest in recent years has been the study of psychosocial stressors where the stressor is another person or other people. A stressor of this nature may be comprised of a number of factors which may not be completely independent of one another. Possible factors or effects involved are: coaction (Allport, 1924), rivalry (Allport, 1924), audience (Zajonc, 1965), evaluation apprehension (Cottrell, 1968), and impending social comparison (Evans, 1974). When studying the effects of a psychosocial stressor, both the nature of the stressor and the nature of the individual's perception of that stressor need to be understood as being equally important in terms of the impact of the situation upon the individual. Although the research in the area of psychosocial stressors began in the late 1800's, the situations studied were not referred to as being 'psychosocially stressful'. Psychosocial stressor is a relatively recent expression capable of referring to all manner of specific situations resulting in an observed or inferred change in the individual.

The present study used a competitive situation as a stressor. In a competitive situation there are a number of processes taking place. The nature of the situation dictates that both individuals are striving towards the attainment of a goal that only one of them may achieve. As one individual is able to move closer to his goal, the other individual moves further away from his (Deutsch, 1968).

With the competition then there may be coaction effects as the competitors sit facing each other. Triplett (1897) studied children in a coactive situation and reported that while in the presence of others performing the same tasks, children were able to turn fishing reels faster and count more quickly than when they performed these tasks alone. Similarly, Allport (1924) reported that when in the presence of others, subjects wrote more associations, produced more vowel cancellations and more perspective reversals, completed more multiplication problems and wrote more refutations of a given argument than when alone. Allport (1924) also maintained that a distinction was necessary between coaction and rivalry, both resulting in the performance increase, the former being the presence of another engaged in the same activity in full view of one another and the latter being a cognitive desire to outperform others. Also in the competitive situation will be audience effects. Zajonc (1965), in his review of the literature, concluded that along with coaction and rivalry should be a factor or effect termed 'mere presence'. He believed that the mere presence of another individual would be capable of enhancing performance. During competition in the present study, the subjects' performance would be observed by the experimenter and in terms of Zajonc's comments, this would be an additional psychosocial stressor. There may also be evaluation apprehension assuming that the outcome of the competition will be evident to both competitors and spectators. Cottrell (1968) took exception with Zajonc's notion of mere presence by maintaining that the audience effect will only enhance performance if the spectator will evaluate the individual's performance. The presence of an audience must be interpreted in terms of impending reward or punishment and it is the anticipation of such evaluation that serves as the stressor. Similar conclusions were reported by Henchy and Glass (1968) and by Paulus and Murdoch (1971). An interesting addition to the evaluation apprehension discussion is the work of Weiss and Miller (1971). They interpreted audience effects first as an aversive stressor where the anticipation of failure is the motivating force and second, as a positive stressor where the audience is a cue for possible positive social reinforcement. These studies have all demonstrated that a psychosocial stressor enhances performance. In these instances the stressor has aroused the individual to a point not beyond his level of optimal arousal.

In the present study subjects were exposed to a psychosocial stressor (competition). Throughout the experiment three measures of individual responses were monitored for both those subjects exposed to the stressor and those not exposed to the stressor (control). Stress is accompanied by a general physiological arousal which, in the present study, was monitored by measuring heart rate.

The second measure used was a self-report rating on a twenty-one point perceived pleasantness scale. Very little work has been done concerning the changes in affect upon presentation and then removal of a stressor. As Selye pointed out, the individual's perception of the situation will greatly influence the total experience of that situation. That is, while one individual may report it to be rewarding and positive, another may report the same situation to be threatening. The first will more likely attend to the task and perhaps improve performance, interpreting the experience as eustress. The second will more likely concentrate on reducing the effects of the threatening situation (anxiety, fear) and may have a decrease in performance. This would then be a distressful situation. Selye believes that we have the ability to deal with potentially threatening stressors in a positive manner and that our attitude towards the stressor will greatly influence our actual behaviour in face of that stressor.

The third measure used was a behavioural measure, performance on a pencil and paper task. Performance can either be enhanced or retarded during stress. Depending upon the nature and degree of the stressor, as well as the response capabilities of the individual, performance may increase or decrease. The relationship between arousal and performance is best understood in terms of an inverted-U (Malmo, 1959). Too much stress will result in a decrease in performance, as will too little stress. Therefore, each individual has his own particular level of stress at which he will perform maximally. This optimal level of arousal is different for each individual and for each individual, is different for each task. In the case of too little stress, boredom results in a performance decrease as attention wanders from the task. In the case of too much stress, the individual's attention is devoted towards reducing the anxiety and discomfort of the stressor rather than towards maximum performance.

The interest in collecting data from these three measures stems from the fact that it is not known whether the apparent physiological advantage of the high aerobic power individual in recovering from stress more quickly than the low aerobic power individual is accompanied by affective or behavioural differences. Fish (1978) demonstrated a positive correlation between heart rate and performance while the individual was exposed to a stressor. That is, heart rate increase was accompanied by performance increase. The present study anticipated a similar correlation after the removal of the stressor. That is, heart rate decrease would be accompanied by performance decrease. In view of the quicker heart rate recovery for high aerobic power individuals, a quicker performance decrease was anticipated for high aerobic power individuals. At first glance this would appear to be a disadvantage for the high aerobic power people for they would likely prefer their performance to not decrease quickly. It must be noted that this present study is only the first step in a series of studies that would be necessary to fully investigate this area. This is a low stress situation with a simple task. Subsequent studies would vary the degree of stress and the degree of task difficulty. If performance does correlate with heart rate following the removal of the stressor and the performance of the high aerobic power people does decrease quickly, the next step would be to investigate the same question under a high stress situation. The implication is that following a situation where individuals were stressed beyond their optimal level of performance, the quicker heart rate recovery of the high aerobic power individual would enable him to more quickly return to an optimal level of performance.

There is no research to indicate how subjects may respond affectively, although intuitively one might expect that as performance deteriorated, subjects would report the experience to be less pleasant. Similarly, as performance increased, subjects might report the experience to be more pleasant. The author had expected the pleasantness ratings of the high aerobic power individuals to decrease more quickly than those of the low aerobic power individuals following the removal of the stressor. Quicker heart rate recovery was expected to be accompanied by quicker performance decrease, and quicker performance decrease was expected to be accompanied by quicker pleasantness rating decrease.

METHOD

Subjects

Eighty Introductory Psychology students were asked to participate in a short test that would determine their level of physical fitness. Forty female subjects and forty male subjects were given two marks towards their final course grade for their participation in the fitness test and in the experiment conducted a few weeks later in the psychology department. The first part of the experiment was conducted in the exercise physiology laboratory. Subjects were encouraged to participate in both parts of the experiment and were informed that partial participation was of no value to the experimenter. Towards the end of the data collection, two subjects could not be contacted and were replaced by one female and one male from a third year psychology course. These participants received no credit towards their course grade. Ages ranged from 18 years to 24 years.

Apparatus

The aerobic power of each individual was measured using the Åstrand-Rhyming (1954) nomogram whereby the individual performed submaximally on a Monark bicycle ergometer. The heart rate of each individual was monitored using a cardiometer measuring heart rate.

During the second part of the experiment in the psychology laboratory, heart rate was measured using a polygraph (Gilson Model M5P). The polygraph was situated behind a wall of shelves in such a way that the subjects were not able to observe the record of their heart rate. The use of heart rate as a measure of physiological arousal has been the focus of debate in recent years (Elliott, 1969, 1972, 1974; Lacey, 1967, 1974). However, Weybrew (1967), writes that an increase in heart rate is an accurate indicator of an increase in psychological stressors. There is good evidence that in situations of incentive manipulations and in situations where task performance will be monitored, heart rate is an accurate comment on changes in physiological arousal (Elliott, 1974; Evans, 1972, 1974). Additional support for the use of heart rate as a measure of stress caused by cognitive stressors has been provided by Blix, Stromme, and Ursin (1974).

On completion of each task trial the experimenter asked the subject to rate his perceived pleasantness on a scale of one to twenty-one. Appendix I contains the perceived pleasantness rating scale.

Performance on a digit-letter substitution task was the behavioural measure used throughout the experiment. There were eight trials of this task given to each subject. Appendix II contains an example of the digit-letter substitution task.

Procedure

The first part of the experiment was conducted in the exercise physiology laboratory and subjects were tested either alone or two at a time. The procedure for testing aerobic power was as outlined by Åstrand and Rodahl (1977). Appendix III provides basic guidelines for the submaximal test of aerobic power.

Subjects first read and then signed a consent form (Appendix IV) indicating that they were prepared to take part in the experiment. Sex, age, weight, and blood pressure (precautionary measure) were recorded. In order to record heart rate throughout the session, a pick-up was placed in the vicinity of the heart and secured with an elastic strap. Males did not wear shirts. Females were instructed on how the pick-up was to be worn and then stepped behind a screen and secured the pick-up beneath their clothing. Subjects were then asked to sit on the bicycle ergometer and the seat was adjusted so that there was full leg extension when pedalling. The pick-up was plugged into the cardiometer (Cardionics ab, P-2) which was situated in such a way that the subject would not be able to observe his heart rate. The subject was instructed to pedal the bicycle to the beat of a metronome set at 100 beats per minute. This resulted in the subject pedalling fifty revolutions per minute.

The subject was asked to rate how physically fit he thought he might be and asked how much he exercised. From this the experimenter set the workload at a level estimated to be sufficient to increase heart rate to approximately 130 bpm by the end of a six minute period. If the workload appeared to be not sufficient to result in this heart rate, it was increased within the first few minutes and the six minute period was begun again. The heart rate after five minutes was recorded and then compared to that after six minutes. If the heart rate remained at a steady state over that one minute period (± 5 bpm), the second six minute period began. If heart rate varied more than 5 bpm from the fifth to the sixth minute, an additional minute was added to the period until steady state was achieved. The second six minute period was conducted with an additional workload designed to result in a steady state heart rate of 150 bpm by the end of the period. Again, heart rate could not vary more than ± 5 bpm during the last minute of the period.

Subjects were then instructed to continue to pedal as the workload was decreased and heart rate recovered. Once heart rate had returned to less than 100 bpm, subjects were instructed to stop pedalling and to remove the pick-up. Subjects were told that they would be contacted within a few weeks in order to set a time for the second part of the experiment, following which the results of the physical fitness test would be available to them. The subject was then dismissed.

A second experimenter was given the obtained data from all subjects and it was this second experimenter who determined the predicted MVO_2 (aerobic power), and then placed subjects in groups according to their measured aerobic power. Aerobic power was determined using charts published by Åstrand and Rodahl (1977, pp. 343-355). Results were checked using a disc provided with the Monark bicycle ergometer (Åstrand, 1960). Subjects were rank-ordered within each sex. The top twenty females and the top twenty males comprised the high aerobic power group while the lower twenty females and the lower twenty males comprised the low aerobic power group.

Upon entering the psychology laboratory for the second part of the experiment, each subject was asked to sit at the table and to make himself comfortable. The plethysmograph was placed on the first finger of the non-preferred hand and its function was explained. Participants were assured that there would be no pain and informed of the importance of keeping the plethysmograph as still as possible throughout the session.

Subjects were made aware of the Perceived Pleasantness Rating Scale and were then asked to make themselves comfortable and to relax as much as possible for a period of time. Following the first relaxation period (three minutes), subjects rated how pleasant they had found the last few seconds of that period and were then introduced to the digit-letter substitution task. Subjects were allowed sixty seconds to complete as many substitutions as possible after which they rated how pleasant they had found doing the task. Three additional trials, each followed by a pleasantness rating, were administered to each subject.

On completion of trial four, the experimenter looked at the cards previously prepared by the second experimenter. It was at this time that the first experimenter discovered which group the subjects had been assigned to, the no competition group or the competition group. If the subject had been assigned to the no competition group, trial five continued as had trials one, two, three, and four. If the subject had been assigned to the competition group the experimenter excused himself from the room, returning within thirty seconds with another first year psychology student. In this situation the second student (a confederate) was asked to sit in the chair opposite the subject. The second plethysmograph was placed on the first finger of the confederate's non-preferred hand and its function was explained. Two tasks were placed face down on the table, one in front of each student. Instructions were again given regarding the procedure and then it was explained that as well as trying to do the task as quickly and as well as possible, each individual was expected to try and beat the other person in the number of completed substitutions in the one minute trial. The trial was then run, after which the confederate was shown from the room and the original subject asked how pleasant he had found the competition.

Trials six, seven, and eight were then administered and the procedure was idential for all subjects. These final three trials were run identically to the first four trials.

On completion of trial eight the subject was asked to once again make himself as comfortable as possible so that he might relax for a short period. Once the subject was comfortable, the three minute relaxation period began. At the end of the relaxation period the subject was asked to rate how pleasant he had found the last few seconds of the relaxation period.

The plethysmograph was then removed and the subject was told that the experiment was completed. The subject was then debriefed and all aspects of the experiment were explained and all questions were answered. With this the session was ended and the subjects were shown from the room.

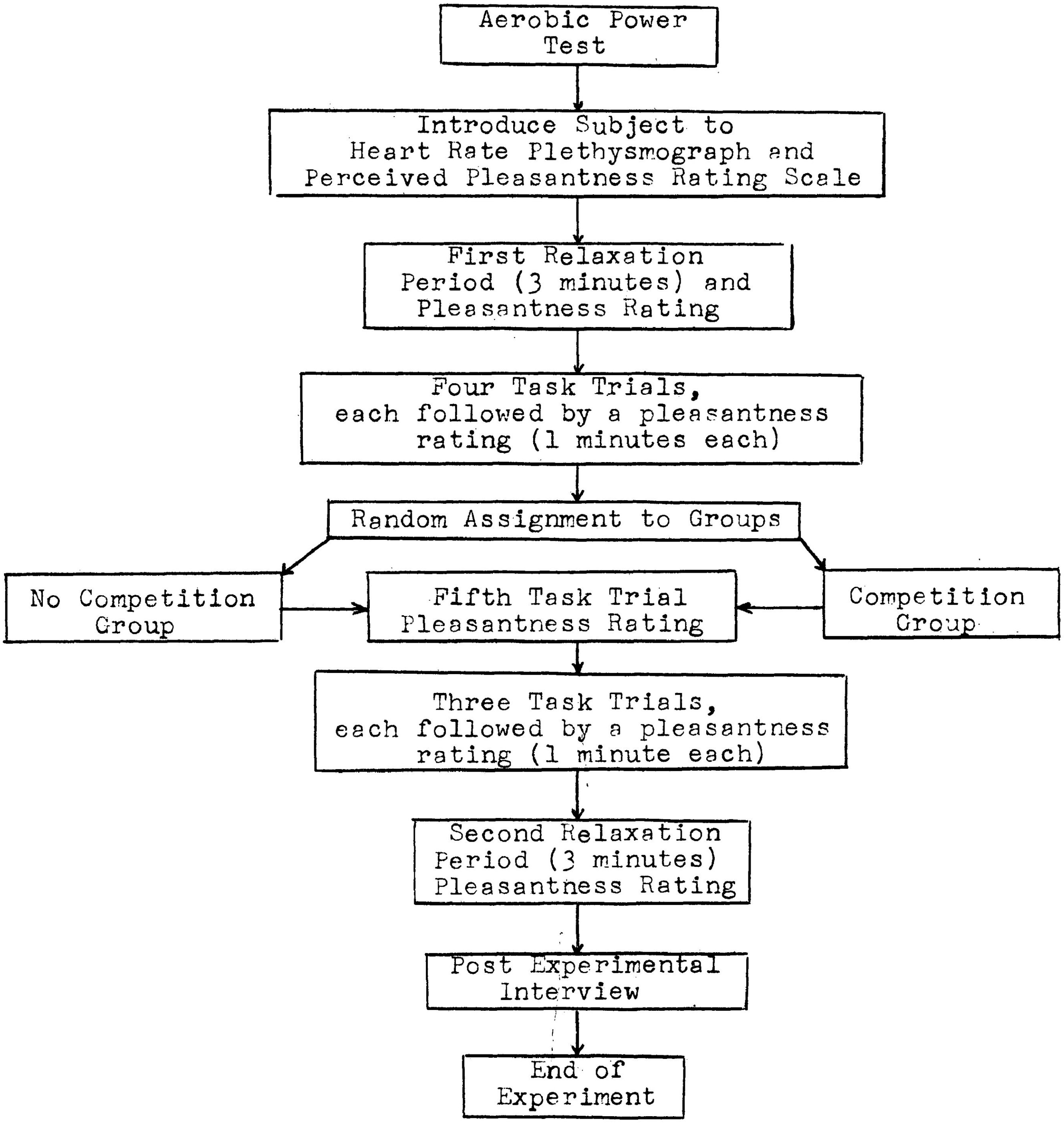
Appendix V contains a set of verbatim instructions and procedure for the experiment. Appendix VI presents the topics covered during the post-experimental interview. Figure I presents a flow chart of the experimental procedure.

Figure I

FLOW CHART

OF

EXPERIMENTAL PROCEDURE



RESULTS

This study used a 2 X 2 X 2 factorial design. The first two factors were classificational variables, each with two levels. The first factor was sex (female, male) and the second factor was aerobic power (low aerobic power, high aerobic power). As explained previously, subjects had been administered a test of aerobic power and then, within each sex, had been classified as either having low aerobic power or high aerobic power. The third factor was the competition manipulation where within sex and aerobic power groups, subjects were randomly assigned to either no competition or competition.

Aerobic Power Analyses

Table I presents the means and standard deviations for aerobic power for each of the eight groups in this design. Aerobic power is presented in milliliters of oxygen utilized per kilogram of body weight per minute (ml/kg/min). Aerobic power data were analyzed using 2 X 2 X 2 factorial analysis of variance to determine whether groups differed on this variable. The analysis on the data presented in Table I indicated a significant main effect due to sex, $\underline{F}(1,72) = 9.26$, $\underline{p} < .01$. Aerobic power for females ($\overline{X} = 36.83$ ml/kg/min) was less than that for males ($\overline{X} = 40.23$ ml/kg/min). There was also a significant main effect due to aerobic power, $F(1,72) = 124.13$, $p < .001$. Aerobic power for the low aerobic power group ($\overline{X}$ = 32.30 ml/kg/min) was lower than that for the high aerobic power group ($\overline{X}$ = 44.75 ml/kg/min). Appendix VII contains a summary of this analysis and the aerobic power data.

Table I

Means and Standard Deviations for Aerobic Power* of All Groups

Independent Variables			N	Mean	Standard Deviation
Female	LAP	NC	10	30.30	3.71
		C	10	30.90	3.63
	HAP	NC	10	43.90	7.82
		C	10	42.20	4.56
Male	LAP	NC	10	34.10	3.76
		C	10	33.90	3.87
	HAP	NC	10	46.50	5.93
		C	10	46.40	5.15
For Entire Sample			80	38.52	8.07

*measured in milliliters of oxygen utilized per kilogram of body weight per minute.

PreStress Measurements

The next analyses were performed on prescores, i.e., the data collected during the fourth trial which was the last trial before the competition manipulation.

Analyses were completed to determine on what variables groups differed before the manipulation was introduced. Three variables were measured during this trial, namely heart rate, perceived pleasantness, and performance.

The analysis on heart rate prescores indicated a significant main effect due to aerobic power, $F(1,72) = 10.71$, $p < .01$. Heart rate for the low aerobic power group ($\bar{X} = 89.58$ bpm) was higher than that for the high aerobic power group ($\bar{X} = 81.60$ bpm). Appendix VIII contains a summary of this analysis.

The analysis on perceived pleasantness prescores did not reveal any significant differences, nor did the analysis on performance prescores. Appendix IX and Appendix X contain summaries of these analyses, respectively.

Stress Measurements

The three dependent variables used to measure the response to stress were heart rate change-scores, perceived pleasantness change-scores, and performance change-scores. Change-scores were calculated by subtracting scores obtained during the fourth trial from scores obtained during the fifth trial. The fifth trial was the trial during which the competition manipulation took place.

The analysis on heart rate change-scores indicated a significant main effect due to sex, $\underline{F}(1,72) = 5.78$, $\underline{p} < .05$. Heart rate change for females ($\bar{X}\Delta = 4.50$ bpm). was less than that for males ($\bar{X}\Delta = 9.40$ bpm). There was also a significant main effect due to competition, $\underline{F}(1,72) = 39.75$, $\underline{p} < .001$. Heart rate change for the no competition groups ($\bar{X}\Delta = .53$ bpm) was less than that for the competition groups ($\bar{X}\Delta = 13.38$ bpm). A sex by competition interaction was also revealed, $\underline{F}(1,72) = 4.98$, $\underline{p} < .05$. For females the difference in heart rate change for the no competition group compared to the competition group was 8.30 bpm. This same difference for males was 17.40 bpm. Figure II illustrates this interaction and Appendix XI contains a summary of this analysis.

The analysis on perceived pleasantness change-scores indicated a significant main effect due to competition, $\underline{F}(1,72) = 8.58$, $\underline{p} < .01$. Perceived pleasantness change for the no competition groups ($\bar{X}\Delta = .02$ points) was slightly positive while that for the competition groups ($\bar{X}\Delta = -1.7$ points) was negative. There was also a sex by competition interaction which approached significance, $\underline{F}(1,72) = 3.33$, $\underline{p} < .07$. For females the difference in perceived pleasantness change for the no competition group compared to the competition group was -2.8 points. This same difference for males was -.65 points. Figure III illustrates this interaction and Appendix XII contains a summary of this analysis.

FIGURE II

DIFFERENCES IN HEART RATE CHANGE FOR FEMALES COMPARED TO MALES

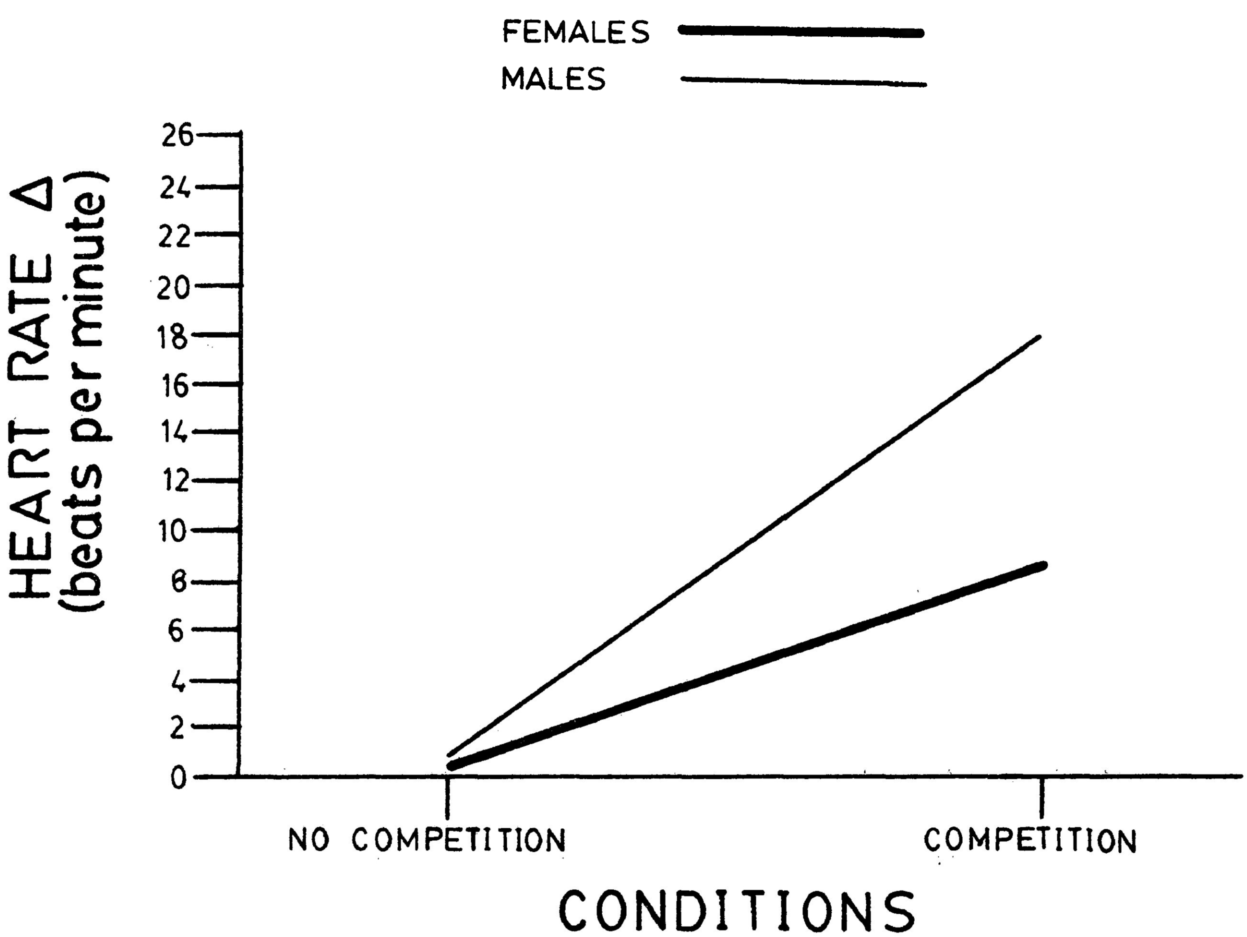
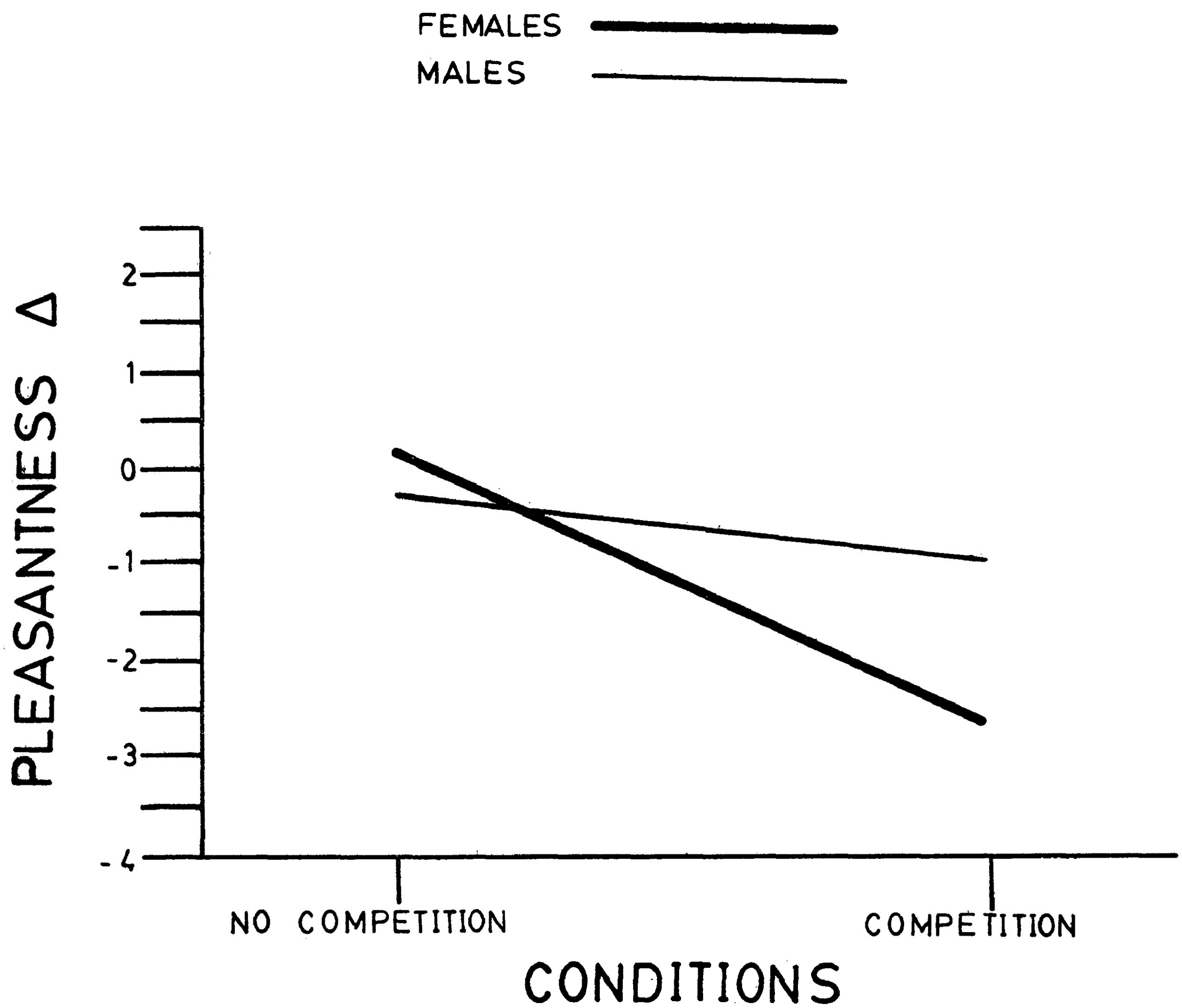


FIGURE III

DIFFERENCES IN PERCEIVED PLEASANTNESS CHANGE FOR FEMALES COMPARED TO MALES



The analysis on performance change-scores did not reveal any significant differences. Appendix XIII contains a summary of this analysis.

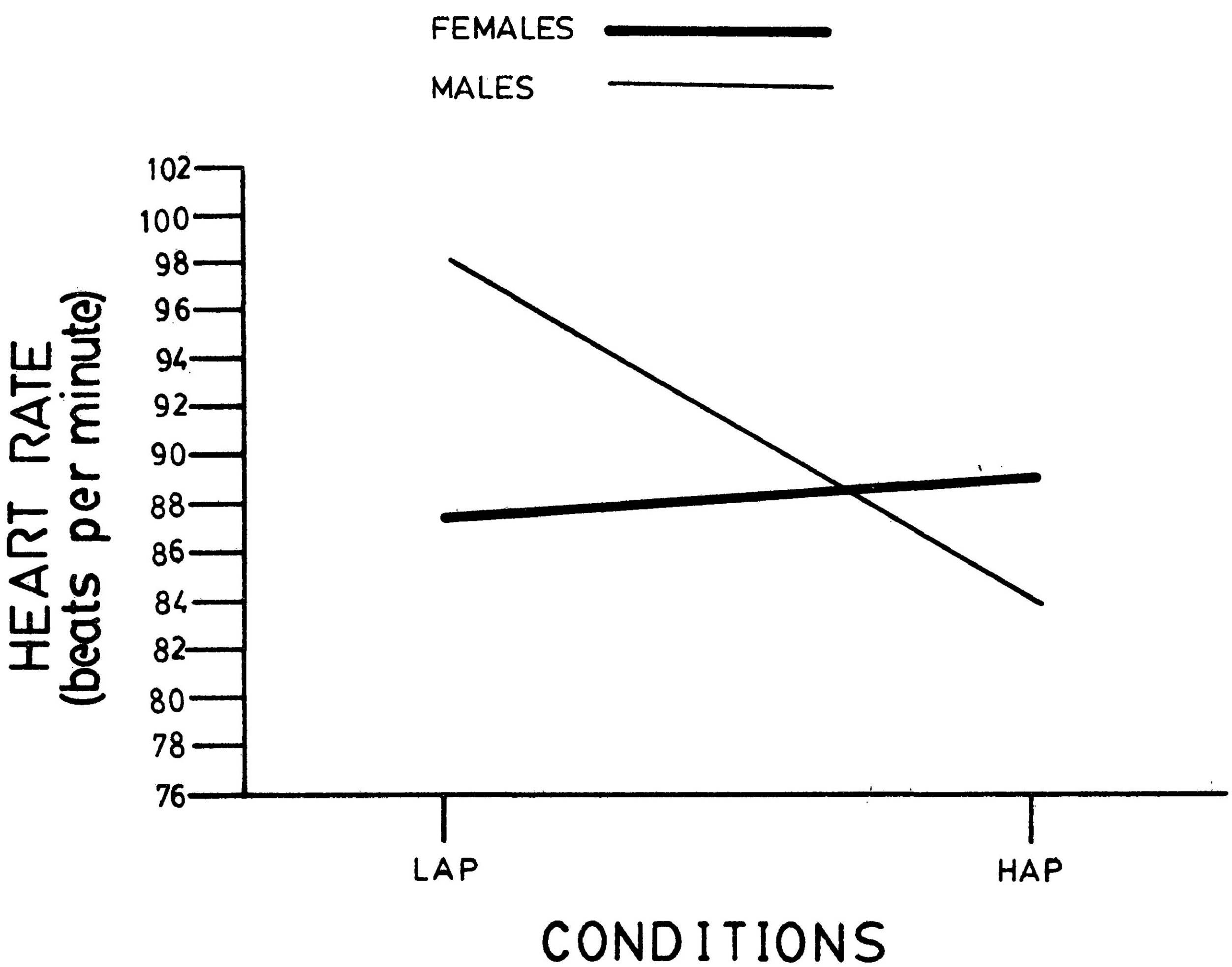
Recovery from Stress Measurements

Analyses were performed to determine whether sex or aerobic power were associated with recovery from stress. Since only the forty subjects exposed to a competitor were stressed, only data from these forty subjects were analyzed.

As mentioned previously there were three recovery trials and a rest period following the competition manipulation during trial five. To investigate recovery from stress, 2 X 2 X 4 analyses of variance were used on heart rate, perceived pleasantness, and performance data. The first between-groups factors was sex (female, male), the second between-groups factor was aerobic power (low aerobic power, high aerobic power), and the within-groups factor was trials (competition trial and three recovery trials). The heart rate analysis revealed a significant sex by aerobic power interaction, $\underline{F}(1,36) = 5.12$, $\underline{p} < .05$. For females the difference in heart rate change between the low aerobic power group and the high aerobic power group was 1.83 bpm. The same value for males was -14.45 bpm. Figure IV illustrates this interaction. There was also a sex by trials interaction, $\underline{F}(1,108) = 3.98$, $\underline{p} < .01$. Across trials, heart rate

FIGURE IV

DIFFERENCE IN HEART RATE RECOVERY CHANGE COLLAPSED ACROSS TRIALS 5,6,7, & 8 FOR FEMALES COMPARED TO MALES



recovery for females (-10.00 bpm) was less than that for males (-17.95 bpm). Figure V illustrates this interaction. A significant aerobic power by trials interaction was also revealed, $\underline{F}(1,108) = 2.63$, $\underline{p} < .05$. Across trials, the heart rate recovery for the low aerobic power people (-10.85 bpm) was less than that for high aerobic power people (-17.10 bpm). Figure VI illustrates this interaction and Appendix XIV contains a summary of this analysis.

The 2 X 2 X 4 analysis on perceived pleasantness did not detect any differences. The analysis on performance change revealed a significant main effect due to sex, $\underline{F}(1,36) = 4.03$, $\underline{p} < .05$. Collapsed across trials, average performance score for females ($\overline{X} = 55.76$ completions) was greater than that for males ($\overline{X} = 50.71$ completions). Summaries of these analyses for perceived pleasantness and for performance are contained in Appendix XV and Appendix XVI respectively.

Upon completion of analyses utilizing the data from the competition trial and the three recovery trials, it appeared that the major proportion of recovery among groups occurred immediately following the competition trial. In order to determine whether differences among groups became apparent during this immediate recovery, subsequent data analyses were done on the first

FIGURE V

DIFFERENCE IN HEART RATE RECOVERY CHANGE FOR FEMALES COMPARED TO MALES

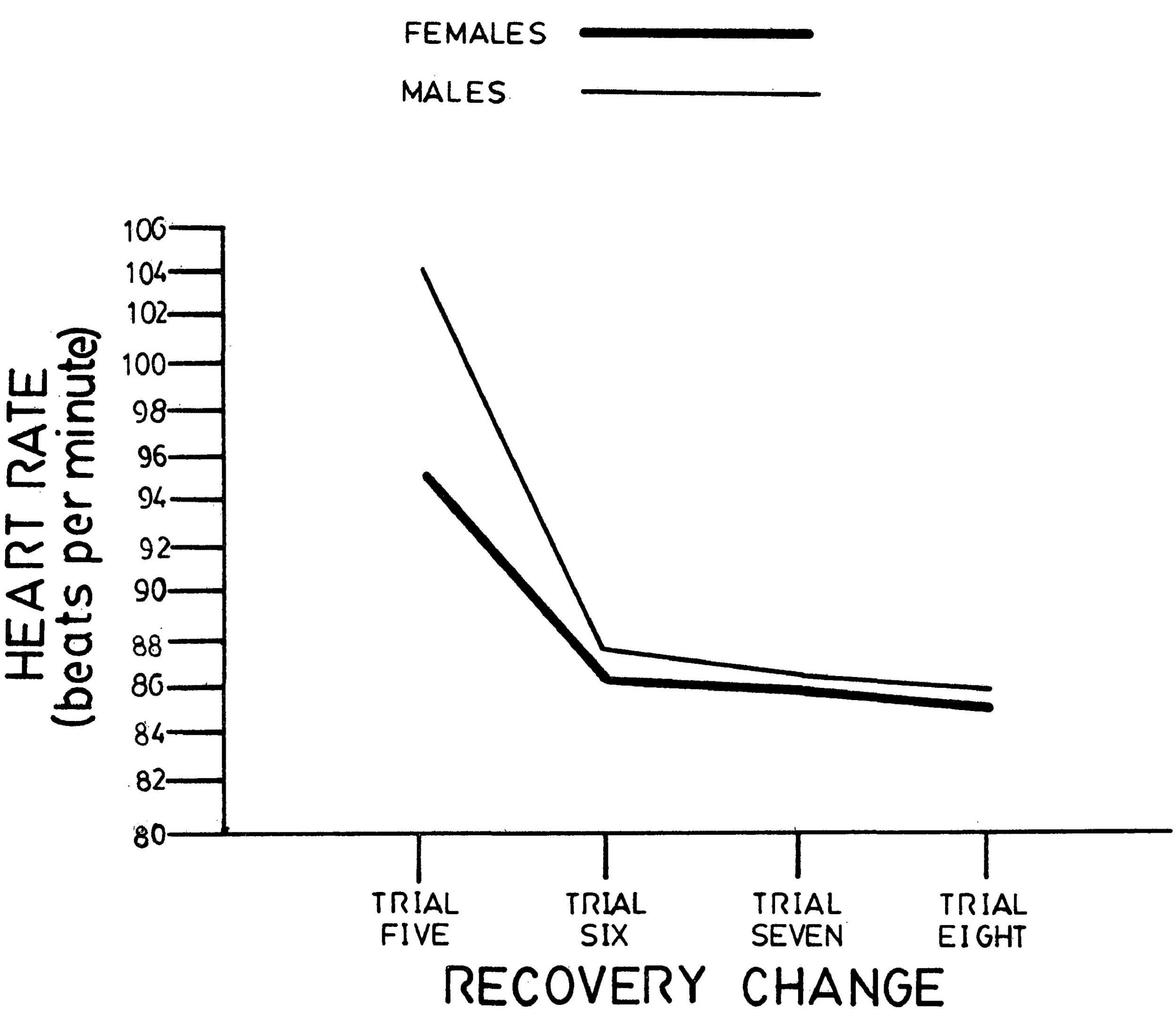
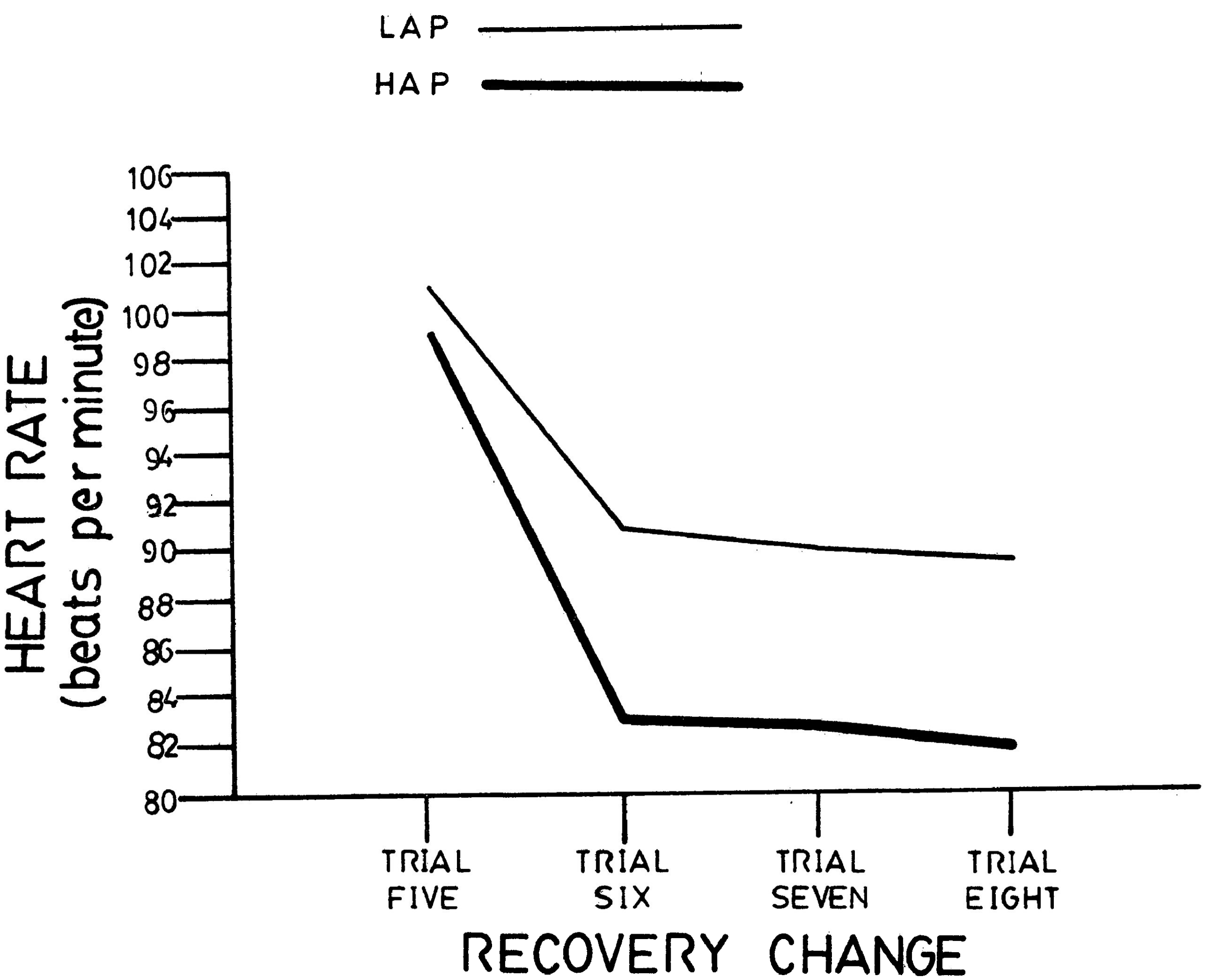


FIGURE VI

DIFFERENCE IN HEART RATE RECOVERY CHANGE FOR LOW AEROBIC POWER PEOPLE COMPARED TO HIGH AEROBIC POWER PEOPLE



recovery trial using 2 X 2 analyses of variance. The first factor was sex (female, male) and the second factor was aerobic power (low, high). Three dependent variables were used to measure immediate recovery from stress, heart rate recovery-change-scores, perceived pleasantness recovery-change-scores, and performance recovery-change-scores. Recovery-change-scores were calculated by subtracting variable scores obtained during trial five, i.e., the competition trial, from corresponding scores obtained during trial six, i.e., the first post-competition trial.

Analysis on heart rate recovery-change-scores indicated a significant main effect due to sex, $\underline{F}(1,36) = 4.12$, $\underline{p} < .05$. Heart rate recovery for females ($\overline{X}\Delta = -9.10$ bpm) was less than that for males ($\overline{X}\Delta = -16.45$ bpm). There was also a main effect approaching sifnificance due to aerobic power, $\underline{F}(1,36) = 3.52$, $\underline{p} < .07$. Heart rate recovery for the low aerobic power group ($\overline{X}\Delta = -9.40$ bpm) was less than that for the high aerobic power group ($\overline{X}\Delta = -16.15$ bpm). Appendix XVII contains a summary of this analysis.

The analysis on perceived pleasantness recovery-change-scores did not reveal any significant differences, nor did the analysis on performance recovery-change-scores. Appendix XVIII and Appendix XIX contain summaries of these analyses.

Relaxation Period Measurements

Analyses utilizing the heart rates and the perceived pleasantness ratings from the two relaxation periods were completed to investigate recovery from stress. To determine whether the stressed groups differed in change from the first relaxation period to the second relaxation period, the values from the first period were subtracted from those of the second period. These data were analyzed using 2 X 2 factorial analyses of variance. The first factor was sex (female, male) and the second factor was aerobic power (low, high). The heart rate data did not reveal any differences among groups. For perceived pleasantness there was a difference which approached significance, $F(1,36) = 3.58$, $p < .07$.. The pleasantness rating for low aerobic power people increased (0.9 points) from the first to the second relaxation period. The corresponding value for high aerobic power people decreased (-0.45 points). Appendix XX and Appendix XXI contain summaries of these analyses, respectively.

Correlations

To investigate possible relationships among physiological, affective, and behavioural variables during stress and during recovery from stress, some correlational analyses were performed.

The first set of analyses were done on change-scores, i.e., the correlations among heart rate change-scores, perceived pleasantness change-scores, and performance change-scores. Recall that change-scores were arrived at by subtracting the values measured during trial four from the corresponding values measured during trial five. The first correlational analysis was done using the data from all eighty of the subjects who participated in the experiment. Then, these same correlations were calculated using the data from the forty subjects who were not stressed, i.e., the forty subjects who were in the no competition group. Finally, these same correlations were calculated using the forty subjects who were stressed, i.e., the forty subjects who were in the competition group. Tables II(a), II(b), and II(c) present these analyses.

The second set of analyses were done on recovery-change-scores, i.e., the scores used to measure recovery from stress. Recovery-change-scores were arrived at by subtracting the values measured during trial five from the corresponding values measured during trial six. The first correlational analysis was done using heart rate recovery-change-scores, perceived pleasantness recovery-change-scores, and performance recovery-change-scores for all eighty subjects. Similar correlations were calculated using data from the forty subjects who were not stressed and then using the data from the forty subjects who were stressed. Tables III(a), III(b), and III(c) present these analyses.

Table II

Correlation Matrix for the Three Dependent Measures used to Measure Stress

a) All Subjects (n = 80)

	heart rate	pleasantness	performance
heart rate		-0.1089	0.1593
pleasantness			0.0945

b) No Competition Subjects (n = 40)

	heart rate	pleasantness	performance
heart rate		0.2470	0.3663*
pleasantness			0.4994**

c) Competition Subjects (n = 40)

	heart rate	pleasantness	performance
heart rate		0.0559	0.0713
pleasantness			-0.0257

* $p < .01$

** $p < .001$

Table III

Correlation Matrix for the Three Dependent Measures used to Measure Recovery from Stress

a) All Subjects (n = 80)

	heart rate	pleasantness	performance
heart rate		-0.0779	0.0203
pleasantness			0.3293*

b) No Competition Subjects (n = 40)

	heart rate	pleasantness	performance
heart rate		0.2132	0.0772
pleasantness			0.4248**

c) Competition Subjects (n = 40)

	heart rate	pleasantness	performance
heart rate		0.1618	0.0256
pleasantness			0.3119*

* $p < .05$

** $p < .001$

DISCUSSION

Analyses were completed on aerobic power data and on prescore data in order to detect differences among groups before the experimental manipulation was introduced. For the aerobic power data, it was found that females had a lower average aerobic power than did males. Based on previous research (Åstrand, 1975), this sex difference was anticipated. For the prescores obtained during trial four, the only difference found was physiological. Average heart rate during trial four for the low aerobic power group was higher than that for the high aerobic power group. One would expect this since aerobic power is a measure of the efficiency of the cardio-vascular-respiratory system, and the individual with a less efficient system tends to have a higher heart rate (Åstrand, 1975). No differences were detected by the analyses on affective prescore data or behavioural prescore data, indicating that the random assignment procedures used were satisfactory.

The main purpose of this study was to determine whether recovery from stress would manifest itself in affective change and behavioural change as well as in physiological recovery. It had been suggested that the benefit of a quicker heart rate recovery, found among individuals with high aerobic power, would be accompanied by a quicker change in affect and performance. Before dealing with the recovery from stress analyses it is necessary that the initial responses of the subjects to the stressor be discussed.

Stress

Competition was an effective stressor producing both physiological change and affective change that was not found among subjects not exposed to competition. Compared to those not in competition, subjects in competition demonstrated a greater increase in heart rate and a greater decrease in perceived pleasantness. It has been well substantiated that the presence of a psychosocial stressor is accompanied by heart rate increase (Cox, Evans, & Jamieson, 1979; Evans, 1972, 1974; Sellick, 1977). The decrease in affect is as one might expect, that people do not generally enjoy competition of this nature. To the author's knowledge no previous work has been reported that might provide empirical evidence supporting this finding. Whether this result is a comment on the nature of the situation or on the nature of the participants (university students) is not known. Regardless, this self-report measure deserves further study.

One additional difference was the way in which females differed from males in reacting to competition. In comparison to their respective no competition groups, females' heart rates increased less than did the males', while females' perceived pleasantness rating decreased more than did the males'. It is possible that females and males respond differently to competition. Neufeld and Davidson (1974) reported some evidence supporting sex differences in response to stress. Males were generally more reactive on heart rate and skin conductance measures following exposure to a stressor (pictures of mutilated bodies). Females were generally more responsive on two of the three self-report indexes, following exposure to the same stressor. However, in the present study other possibilities could account for the sex differences. The competitor was female, so females competed with a member of the same sex while males competed with a member of the opposite sex. Further, the experimenter was male which may have been a factor involved in the obtained sex differences. Subsequent research would be necessary to investigate these sex differences further.

Competition was not accompanied by a significant increase in performance compared to no competition. This is surprising in view of the work of Evans (1974) and Fish (1978) where performance on a similar task and an identical task respectively, did increase in competition. The present situation, as presented by the experimenter and the competitor, may have been quite different from the situations presented in these two earlier studies.

As mentioned, the competitor was female and she was very pleasant throughout the session. The experimenter had previously spent approximately one hour with each subject (testing subjects' aerobic powers) and perhaps presented a very comfortable and non-threatening situation. These, among many other reasons could be responsible for the rather surprising lack of an increase in performance during competition compared to no competition.

Recovery from Stress

As mentioned previously, since only the forty subjects exposed to a competitor were stressed, only the data from those forty subjects were analyzed. Following the competition, heart rate recovery of the high aerobic power group was greater than that of the low aerobic power group and, heart rate recovery for females was less than that of males. This first difference is consistent with results reported by Sellick (1977) and by Cox, Evans, and Jamieson (1979). Concerning the second difference, since aerobic power of females was less than that of males, one would expect females to recover more slowly. However, this finding may also represent a sex difference worthy of further investigation.

In the Cox et al. (1979) study, the difference in heart rate recovery of the low aerobic power group and the high aerobic power group was revealed at the end of the five minutes relaxation period. Following the removal of the stressor, subjects were asked to complete a short questionnaire and then to sit and wait quietly. In the present study subjects were immediately given three additional tasks to complete before being asked to relax. In this situation the difference in heart rate recovery was detected within two minutes of the removal of the stressor. In the Cox et al. study, the average heart rate increase in response to the stressor was 33.39 bpm while in the present study the average heart rate increase in response to the stressor was 13.38 bpm. Although this may account very well for the difference between the studies, another possibility is worth considering. In the Cox et al. study subjects were allowed to relax and in this way were perhaps encouraged to contemplate their performance. The present study immediately directed the subject's attention towards additional tasks. The implication is that directing one's attention towards something other than the previous performance may be a coping strategy capable of eliciting quicker recovery.

No differences were detected by analyses on post competition affect or performance. It is possible that there may be no difference between aerobic power groups in affect or behaviour following exposure to a stressor. Another possibility is that the measures used in the present study were not sensitive enough to detect differences that may have been present. In addition, all subjects had returned to their pre-competition heart rate before the end of the first post-competition trial. Measurements were not taken until this trial was completed. It is the author's opinion that further investigation in this regard is worthwhile.

Relaxation Periods

In terms of the whole experiment, the aerobic power groups differed on perceived pleasantness change from the beginning of the experimental session to the end. While the low aerobic power group's pleasantness rating increased, the high aerobic power group's pleasantness rating decreased. Although it had been anticipated that any differences would have been in the opposite direction, this link between a physiological difference and a difference on a measure of affect is worth noting. However, this difference only approached significance and is presented only as a trend worth considering.

Relationships Among Dependent Variables used to Measure Stress

Analyses using heart rate change-scores, perceived pleasantness change-scores, and performance change-scores (trial four to trial five) revealed significant correlations among the no competition subjects. There were significant correlations between heart rate change and performance change, and between perceived pleasantness change and performance change. This first correlation has been found previously (Evans, 1974; Fish, 1978). Heart rate increases tend to be accompanied by increases in performance on the digit-letter task. In the present study, subjects' heart rates increased from trial four to trial five and so did their level of performance on the digit-letter substitution task.

The second correlation, where positive change in perceived pleasantness accompanied a performance increase, has not been reported previously. Apparently previous attempts at correlating performance change with changes in self-report measures have not been all that successful (Geen & Gange, 1977). In the present study, as individual subjects' performance on the digit-letter substitution task increased from trial four to trial five, so did their perceived pleasantness rating.

The correlation between heart rate and performance, and the correlations between perceived pleasantness and performance were found only among the forty no competition subjects. There were no significant correlations among the change-scores of the competition subjects. Therefore, when subjects were not exposed to a competitor, their heart rate changes were accompanied by performance changes. When the performance of these subjects changed, so did their perceived pleasantness rating. In other words, when not exposed to a stressor, individual measures of stress reactions are somewhat associated. It is interesting then that when competition is introduced, these correlations disappear. Heart rate change is not associated with performance change. Similarly, performance change is not associated with perceived pleasantness change. What occurs then is a fractionation of responses. As mentioned, while performance increased, some found it to be pleasant while others found it to be unpleasant, perhaps more a function of a specific attitude towards competition than of a specific attitude to a single performance. In any case, individual differences among subjects are made prominent, or are amplified by competition. Psychosocial stressors seem to cause fractionation of responses within individuals. Reacting and coping with a stressor seems to become a very individualistic phenomenon. This has been discussed by Lacey (1967), pointing out that even among physiological processes that are simultaneously thrown into action, only moderate correlations are revealed at best.

Relationships Among Dependent Variables used to Measure Recovery from Stress

Analyses using heart rate recovery-change-scores, perceived pleasantness recovery-change-scores, and performance recovery-change-scores (trial five to trial six) revealed significant correlations among the group of all subjects, among the group of no competition subjects, and among the group of competition subjects. In these three groups, analyses revealed that there were significant correlations between perceived pleasantness change and performance change. That is, positive changes in perceived pleasantness accompanied increases in performance. When subject's performance improved there tended to be an increase in perceived pleasantness. When subject's performance deteriorated there tended to be a decrease in perceived pleasantness. During the competition, similar correlations were found only among the no competition subjects and it was suggested that the competition resulted in a fractionation of responses. During this first recovery trial the fractionation which appears to have resulted from the competition, seems to have partially disappeared. That is, there is again a correlation between perceived pleasantness change and performance change.

A somewhat innovative method of measuring stress responses may be to watch for the point at which the responses of individuals fractionate. Determining the point at which previously revealed correlations disappear may be one method of measuring the effects of a stressor. Possibly then the reappearance of correlations would signal the relative absence of stressors.

In summary, the purpose of this study was to investigate differences between low and high aerobic power individuals regarding recovery from stress. From previous research it was known that these two groups differed on a physiological measure, and the present study monitored not only a physiological measure but also a measure of affect and a measure of performance in order to determine whether the two aerobic power groups would differ on the two latter measures. Physiological differences between low and high aerobic power groups were replicated. However, no convincing data regarding affect or performance were revealed.

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LIST OF APPENDICES

PLEASANTNESS SCALE

21

20

19 extremely pleasant

18

17 very pleasant

16

15 pleasant

14

13 slightly pleasant

12

11 neither pleasant nor unpleasant

10

9 slightly unpleasant

8

7 unpleasant

6

5 very unpleasant

4

3 extremely unpleasant

2

1

Appendix II

Digit-Letter Substitution Task

0	1	2	3	4	5	6	7	8	9
K	L	V	T	A	E	N	W	X	H

5	1	0	6	6	2	0	6	9	9	2	9	7	5	9	5	3	2	0	5	7	7	3	4

6	9	8	2	6	6	2	2	4	2	4	0	1	5	9	6	7	4	9	0	7	5	8	9

5	0	1	4	9	0	9	6	6	3	3	6	7	4	6	9	0	9	6	3	3	4	8	8

1	9	9	8	0	8	5	2	8	2	6	3	7	2	9	2	9	2	3	6	5	0	2	6

6	6	7	0	0	0	2	2	1	5	0	1	9	3	9	9	5	9	1	6	2	3	7	7

1	3	0	1	3	5	7	4	2	8	3	6	3	6	7	3	0	5	8	8	7	2	2	9

8	7	4	8	3	1	4	4	6	8	0	2	3	7	3	1	2	5	2	9	6	3	6	7

6	2	3	0	4	8	2	9	6	3	8	3	5	2	2	3	8	1	6	6	4	0	9	4

Appendix III

The Submaximal Test of Aerobic Power

1. The person to be tested should be basically healthy and not under the influence of any drug.
2. For two hours before the test:
   - (a) No hard physical activity,
   - (b) No heavy meals.
3. For one hour before the test:
   - (a) No smoking,
   - (b) No light meals.
4. Approximate choice of initial workload:
   - (a) Males = 300 kpm (ergometer @ 1)
   - (b) Females = 150 kpm (ergometer @ .5)
5. Appropriate Heart Rates:
   - (a) Heart rate from the 5th to 6th minute cannot vary more than 5 bpm or else a steady state has not been reached.
   - (b) Average the heart rate from the 5th minute and the 6th minute to get an appropriate value.
   - (c) Heart rate after the first six minutes should be 130 $\pm$ 5 bpm and at a steady state.
   - (d) Heart rate after the second six minutes should be 150 $\pm$ 5 bpm and at a steady state.
6. Check workload setting every minute.
7. Increase workload after the first six minute period by:
   - (a) 1 for males,
   - (b) .5 for females.

Appendix IV

CONSENT FORM

I, ________________________, have been informed that the research in which I am about to participate will place me in some demanding situations. I understand that the demands may be both physical and mental in nature but that the experience will not be dangerous for a normal healthy person. I also realize that if at any time I wish to discontinue an experimental session, I may indicate this to the experimenter and I will be free to leave. I have been told by the experimenter that the research techniques are standard procedures that have been well thought out and tested. With this understanding, I have consented to be a participant.

Signed ______________________

Date ________________________

Appendix V

Experimental Procedure

--bring the subject into the room and ask him to be seated at the table.

--explain that you are going to keep a record of his heart rate throughout the experiment and for this reason you will be using the plethysmograph. Place the plethysmograph on the index finger of the subject's non-preferred hand and inform him that the plethysmograph must be kept still if it is to record accurately.

--read the following instructions:

"Now you will have to sit here for a little while and relax completely so that I can record your heart rate at a resting level. Just relax and don't think about the experiment. There is nothing to worry about and I promise that you won't be hurt.

Every once in a while during the experiment I am going to ask you to rate how pleasant you found doing something. For example, at the end of the relaxation period I will ask you: How pleasant were the last few seconds of the relaxation period? Then, what I want you to do is give me a number from the PLEASANTNESS SCALE. If, for example, you found the relaxation period pleasant, you should say fifteen (point). If, for another example, you found it very unpleasant, you should say five (point). If, for some reason, you cannot decide whether the relaxation period was pleasant or unpleasant, you should say eleven (point). Whenever I ask you how pleasant something was you will have to give me a number. This number can vary from 21 to 1 (point), OK? During the relaxation period you should relax as much as possible. Also, every once in awhile you should rate, just to yourself, how pleasant you are finding the relaxation period. This will give you some practice at rating pleasantness.

During the relaxation period you will have to keep the plethysmograph as still as possible. You should move around as little as possible, and you won't be able to ask any questions. So, if you have any questions you should ask them now and you should make yourself as comfortable as possible so that you will be able to stay still during the relaxation period. Any questions?"

--encourage questions and help the subject to make himself as comfortable as possible.

--go behind the shelves and ask the subject if he is ready to begin the relaxation period. If the subject gives an affirmative response say:

"The relaxation period is beginning now."

--as you say 'now' press the event marker.

--remain absolutely quiet and still during the subject's relaxation period.

--after exactly three minutes press the event marker and say:

"OK--the relaxation period is finished. How pleasant were the last few seconds of the relaxation period?"

--record subject's response.

--bring out digit-letter task (1)

--if subject is left handed, special procedure.

--read the following instructions:

"This is a digit-letter substitution task. What you have to do is...under each of these numbers (point) put the appropriate letter from above. You are to start here (point) and continue on. When you reach the end of a line go on to the next line. You have to do the substitutions in sequential order, in other words, one after the other. You cannot do all the zero's and then all the ones and then all the twos, etc. OK? Get yourself into a comfortable position for doing the task and remember that you have to keep the plethysmograph as still as possible."

--turn the task face-down and help the subject find a good comfortable position for doing the task in such a way that he is able to do the task while keeping the plethysmograph still.

--pick up the buzzer and read the following instructions:

"When I'm ready to begin having you do the digit-letter task I will say...turn over the task...and you should turn over the task with your free hand once again remembering to keep the plethysmograph still. Then I will say...ready?...and when you are ready to begin doing the task you should say...yes. After you have said yes, I will say OK, and then I will buzz the buzzer (demonstrate). When I buzz the buzzer begin doing the task as quickly and as well as possible. When time is up I will buzz the buzzer again and you will have to stop immediately, put your pencil down, and turn over the task. Once again remember that you have to keep the plethysmograph still even when doing the digit-letter task. Any questions?"

--run the first trial (60 seconds).

--as soon as the first trial is finished say:

"How pleasant was doing the task?"

--score, point out errors, give score.

--bring out task two and put it face down in front of the subject.

--read the following instructions:

"Now you have to do another form of the task the same way that you did the last one. Remember you are always to do the digit-letter task as quickly as possible."

--run the second trial.

--as soon as the second trial is finished say:

"How pleasant was doing the task?"

--score, point out errors, give score.

--bring out task three and put it face down in front of the subject, and say:

"Now task three."

--run the third trial.

--as soon as the third trial is finished say:

"How pleasant was doing the task?"

--score, point out errors, give score.

--go through the same procedure for the fourth trial.

--on completion of the fourth trial check in file to discover what condition the subject has been randomly assigned to (as determined by second experimenter).

--go to the appropriate set of instructions.

No Competition Group

--procede with trial five as trials one, two, three, and four had been administered.

Competition Group

--excuse yourself and leave room, returning approximately thirty second later with competitor. Introduce subject and competitor to one another and ask the competitor to sit in the chair opposite the subject.

--put the plethysmograph on the competitor's index finger of non-preferred hand.

--bring out two tasks (trial five) and put them face-down in front of the two people and say:

"By now you both know haw to do the digit-letter task...right? Now, I am going to have you do another form of the same task. The only difference between this and earlier trial is that instead of just doing the task as quickly and as well as possible, I also want you to try and do it faster than the other person. In other words, we are going to have a competition. On completion of the experiment I can let you know who won. When I'm ready to begin having you compete I will say...turn over your tasks...and each of you should turn over your task with your free hand, remembering to keep your plethysmograph still. Then I will say...ready?...and when you are ready to begin competing you should say...yes. After both of you have said yes I will say OK! and then I will buzz the buzzer like this (demonstrate). When I buzz the buzzer begin doing the task as quickly and as well as possible, while at the same time trying to beat the other person. When time is up I will buzz the buzzer again and you will have to stop immediately, put your pencil down, and turn over your task. Once again, remember that you have to keep the plethysmograph still even when competing. OK?"

--run the competitive trial.

--take the competitor's plethysmograph off, ask her to take her digit-letter task with her back to the other room where she had been waiting.

--as soon as you have seen the competitor out and have shut the door, say:

"How pleasant did you find doing the task?"

Recovery Trials

--all subjects are to be administered the same instructions regardless of which group they had been assigned to for trial five.

--procede with trial six, trial seven, and trial eight as trial four had been administered.

Final Relaxation Period

--on completion of trial eight read the following:

"What I want you to do know is make yourself as comfortable as possible and once again relax as much as you can. If you are all set, the relaxation period will begin...now."

--remain absolutely quiet and still during the subject's relaxation period.

--after exactly three minutes press the event marker and say:

"OK...the relaxation period is finished. How pleasant were the last few seconds of the relaxation period?"

--record the subject's response.

--inform subject that the experiment is over and remove plethysmograph from finger.

--conduct Post-Experimental Interview

Post-Experimental Interview

--What thoughts did you have about the experiment?

--What do you think it was about?

--Did you hear anything about it before?

--Any ideas or suggestions?

--Explain experiment!

--Can't be in experiment again!

--Will be credited!

--Please keep it confidential...or this will have been a waste of time!

--Ask again...had you heard about the experiment before?

--Get a verbal commitment to confidentiality!

--Thank you!

--Rate the experience of participating in the experiment!

Appendix VII

Aerobic Power

Analysis of Variance

Source of Variation	SS	df	MS	F	Probability
Sex (S)	231.20	1	231.20	9.26	0.003
Aerobic Power (AP)	3100.05	1	3100.05	124.13	0.000
Competition (C)	2.45	1	2.45	0.10	0.755
S X AP	0.00	1	0.00	0.00	1.000
S X C	0.80	1	0.80	0.03	0.858
AP X C	6.05	1	6.05	0.24	0.624
S X AP X C	7.20	1	7.20	0.29	0.593
Error	1798.17	72	24.98		
Total	5145.92	79	65.14		

Aerobic Power Data

(ml/kg/min)

		Female	Male
Low Aerobic Power	No Competition	23	28
		26	30
		28	30
		30	33
		31	34
		31	36
		32	36
		33	37
		34	38
		35	39
	Competition	25	27
		27	30
		28	31
		29	33
		31	33
		31	35
		33	36
		34	36
		35	39
		36	39
High Aerobic Power	No Competition	37	39
		38	40
		38	42
		40	44
		41	45
		42	47
		44	49
		46	49
		50	51
		63	59
	Competition	37	40
		37	42
		38	42
		40	44
		40	45
		44	45
		44	48
		45	50
		46	51
		51	57

Appendix VIII

Heart Rate Prescores

Analysis of Variance

Source of Variation	SS	df	MS	F	Probability
Sex (S)	214.51	1	214.51	1.60	0.210
Aerobic Power (AP)	1436.51	1	1436.51	10.71	0.002
Competition (C)	117.61	1	117.61	0.88	0.352
S X AP	324.01	1	324.01	2.42	0.125
S X C	143.11	1	143.11	1.07	0.305
AP X C	103.51	1	103.51	0.77	0.383
S X AP X C	189.11	1	189.11	1.41	0.239
Error	9659.39	72	134.16		
Total	12187.79	79	154.28		

Heart Rate Prescores

Summary of Means and Standard Deviations

No Competition Subjects		Mean	Standard Deviation
Female	LAP	92.00	10.92
	HAP	82.20	11.33
Male	LAP	87.00	13.78
	HAP	75.30	11.20

Competition Subjects		Mean	Standard Deviation
Female	LAP	86.40	12.19
	HAP	87.30	6.36
Male	LAP	92.90	13.05
	HAP	79.60	12.28

Appendix IX

Perceived Pleasantness Prescores

Analysis of Variance

Source of Variation	SS	df	MS	F	Probability
Sex (S)	6.61	1	6.61	1.01	0.318
Aerobic Power (AP)	0.31	1	0.31	0.05	0.827
Competition (C)	1.51	1	1.51	0.23	0.632
S X AP	5.51	1	5.51	0.84	0.361
S X C	3.61	1	3.61	0.55	0.459
AP X C	4.51	1	4.51	0.69	0.409
S X AP X C	0.61	1	0.61	0.09	0.760
Error	470.30	72	6.53		
Total	492.98	79	6.24		

Perceived Pleasantness Prescores

Summary of Means and Standard Deviations

No Competition Subjects		Mean	Standard Deviation
Female	LAP	12.60	2.01
	HAP	12.60	2.37
Male	LAP	12.80	2.90
	HAP	12.10	3.00

Competition Subjects		Mean	Standard Deviation
Female	LAP	12.10	3.12
	HAP	13.40	2.95
Male	LAP	11.80	1.55
	HAP	11.70	2.11

Appendix X

Performance Prescores

Analysis of Variance

Source of Variation	SS	df	MS	F	Probability
Sex (S)	168.20	1	168.20	2.96	0.089
Aerobic Power (AP)	3.20	1	3.20	0.06	0.813
Competition (C)	7.20	1	7.20	0.13	0.723
S X AP	11.25	1	11.25	0.20	0.658
S X C	76.05	1	76.05	1.34	0.251
AP X C	18.05	1	18.05	0.32	0.575
S X AP X C	3.20	1	3.20	0.06	0.813
Error	4086.78	72	56.76		
Total	4373.93	79	55.37		

Performance Prescores

Summary of Means and Standard Deviations

No Competition Subjects		Mean	Standard Deviation
Female	LAP	50.50	3.57
	HAP	51.10	11.11
Male	LAP	49.00	9.06
	HAP	50.70	5.52

Competition Subjects		Mean	Standard Deviation
Female	LAP	53.00	9.55
	HAP	51.30	6.46
Male	LAP	47.80	5.05
	HAP	46.80	6.86

Appendix XI

Heart Rate Change-Score

Analysis of Variance

Source of Variation	SS	df	MS	F	Probability
Sex (S)	480.20	1	480.20	5.78	0.019
Aerobic Power (AP)	186.05	1	186.05	2.24	0.139
Competition (C)	3302.45	1	3302.45	39.75	0.000
S X AP	1.25	1	1.25	0.02	0.903
S X C	414.05	1	414.05	4.98	0.029
AP X C	51.20	1	51.20	0.62	0.435
S X AP X C	7.20	1	7.20	0.09	0.769
Error	5981.30	72	83.07		
Total	10423.70	79	131.95		

Heart Rate Change-Score

Summary of Means and Standard Deviations

No Competition Subjects		Mean	Standard Deviation
Female	LAP	-0.80	3.55
	HAP	1.50	2.32
Male	LAP	0.40	3.03
	HAP	1.00	2.91

Competition Subjects		Mean	Standard Deviation
Female	LAP	6.50	7.82
	HAP	10.80	11.28
Male	LAP	15.60	14.09
	HAP	20.60	15.56

Appendix XII

Perceived Pleasantness Change-Score

Analysis of Variance

Source of Variation	SS	df	MS	F	Probability
Sex (S)	7.81	1	7.81	1.13	0.292
Aerobic Power (AP)	7.81	1	7.81	1.13	0.292
Competition (C)	59.51	1	59.51	8.58	0.005
S X AP	0.11	1	0.11	0.02	0.899
S X C	23.11	1	23.11	3.33	0.072
AP X C	6.61	1	6.61	0.95	0.332
S X AP X C	0.61	1	0.61	0.09	0.767
Error	499.30	72	6.94		
Total	604.88	79	7.66		

Perceived Pleasantness Change-Score

Summary of Means and Standard Deviations

No Competition Subjects		Mean	Standard Deviation
Female	LAP	0.40	2.88
	HAP	-0.10	1.45
Male	LAP	-0.30	1.06
	HAP	-0.10	1.60

Competition Subjects		Mean	Standard Deviation
Female	LAP	-2.00	2.75
	HAP	-3.10	3.25
Male	LAP	-0.20	3.36
	HAP	-1.50	3.47

Appendix XIII

Performance Change-Score

Analysis of Variance

Source of Variation	SS	df	MS	F	Probability
Sex (S)	12.01	1	12.01	0.69	0.408
Aerobic Power (AP)	1.51	1	1.51	0.09	0.769
Competition (C)	27.61	1	27.61	1.59	0.211
S X AP	9.11	1	9.11	0.53	0.471
S X C	1.01	1	1.01	0.06	0.810
AP X C	13.61	1	13.61	0.79	0.379
S X AP X C	0.11	1	0.11	0.01	0.936
Error	1248.49	72	17.34		
Total	1313.48	79	16.63		

Performance Change-Score

Summary of Means and Standard Deviations

No Competition Subjects		Mean	Standard Deviation
Female	LAP	2.90	5.28
	HAP	1.20	3.05
Male	LAP	1.30	3.20
	HAP	0.80	3.49

Competition Subjects		Mean	Standard Deviation
Female	LAP	3.10	5.47
	HAP	2.90	3.41
Male	LAP	1.80	4.69
	HAP	3.10	3.96

Appendix XIV

Heart Rate Across

Trials Five, Six, Seven, and Eight

Analysis of Variance

Source of Variation	SS	df	MS	F	Probability
Sex (S)	357.01	1	357.01	0.68	0.416
Aerobic Power (AP)	1593.91	1	1593.91	3.08	0.091
S X AP	2648.76	1	2648.76	5.02	0.031
Error	19012.28	36	528.12		
Trials (T)	5436.32	3	1812.11	46.80	0.000
S X T	461.72	3	153.91	3.98	0.010
AP X T	305.02	3	101.67	2.63	0.054
S X AP X T	33.07	3	11.02	0.28	0.836
Error	4181.63	108	38.72		
Total	10417.75	120	86.81		

Heart Rate Across

Trials Five, Six, Seven, and Eight

Summary of Means and Standard Deviations

Competition Subjects			Trial Five	Trial Six	Trial Seven	Trial Eight
Female	LAP	Mean	92.90	85.90	85.70	85.30
		SD	15.81	11.47	10.08	9.64
	HAP	Mean	98.10	86.90	86.40	85.70
		SD	16.25	8.32	6.13	7.32
Male	LAP	Mean	108.50	96.70	94.70	94.40
		SD	23.48	14.48	12.53	12.82
	HAP	Mean	100.20	79.10	78.80	78.40
		SD	14.16	10.83	9.62	9.17

Appendix XV

Perceived Pleasantness Rating Across

Trials Five, Six, Seven, and Eight

Analysis of Variance

Source of Variation	SS	df	MS	F	Probability
Sex (S)	0.06	1	0.06	0.00	0.959
Aerobic Power (AP)	1.06	1	1.06	0.05	0.826
S X AP	33.31	1	33.31	1.55	0.221
Error	773.18	36	21.48		
Trials (T)	74.47	3	24.82	7.89	0.000
S X T	6.17	3	2.06	0.65	0.582
AP X T	5.07	3	1.69	0.54	0.658
S X AP X T	3.32	3	1.11	0.35	0.788
Error	339.73	108	3.15		
Total	428.75	120	3.57		

Perceived Pleasantness Rating Across

Trials Five, Six, Seven, and Eight

Summary of Means and Standard Deviations

Competition Subjects			Trial Five	Trial Six	Trial Seven	Trial Eight
Female	LAP	Mean	10.10	11.90	11.70	11.60
		SD	2.69	2.81	3.23	3.50
	HAP	Mean	10.30	12.60	12.80	12.60
		SD	3.56	2.27	2.53	2.68
Male	LAP	Mean	11.60	12.50	12.30	12.70
		SD	3.13	2.27	2.11	2.36
	HAP	Mean	10.20	11.90	11.80	10.90
		SD	2.15	2.81	2.94	2.88

Appendix XVI

Performance Across

Trials Five, Six, Seven, and Eight

Analysis of Variance

Source of Variation	SS	df	MS	F	Probability
Sex (S)	1020.10	1	1020.10	4.03	0.052
Aerobic Power (AP)	4.90	1	4.90	0.02	0.890
S X AP	15.63	1	15.63	0.067	0.805
Error	9118.35	36	253.29		
Trials (T)	49.63	3	16.54	2.09	0.106
S X T	19.75	3	6.58	0.83	0.480
AP X T	3.65	3	1.22	0.15	0.927
S X AP X T	22.12	3	7.37	0.93	0.429
Error	856.85	108			
Total	952.00	120			

Performance Across

Trials Five, Six, Seven, and Eight

Summary of Means and Standard Deviations

Competition Subjects			Trial Five	Trial Six	Trial Seven	Trial Eight
Female	LAP	Mean	56.10	57.90	56.00	55.00
		SD	11.03	9.53	10.01	9.31
	HAP	Mean	54.20	56.00	55.50	55.40
		SD	8.90	9.37	8.72	8.21
Male	LAP	Mean	49.60	50.50	50.80	51.40
		SD	8.49	7.84	6.46	6.50
	HAP	Mean	49.90	51.70	50.70	51.10
		SD	6.89	6.06	5.72	8.02

Appendix XVII

Heart Rate Recovery-Change-Score

Analysis of Variance

Source of Variation	SS	df	MS	F	Probability
Sex (S)	540.23	1	540.23	4.17	0.048
Aerobic Power (AP)	455.63	1	455.63	3.52	0.069
S X AP	65.03	1	65.03	0.50	0.483
Error	4662.07	36	129.50		
Total	5722.95	39	146.74		

Heart Rate Recovery-Change-Score

Summary of Means and Standard Deviations

Competition Subjects		Mean	Standard Deviation
Female	LAP	-7.00	8.91
	HAP	-11.20	11.89
Male	LAP	-11.80	10.90
	HAP	-21.10	13.36

Appendix XVIII

Perceived Pleasantness Recovery-Change-Score

Analysis of Variance

Source of Variation	SS	df	MS	F	Probability
Sex (S)	5.63	1	5.63	0.71	0.405
Aerobic Power (AP)	4.23	1	4.23	0.53	0.470
S X AP	0.23	1	0.23	0.03	0.867
Error	284.70	36	7.91		
Total	294.77	39	7.56		

Perceived Pleasantness Recovery-Change-Score

Summary of Means and Standard Deviations

Competition Subjects		Mean	Standard Deviation
Female	LAP	1.80	2.25
	HAP	2.30	2.50
Male	LAP	0.90	1.97
	HAP	1.70	4.06

Appendix XIX

Performance Recovery-Change-Score

Analysis of Variance

Source of Variation	SS	df	MS	F	Probability
Sex (S)	2.03	1	2.03	0.15	0.704
Aerobic Power (AP)	2.03	1	2.03	0.15	0.704
S X AP	2.03	1	2.03	0.15	0.704
Error	497.70	36	13.83		
Total	503.77	39	12.92		

Performance Recovery-Change-Score

Summary of Means and Standard Deviations

Competition Subjects		Mean	Standard Deviation
Female	LAP	1.80	3.46
	HAP	1.80	2.57
Male	LAP	0.90	4.46
	HAP	1.80	4.10

Appendix XX

Relaxation I minus Relaxation II

Heart Rate Change-Score

Analysis of Variance

Source of Variation	SS	df	MS	F	Probability
Sex (S)	10.00	1	10.00	0.53	0.470
Aerobic Power (AP)	22.50	1	22.50	1.20	0.281
S X AP	0.40	1	0.40	0.02	0.885
Error	676.20	36	18.78		
Total	709.10	39	18.18		

Summary of Means and Standard Deviations

Competition Subjects		Mean	Standard Deviation
Female	LAP	-1.00	5.16
	HAP	0.30	3.83
Male	LAP	-2.20	4.42
	HAP	-0.50	3.78

Appendix XXI

Relaxation I minus Relaxation II

Perceived Pleasantness Change-Score

Analysis of Variance

Source of Variation	SS	df	MS	F	Probability
Sex (S)	4.23	1	4.23	0.83	0.368
Aerobic Power (AP)	18.23	1	18.23	3.58	0.067
S X AP	13.23	1	13.23	2.60	0.116
Error	183.30	36	5.09		
Total	218.98	39	5.62		

Summary of Means and Standard Deviations

Competition Subjects		Mean	Standard Deviation
Female	LAP	0.00	2.45
	HAP	0.20	1.48
Male	LAP	-1.80	2.44
	HAP	0.70	2.50