RECOVERY FROM PHYSICAL AND PSYCHOLOGICAL STRESS AS A FUNCTION OF PHYSICAL FITNESS

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Abstract

Recovery From Physical and Psychological Stress
as a Function of Physical Fitness

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Although recent studies have suggested that physical fitness promotes psychological health, definitive evidence for a physical-psychological interrelationship is lacking. In the present study, experimental manipulation of physical fitness was performed in order to determine whether improvement in physical fitness results in quicker recovery from physical and psychological stress. Ten males and ten females each were randomly assigned to either exercise, music appreciation or meditation classes which met four days weekly for ten weeks. In each of three test sessions, physical fitness was inferred from heart rate recovery time following a standard stepping task, and psychological fitness from GSR recovery during stress-inducing tasks. A life-style questionnaire and mood adjective checklist were also administered. While there were initially no group differences on all measures, by the end of the study, Group Exercise recovered significantly faster from both physical and psychological stress than Groups Music and Meditation. Group Exercise increased overall activity levels as well, but other changes in life-style and mood for the three groups were negligible. These findings suggest that the physically fit cope better with physical and psychological stress than the unfit, and also demonstrate the validity of autonomic recovery as an index of psychological well-being.

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Research over the last half century on the interrelationship between physical and psychological functioning has firmly established that psychological health influences physical well-being. The acceptance of this finding has resulted in the development of new areas of study, such as psychosomatic medicine (e.g., Winters, 1962). Studies investigating the effect of physical fitness on psychological well-being, however, have emerged only in the last two decades (e.g., Collingwood, 1972). These studies have suggested that good physical fitness promotes psychological health.

Several conceptual and methodological problems have impeded the study of the interrelationship between physical and psychological functioning. Initially, ambiguity surrounding the definition of physical fitness hindered the development of physical fitness tests. Both problems have recently been resolved by a consensus over what physical fitness means and how it can be quantified. The early definition and measurement of psychological fitness also presented difficulties. Discrepant approaches to the assessment of psychological fitness still exist, but there has been more agreement on both its meaning and measurement in recent years. These issues will be treated sequentially below.

Physical Fitness

The immediate source of energy for muscular activity is adenosine triphosphate (ATP). This is formed with the energy released from food and is stored in muscle cells (Mathews & Fox, 1976).

ATP stores, however, can only supply enough energy for several seconds of work. To continue muscular activity beyond this, energy must be derived from the anaerobic system in which the basic raw material processed to provide energy is glycogen (a simple sugar). During anaerobic metabolism, glycogen is broken down in the absence of oxygen and produces lactic acid. Because lactic acid accumulation produces muscular fatigue (Fitts, 1977), anaerobic metabolism is limited to short time periods.

If submaximal exercise is prolonged, metabolism gradually shifts from anaerobic to aerobic modes and stabilizes after three or four minutes. Glycogen continues to be the main source of energy in the aerobic system, but since glycolysis occurs in the presence of oxygen, lactic acid is not produced. Instead, the byproducts are carbon dioxide and water.

During recovery from exercise, the extra lactic acid that has accumulated prior to the aerobic changeover is burned by the muscles or else reconverted by the liver into its precursor, glycogen. The extra energy requirements of these tasks, however, create an oxygen debt (Hill, 1924), which is paid for through the continued deep respiration and elevated heart rate at the end of exercise.

Aerobic training increases a person's aerobic capacity or maximal oxygen uptake, which represents the maximum rate at which the cardiovascular system can provide oxygen to the working muscles (Scheuer & Tipton, 1977). Thus, a trained athlete can sustain an activity for longer periods of time than an untrained individual, with less effort and without creating an intolerable oxygen debt. Optimal training effects, however, depend on the frequency, intensity and duration of exercise (Skinner, 1975). Training should last 20 to 30 minutes a day, two to four days a week, at about 60 to 75% of the individual's maximal oxygen capacity.

Physiological Changes Produced by Aerobic Training

Changes produced by aerobic training are reflected in almost all physiological systems. This section deals specifically with the cardiovascular, respiratory, muscular, and metabolic systems.

The acute changes of the cardiovascular system include increased heart rate, oxygen consumption, and stroke volume (the amount of blood pumped by the heart per beat). In addition, blood flow is redistributed from the inactive to the active muscles (Mathews & Fox, 1976). Chronic cardiovascular changes include increases in heart rate recovery time following exercise and maximal oxygen uptake. Working and resting stroke volume also increase (Scheuer & Tipton, 1977).

Acute changes on the respiratory system that are produced by aerobic training include an increase in the volume of air inspired or expired per breath (tidal volume) and also per minute (minute volume). Chronic changes include increased lung volume and diffusion capacities both at rest and during work (Mathews & Fox, 1976).

An acute muscular change is a rise in muscle temperature;

chronic changes include greater oxygen utilization by the peripheral musculature and increased muscle tone and maximal muscle strength (Astrand & Rodahl, 1970). Another acute change produced by aerobic training is a substantial rise in lactic acid (Karpovitch, 1966). Chronic changes, in contrast, include a greater tolerance for, and lower levels of, lactate. Aerobic training also increases fat metabolism and decreases total body fat and weight, although these latter two changes are less pronounced in the already lean individual (Mathews & Fox, 1976).

Tests of Physical Fitness

The absence of a consensus over the definition of physical fitness caused much confusion in the initial development of physical fitness tests. Because physical fitness was defined variously as speed, endurance, muscular strength, and flexibility, a number of single-measure tests were devised to assess each of these aspects. These single-measure tests were superseded by a multiple-index of physical fitness, the Schneider Index (Schneider, 1920). It measured reclining and standing pulse rate and systolic blood pressure, as well as working and recovery heart rate. Working heart rate was determined by having a subject climb an 18-inch chair five times in 15 seconds; recovery heart rate represented the time required for the heart rate to return to initial standing level.

Schneider's innovative use of heart rate recovery time from a stepping task had a lasting impact. During World War Two, a step test was devised at Harvard University to assess cardiovascular fitness of potential combat officers (Keen & Sloan, 1958). Several investigators (e.g., Hardy, Clarke & Brouha, 1943) introduced the step test into laboratory testing, establishing the Harvard step as a standard physiometric instrument. Despite the popularity of the step test, studies have traditionally inferred fitness level from post-test heart rate. Preliminary work, however (Keller, Note 1), supported Schneider's finding that heart rate recovery, is a more valid measure of physical fitness.

The confusion of early tests of physical fitness has been resolved in recent years with the advent of direct and indirect measures of aerobic capacity. In the treadmill test, for example, the proportion of expired gases (oxygen and carbon dioxide) is measured directly while the subject walks or runs to exhaustion on a variable speed and incline conveyor belt. In other tests (e.g., bench-stepping) maximal oxygen uptake is predicted from heart rate change during submaximal exercise.

Although treadmill testing is considered the most efficient index of aerobic fitness (Kavanagh, 1976), it is time consuming and physically exhausting to perform. In addition, it is difficult to determine when the subject has reached his maximal oxygen uptake level (Astrand & Rodahl, 1970; Williams, 1972). Submaximal tests, in contrast, are less demanding of the subject, easier to administer, and accomodate a wider age and ability range. Strong correlations between the treadmill and the step test have also been found (Kasch, Phillips, Ross, Carter & Boyer, 1966).

Psychological Fitness

The possibility that emotional and physiological states may be related was first considered almost one century ago. James (1890) identified emotion as a purely physiological event and defined it as the result of bodily reactions. His theory was modified by Cannon (1927), who postulated that physiological arousal follows, rather than precedes, the perception of an emotion. Cannon's theory was important for being one of the first to propose that the autonomic nervous system plays a critical role in the production of emotion (Candland, Fell, Keen, Leshner, Plutchik & Tarpy, 1977). The Cannon-James controversy that ensued concerned not only the sequence of events that produce an emotion, but also the relevance of physiological arousal. James regarded bodily changes as both necessary and sufficient conditions for the production of an emotional state, whereas Cannon questioned the importance of their very existence within a theory of emotion.

The Cannon-James controversy has been resolved in recent years, by Schachter and Singer (1962) who demonstrated that physical arousal is a necessary component of emotion. While incorporating the major tenents of these traditional theories of emotion into his own, Schachter further proposed that these physiological changes are not sufficient in themselves to produce an emotional state. Rather, an individual will interpret his autonomic arousal according to the cognitions available to him.

Schachter's cognitive theory of emotion has recently been extended to accomodate the notion that it is not the amount of autonomic lability, but rather the recovery from these altered states, that defines the level of emotional arousal. This was demonstrated by Johansson (1976) who found urinary excretion of adrenaline and noradrenaline to return more rapidly to baseline levels under conditions of mental relaxation than under emotional stress, and Malmo (1975) who distinguished anxious from non-anxious subjects by the rate at which muscle tension recovered following a mild stressor.

Assessment of Psychological Fitness

Initial attempts to assess psychological fitness were fraught with many discrepancies. The earliest approach was based on clinical diagnoses; that is, individuals exhibiting psychological abnormalities were merely compared to those of apparent psychological health. A second approach has been to quantitatively measure personality traits on paper-and-pencil personality inventories (e.g., the Minnesota Multiphasic Personality Inventory (MMPI)). Self-report questionnaires surveying mood and personality states (e.g., the Taylor Manifest Anxiety Scale) have also been employed to distinguish normal from abnormal psychological functioning. A fourth and perhaps more reliable technique has been to infer emotional arousal from autonomic indices. This approach is based on the longstanding knowledge (James, 1890) that the subjective experience of emotion is accompanied by physiological changes and also Cannon's (1932) principle of homeostasis that the system automatically recovers from these changes. The use of autonomic indices as a measure of psychological fitness is currently gaining wider recognition. While Candland (1962) has reviewed the various autonomic changes that accompany emotion (e.g., increased blood pressure, heart rate, and muscle tension), Johansson (1976) and Malmo (1975) have demonstrated that the critical measure of well-being is not the magnitude of autonomic response, but rather the rapidity with which the autonomic activity returns to baseline levels.

Review of Physical-Psychological Studies

The first studies on physical-psychological relations sought to determine differences in physical fitness level between psychiatric and mentally healthy persons (Hammett, 1967). McFarland and Huddleson (1936) administered the Schneider test of physical fitness to psychotics and neurotics as well as to unselected and athlete controls. Mean standing, working, and recovery pulse rates were significantly greater for the psychiatric group than for the two controls. Overall fitness scores indicated the athletes to be the most, and the psychiatrics the least fit. The authors concluded that physical fitness deteriorates with progressive psychosis and psychoneurosis. In a similar study, Linton, Hamelink and Hoskins (1934) demonstrated an inverse relationship between physical fitness and schizophrenia.

While both studies provided evidence of a relationship between physical and psychological health, they failed to determine whether the poorer physical fitness of psychiatrics is the cause or effect of the disturbed psychological state. The authors also failed to state if the patients were hospitalized or not. In addition, McFarland and Huddleson did not report whether their psychiatric patients abstained from medication prior to and during the testing period.

An increasing number of studies on the influence of physical fitness on psychological functioning has emerged in the last two decades. Despite reports that improved levels of physical fitness increase self-image, feelings of well-being, and ability to relax (Ismail & Trachtman, 1973; Ogilvie & Tutko, 1971), the methodological and interpretive practices of these studies have been severely criticized (Hammett, 1967; Rushall, 1973). Typically, personality inventories or self-report questionnaires are administered to athletes or subjects enrolled in physical fitness programs. Changes in these personality tests are then correlated with changes in tests of physical fitness. Not only are these studies correlational, but sampling from varsity and champion athletes does not permit the generalization of results to the population at large. Sampling from athletes also introduces the question of whether individuals with certain personality structures gravitate toward athletics, or whether athletic participation actually influences personality dynamics. Additionally, many of the personality inventories (e.g., the MMPI) were designed to detect psychopathology, not to measure psychological changes in "normals". Self-report questionnaires do not control for subjects' and experimenters' expectations, a major problem in physical-psychological research, as individuals frequently have preconceptions of the physiological and psychological changes produced by physical training. The retrospective nature of self-report questionnaires further limits their usefulness as subjects' reports of how they felt or reacted in past situations may be hampered by inaccurate recall.

Despite the number of criticisms that have been raised, several recent studies have provided clearer evidence that exercise benefits both the healthy and the infirm. In an investigation by Folkins, Lynch and Gardner (1972), students chose to enroll in a four-month jogging, golf or archery course (the latter two courses served as controls). Psychological and physical measures were obtained before and after training, the former including self-assessments of personal adjustment, self-confidence, anxiety, depression, work efficiency and quality of sleep, and the latter, resting heart rate and time to run 1.75 miles. Significant decreases in running time and resting heart rate for the exercise group indicated improved fitness level. All but the work efficiency index of psychological fitness were significantly improved for the women, while there were no significant changes for the men. Performance changes on the 1.75-mile run were significantly correlated with changes on the indices of psychological fitness for the women, but correlations failed to reach significance for the males. These negative findings for the men were interpreted as reflecting the fact that they rated higher in physical fitness than the women on the pretraining tests and were therefore psychologically healthier at the onset of the program.

The authors' failure to randomly assign subjects to treatment groups could have contributed to the significant differences in pretreatment scores. As well, they did not report the control groups' post-treatment scores which forces the reader to assume that neither archery nor golf elicited psychological changes. Having a comparison of control and experimental scores could have better differentiated the joggers' scores.

Folkins (1976) assessed the effects of fitness on the psychological functioning of 40 men at high risk of coronary artery disease. Twenty men were assigned to an exercise group and another 20 to a control group. Exercise classes met three days a week for three months, while control subjects were simply asked to maintain current activity levels and life-styles. Pre- and post-exercise data were collected on both physical and psychological measures, the latter including anxiety, depression, self-confidence, and personal adjustment. The exercisers' fitness levels significantly improved, and their anxiety and depression scores significantly decreased, while the control group demonstrated no significant change on any measure.

The majority of studies on physical-psychological relations evaluated the effects of physical training on mood and personality traits. A study by Heinzelmann (1975) represents one of the few attempts to not only assess changes in life-style, but also to experimentally manipulate fitness level. He randomly assigned middle-aged men at coronary risk to either an exercise program or an inactive control group. Questionnaires surveying social-psychological variables were administered 18 months later. Men adhering to the exercise program reported improved work performance and satisfaction, increased stamina and energy, feelings of better health, and greater tolerance to stress. Approximately 45% (vs 28% of the controls) ate less and avoided between-meal snacks, and 40% (vs 22%) increased recreational activities and relied less on elevators and cars for transportation than before the program. Changes in sleep patterns were also observed. Thirty-five percent of the exercisers as opposed to 10% of the controls reported a need for less sleep and achieved deeper and more relaxed sleeps.

The administration of contrived tasks to elicit autonomic responses is a recognized, albeit largely neglected, approach to the study of physical-psychological relations. Evans, Cox and Jamieson (Note 2) determined the aerobic capacity of students and then measured heart rate reaction to, and recovery from, psychological stress (false feedback on performance of perceptual and intelligence tests, as well as experimenter harassement). Although aerobic capacity was not found to be related to the magnitude of response to stress, subjects with the highest aerobic capacities recovered the most quickly.

The evidence that physical fitness improves psychological well-being has prompted the use of physical training programs for rehabilitation purposes. The benefits derived by post-coronary patients have been amply documented (Kavanagh, 1976; Prosser, Carson, Gelson, Tucker, Neophytou, Phillips & Simpson, 1978). Not only have fitness programs increased cardiac efficiency and reduced the incidence of recurrent heart attacks, but subjective measures have also indicated that depression is reduced and morale and self-confidence restored. Physical training has also been found to relieve emotional and physical disorders (Collingwood & Willett, 1971; Klein & Defenbacher, 1977). Although a number of researchers (Murphy, Bennett, Hagen & Russell, 1972) have reported that exercise benefits alcoholics psychologically, none has mentioned its influence on alcohol consumption. An informal follow-up by Guthrie (Note 3) confirmed that regular jogging failed to diminish the drinking habits of his subjects.

Despite the popularity of prescribing physical activity for such diverse disorders, it has been suggested (Pitts, 1969; Pitts & McClure, 1967) that exercise may be detrimental to psychological well-being. In a double-blind experiment, Pitts and McClure demonstrated that the infusion of lactate (i.e., the byproduct of anaerobic muscle contraction) precipitated anxiety attacks in anxiety neurotics. Although fewer and less severe, normal controls experienced some of these symptoms as well. The ensuing Pitts-McClure hypothesis, that physical activity produces anxiety in almost all persons, therefore discourages the use of exercise as a rehabilitative treatment. However, the fact that the subjects received injections, albeit blindly, and were then asked to give self-reports on anxiety states, could have led them to attribute their physiological sensations solely to the injection, and also to label these sensations as anxiety.

The experimental test of the Pitts-McClure hypothesis has been performed in a series of investigations by Morgan (Note 4; Morgan, Roberts & Feinerman, 1971). They observed that muscular exertion resulting in lactate accumulation not only reduced state anxiety and depression, but actually enhanced feelings of well-being in both anxious and non-anxious persons. These studies serve to clearly challenge the Pitts-McClure hypothesis.

Present Study

History of presently employed stress-inducing tasks. Not only have subjective psychological measures weakened the findings of many studies (Folkins, 1976; Johnson, Fretz & Johnson, 1968), but contemporary theorists (e.g., Mandler, 1962; Schachter, 1966) have emphasized autonomic reactivity as a necessary component of emotionality. Six cognitive and perceptual tasks were therefore employed in this present study to induce autonomic arousal; that is, they were chosen not to test subjects' performances, but rather for their stress-inducing abilities. All tasks were presented in an abbreviated time period in order to create a greater number of errors than would ordinarily be made.

One task employed in the present study was the Stroop color-word. This is a color-word interference test which was introduced into American psychology by Stroop in 1897. The color-word phenomenon has been interpreted as an interference effect caused by response competition between habits of unequal strengths, with the stronger habit (word reading) being inhibited in favor of the weaker one (color-naming). Despite individual differences in the magnitude of this phenomenon, all literate persons are said to be subject to it (Jensen & Rohwer, 1966). The various behavioral manifestations elicited by this test, such as laughter, embarrassment, etc., have prompted its use in psychological research as a stress inducer (e.g., Jorgenson, 1977; Pallak, Pittman, Heller & Munson, 1975).

While the mirror star-tracing task was designed to exhibit bilateral transfer of learning (Underwood, 1966), the required reversal of movement renders it a conflict task in visual and kinesthetic feedback. It was for this ability to induce stress that the mirror star-tracing task was selected for this present study.

A third task employed in this study was block design. It was first introduced in 1923 as a non-verbal measure of intelligence, and was later incorporated into the Wechsler Adult Intelligence Scale (WAIS). Block design measures the reproductive aspect of visual-motor coordination, involving both analysis and synthesis.

Digit span, another subtest of the WAIS, takes its origins from the Stanford-Binet Test of Intelligence. It was designed to measure immediate auditory recall (short-term memory) and consists of both a backward and forward version. Only forward recall was employed for purposes of this present study.

Raven's progressive matrices, another task employed in this study, was developed in 1943 for the use of Great Britain's

War Officer Selection Boards. In 1947 it was revised for general use as a test of an individual's capacity for coherent perception and orderly thinking under stress. The Advanced Set II, used in this present study, was prepared for adolescents and adults of above-average intelligence. Presented with a time limit, as in this experiment, Raven's progressive matrices becomes a speed test of intellectual efficiency (Raven, 1965).

The bolt head maze, a sixth task used in this study, was originally devised by Barker (1931) as a means of studying maze learning involving spatial elements. The apparatus was modified by Milner (1965) for the study of nonverbal learning in brain-damaged patients. The maze employed in this present study was modeled on the one designed by Milner.

Experimental design. The present study experimentally manipulated fitness levels to determine if regular physical activity influences recovery from physical and psychological stress. Subjects were randomly assigned to one of three groups. One received training in physical fitness, another in Yoga meditation, and the third was exposed to music appreciation classes. The expectation of enhanced feelings of well-being common to both fitness and meditation training, coupled with evidence from Michaels, Huber and McCann (1976) and Sime (Note 5) that meditation is of little therapeutic value,, prompted the use of meditation as a control for subject's expectancy. Music classes acted as a further control for group participation in an experimental activity.

All subjects were individually tested at the beginning, midpoint, and end of the study. Physical fitness was assessed by heart rate recovery time following a step test, while autonomic change during emotionally stressful tasks provided the index of psychological fitness.

On the basis of prior studies on the physiological changes produced by aerobic exercise (e.g., Joseph, 1974; Smith & Stransky, 1975), it was expected that the exercisers would gradually exhibit faster heart rate recovery times from the step test as they progressed through the study. The two control groups were expected to maintain consistently slow recovery times. If improved physical fitness also enhances psychological well-being, it was expected that the exercisers would recover more quickly from the stress-inducing tasks as their fitness levels improved. In contrast, Groups Music and Meditation, whose fitness levels remained static, were expected to manifest consistently high levels of stress in each test session.

Method

Subjects

Subjects were recruited by advertisements posted in universities and colleges throughout Montreal. In a telephone interview, respondents received brief descriptions of the study and the three prospective classes: exercise, music appreciation, and meditation. An order of preference for the classes was requested, as well as whether willingness to participate in the study was conditional on class assignment. Those who insisted on placement in a specific group were rejected. Screening with respect to current participation in physical activities and past medical history was also conducted. Individuals reporting minimal levels of recreational activities and no physical abnormalities that would endanger themselves or affect performance were selected. Approximately 10% of the respondents were excluded because of the above considerations or regular athletic participation.

Thirty males and thirty females (mean age, 23.2 years) served as subjects. Except for designating an equal number (10) of males and females to each group, initial group assignment was random. However, difficulties in class scheduling often necessitated re-assignment, although the ratio was maintained in all groups.

As a precautionary measure, individuals 30 years and over were required to procure medical examinations. Participants in non-exercise treatments were asked to maintain current levels of physical activities. All subjects were offered a salary of $200.00 contingent upon satisfactory attendance. Payment was spread throughout the study in three installments. If class attendance fell below 85%, remuneration was based on the proportion of classes attended.

Apparatus

A GSR Preamplifier, Physiograph model MK11, attached to a Physiograph Projector, model PMP-4A, monitored GSR. Wire passed through 1½ square inch pieces of sponge moistened in saline served as electrodes. GSR was monitored on AC mode which recorded change relative to baseline. Pulse rate was monitored on a Gulf and Western pulse watch, model 420, via a photo cell electrode clipped to the fingertip. A carpeted wooden step, 16 inches high, 18½ inches long, and 11 inches wide served as the step for the test of physical fitness.

Stress Inducing Tasks

Five minutes were allotted to each of six stress-inducing tasks (see Appendix A) as measured with an elapsed time meter clearly visible to the subject. This time limit was found in pilot work to be insufficient for successful completion of any of the tasks. The subject performed each test with his non-dominant hand.

Stroop color-word task. The Stroop color-word test consisted of ten-inch square cards on which five incongruously printed color-words were randomly arranged in a ten-by-ten matrix. The task was to name the color of the ink of each successive word, synchronized to the beat of a metronome set at 66 beats per minute.

The total number of errors and cards completed within the five minutes were recorded.

Mirror star-tracing task. The mirror star-tracing task consisted of an upright mirror and a six-pointed star engraved in plywood. Another piece of wood attached to a support served to completely obstruct the subject's direct view of the star. The task was to direct an electromechanical stylus down the centre of the path in a counter-clockwise direction while following the image in the mirror. When the stylus deviated from the centre to the path's sides, a buzzer was activated. The number of errors and tracings completed in the five-minute time limit were recorded.

Block design. Block design consisted of nine wooden blocks (cubes) painted red on two sides, white on another two, and red/white on the remaining two. Five cards with geometric designs incorporating all nine blocks were presented one at a time to the subject. One minute was given to reproduce each pattern.

Digit span. Sixty-eight random series of seven-, eight-, and nine-digit numbers comprised a modified version of digit span. Single digit numbers which never appeared twice in any given series were used. Three practice sequences preceded the test proper. All stimuli were prepared and presented on a casette tape recorder. The task was to repeat each sequence of numbers without error in the three-second pause which separated each series. Subjects were told to continue for five minutes or until the criterion of ten consecutive correct repetitions was met.

Raven's progressive matrices. A modified Raven's progressive matrices consisted of 20 slides of incomplete matrices which were presented in order of increasing difficulty. The subject was required to select the design which provided the missing part from eight response alternatives. Each matrix was presented for 15 seconds. Subjects were told that five consecutive correct responses would terminate the test.

Bolt head maze. The subject was required to advance a stylus through a ten-by-ten matrix of bolt heads countersunk in plywood on an unmarked path via vertical and horizontal movements. A buzzer indicated each error, at which time the subject was instructed to return the stylus to the last correct bolt head. The task was introduced as a learning one; that is, the subject was required to repeatedly trace the path until he achieved one errorless run. The experimenter recorded the number of tracings and errors the subject completed in the five-minute time limit.

Life-Style Questionnaire

A 66-item questionnaire (see Appendix B) was administered to subjects in each test session. Demographic information, recreational activities, frequency of illness, as well as eating, smoking, sex, and sleeping habits were surveyed. The final section of the questionnaire was a modified version of Myers' (1966, cited by

Radloff & Helmreich, 1968) mood adjective checklist consisting of 25 adjectives describing five moods: anger, happiness, depression, psychological well-being, and lethargy. Employing a rating scale from 1 to 3, subjects rated the degree (from 'not at all' to 'mostly or generally') to which each mood characterized their life-styles over the previous month.

Treatments

Each group met for 30 minutes four days a week for ten weeks. Exercise and music classes were conducted by the author, while the meditation classes were led by a certified member of the International Meditation Institute of Montreal.

Exercise. Classes for Group Exercise were scheduled to be held at the Physical Education complex of the Université du Québec à Montréal, but as the study occupied the summer months, the majority of classes were conducted outdoors at a nearby park. The classes were held in the early afternoon, and consisted of progressive running and calisthenics modeled on the YMCA method (Myers, 1975). The first four classes were composed of ten-minute walk/run sequences, supplemented with 20 minutes of general conditioning exercises. Running time was increased gradually as the study progressed so that by the tenth week subjects were completing two miles of nearly continuous running.

Music appreciation. Classes for Group Music were held in the late afternoon in a seminar room at Concordia University, Sir George Williams campus. Each class began with a brief lecture on the history of music and the biographies of various composers. Classical recordings were played to illustrate the day's lecture material. A relaxed atmosphere was maintained by encouraging subjects to request their favorite compositions, and by permitting them to read or rest with their eyes closed while listening to the records.

Meditation. Classes for Group Meditation were held in the early evening in a carpeted lounge at Concordia University, Sir George Williams campus. Subjects received a joint Mantra and were instructed in the basic techniques of Yoga meditation. Each session began with a brief reading of the philosophy and science of meditation while subjects sat cross-legged on the floor. They then meditated for approximately 20 minutes.

Procedure

The study extended for ten weeks between late June and early September. Subjects participated in exercise, music appreciation, or meditation classes four days a week. Individual test sessions occurred during the second, sixth, and tenth weeks, with at least six hours separating a test session from a subject's last class. Testing procedures for the three sessions were identical. In each session the subject first received the step test of physical fitness, and then two of the six stress-inducing tasks which were counterbalanced across the three conditions and the three test sessions. All testing was conducted in a small copper-shielded laboratory.

The subject first entered a closed hallway where a desk, questionnaires, pencils, and a list of instructions were provided. He was requested to remove his shoes and all jewelry from hands and arms and then to start answering the life-style questionnaire until called into the laboratory. After weighing the subject, the experimenter explained the step test and demonstrated the stepping sequence as well as the technique of stretching the back and knees and lowering the heels on each step. The pulse watch electrode was then clasped onto the middle finger of the subject's right hand. Basal pulse rate was recorded as he stood facing the step just prior to commencement of the test. At the signal "go", the subject began the test which lasted two minutes. A metronome set at 116 beats per minute paced the subject's stepping. He placed one foot on the step, followed immediately by his second foot and then stepped down, one foot at a time, starting with the leading foot. Working heart rate was recorded half-way through the test, and immediately upon its completion. Subject sat quietly on the step during the post-test recovery period during which pulse rate continued to be recorded once a minute for eight minutes or until it returned to basal level. GSR electrodes were then secured to the palm and wrist of the subject's dominant hand, and two five-minute stress-inducing tasks, separated by a three-minute break, were administered. The subject then returned to the hallway to complete the questionnaire if he had not already done so.

Data Analysis

Post-test recovery time, the time required for heart rate to return to basal level, provided the index of physical fitness. Emotional arousal was inferred from GSR lability during the two five-minute stress-inducing tasks. Absence of arousal was considered to produce GSR scores with little lability. The polygraph curves would therefore be relatively flat and the tracings short. Greater arousal, resulting in greater lability, would produce longer tracings as they would be more curvilinear. The length of the polygraph curves was traced with a map measurer, model 102, Harrison Co., Montreal, to provide an indirect assessment of GSR lability. A ratio was then calculated, comparing the lability score of the second test to the pooled scores of both tests. Lability ratios less than 50% represent a decrease in the second half of the pooled scores (i.e., recovery from arousal), whereas ratios greater than 50% indicate an increase in fluctuation. Lability ratios of 50% represent continued arousal.

Results

Appendix C contains individual subject's data for basal, working and recovery heart rates for the three test sessions. Lability ratios and separate GSR lability scores for the two stress-inducing tasks administered in each test session are presented in Appendix D. Appendix E contains mean scores of each adjective included on the mood adjective checklist, while Appendix F contains standard deviations for basal and recovery heart rates as well as GSR lability ratios. Summary tables of Tukey tests comprise Appendix G.

Heart Rate

Figure 1 contains group means for time required for heart rate to return to basal level after completion of the step test. A 3 x 3 (Groups x Sessions) repeated measures analysis of variance (ANOVA) for each of the three test sessions was performed on heart rate recovery times (see Table 1). A significant groups effect was revealed ($F(2,54) = 3.35$, $p < .05$). To determine where group means were significantly different from each other, subsequent one-way ANOVA's on each test session were calculated. F-ratios were only significant for Session 3 ($F(2,54) = 5.74$, $p < .01$). A Tukey post-hoc test, using a harmonic mean to average unequal n's, revealed that Group Exercise recovered significantly faster than Groups Music ($p < .05$) and Meditation ($p < .01$).

Basal and post-test heart rates were examined as well (see Figure 2). No significant trends were revealed in the latter measure; the maximum difference of basal heart rates for all groups and sessions was less than two standard deviations from the mean. One-way ANOVA's on basal heart rates revealed significant differences in Session 3

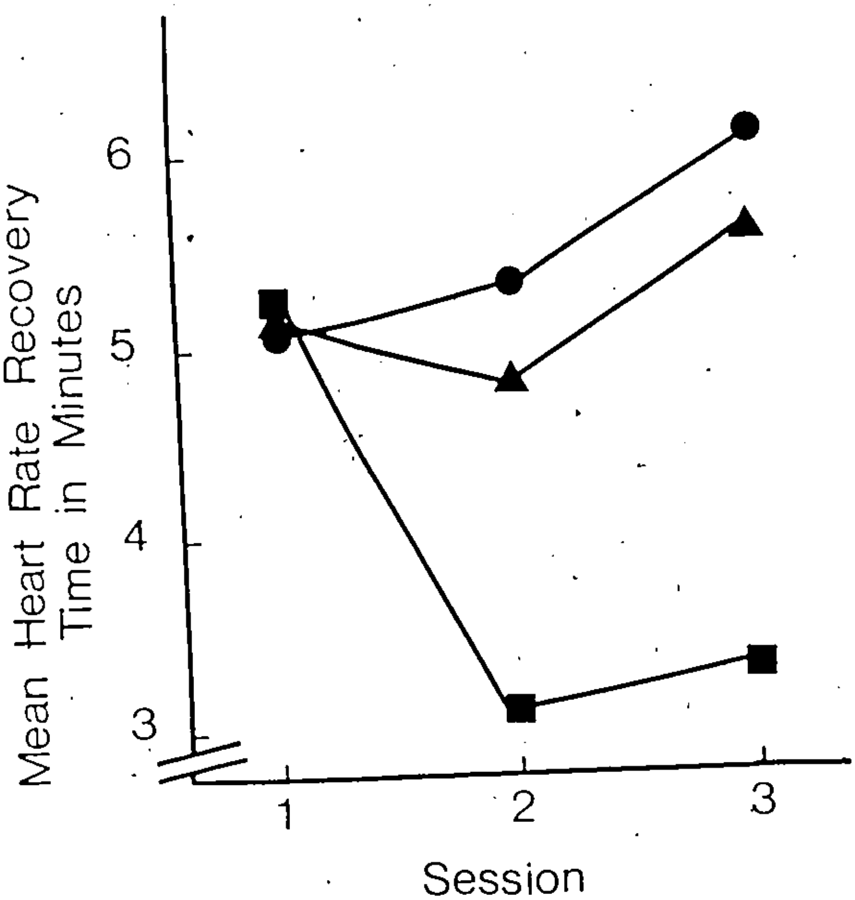

Figure 1. Mean heart rate recovery time in minutes for Groups Exercise (■), Music (▲) and Meditation (●) across the three test sessions.

Table 1

Summary of Two-Way Repeated Measures Analysis of Variance on Heart Rate Recovery Times

Source of Variance	SS	df	MS	F
Between Subjects				
Group	92.495	2	46.247	3.354*
Error (between)	744.508	54	13.787	-
Within Subjects				
Session	19.705	2	9.852	2.444
Group x Session	27.256	4	6.814	1.690
Error (within)	435.342	108	4.030	-

$^{*}p < .05$

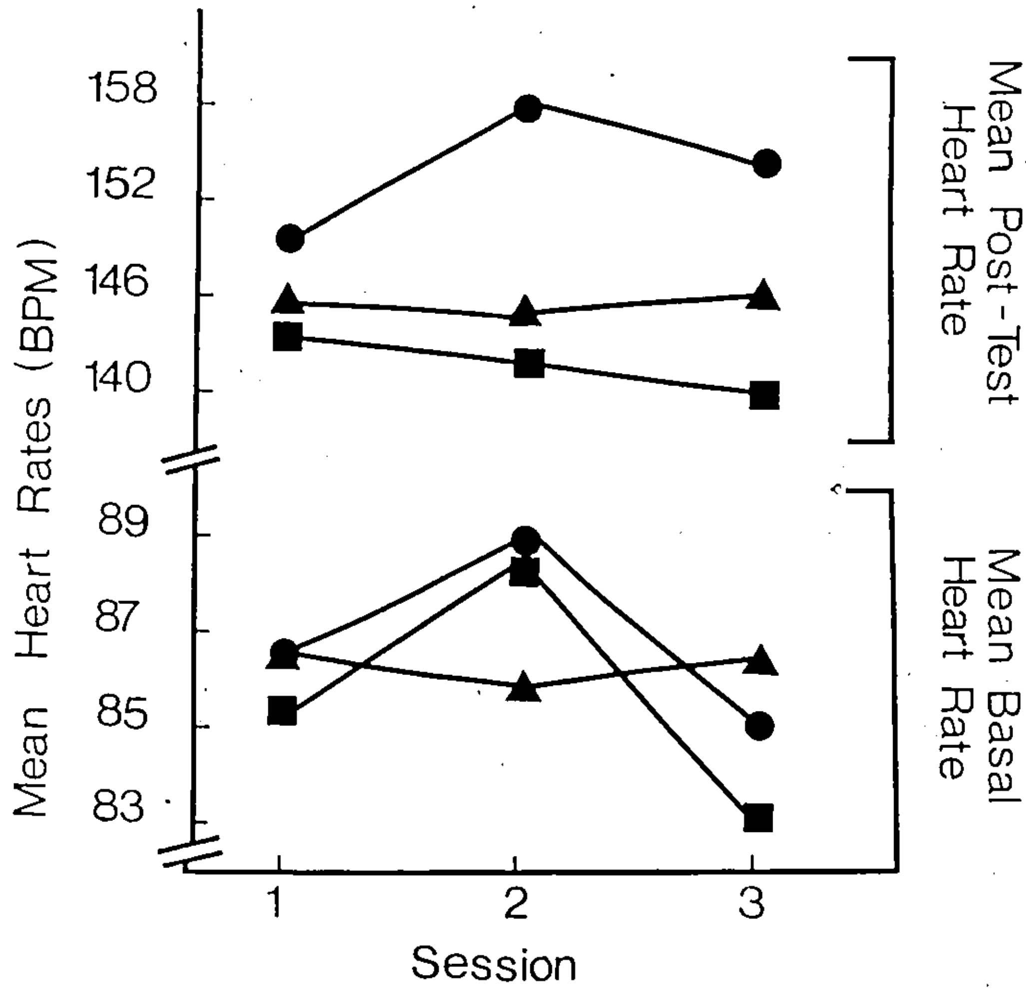

Figure 2. Mean basal and post-test heart rates for Groups Exercise (■), Music (▲) and Meditation (●) across the three test sessions.

(F(2,54) = 8.47, $p < .01$). A Tukey test indicated that Group Exercise had significantly lower basal heart rates than both Groups Music ($p < .01$) and Meditation ($p < .05$).

Galvanic Skin Response

Figure 3 presents mean GSR lability ratios. A 3 x 3 (Groups x Sessions) repeated measures ANOVA for each of the three test sessions was performed on GSR lability ratios (see Table 2). A significant main group effect was revealed ($F(2,54) = 10.35$, $p < .001$), as well as a significant interaction between sessions and groups ($F(4,108) = 3.47$, $p < .01$). One way ANOVA's indicated significant differences in Sessions 2 and 3. Tukey post-hoc tests indicated that Group Exercise had significantly smaller lability ratios than Groups Music ($p < .01$) and Meditation ($p < .01$) in both sessions.

GSR Data on the First Stress-Inducing Task

A 3 x 3 (Groups x Sessions) repeated measures ANOVA for each of the three test sessions was performed on the GSR lability scores of the first of the two tasks administered in each test session (see Table 3). A significant group effect was found ($F(2,54) = 3.99$, $p < .05$), but neither sessions nor the interaction between groups and sessions reached statistical significance. Individual one-way ANOVA's were calculated on each test session revealing significant differences in Session 3 only ($F(2,54) = 4.62$, $p < .05$). A Tukey test indicated that Group Exercise had significantly smaller lability scores than Groups Music ($p < .05$) and Meditation ($p < .05$).

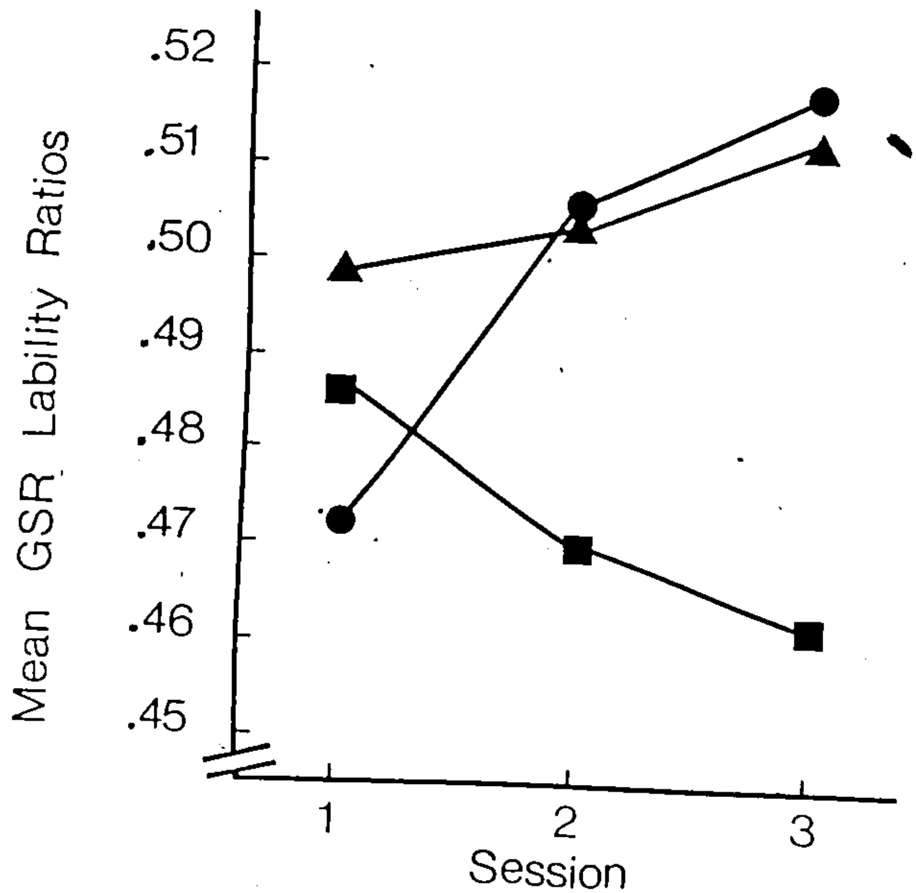

Figure 3. Mean GSR lability ratios for Groups Exercise (■), Music (▲) and Meditation (●) across the test sessions.

Table 2

Summary of Two-Way Repeated Measures Analysis of Variance

on GSR Lability Ratios

Source of Variance	SS	df	MS	F
Between Subjects				
Group	.030	2	.015	10.348***
Error (between)	.079	54	.001	-
Within Subjects				
Session	.004	2	.002	1.437
Group x Session	.021	4	.005	3.465**
Error (within)	.165	108	.001	-

** $p < .01$

*** $p < .001$

Table 3

Summary of Two-Way Repeated Measures Analysis of Variance on GSR Lability Scores on the First Test in Each Test Session

Source of Variance	SS	df	MS	F
Between Subjects				
Group	16514.80	2	8257.420	3.997*
Error (between)	111514.00	54	2065.570	–
Within Subjects				
Session	1347.93	2	673.965	0.580
Group x Session	7731.25	4	1932.810	1.665
Error (within)	125360.00	108	1160.740	–

* $p < .05$

Life-Style Questionnaires

Six main categories were extracted from the questionnaire for individual analysis: activities (running, swimming, cycling, squash, weight lifting, tennis, and soccer), illnesses (backaches and headaches), eating, smoking, sex, and sleep. Percentiles were calculated, comparing the replies of each category across the three test sessions. Differences greater than 10% represented a change, whereas differences less than 10% represented no change (see Table 4). An increase or decrease in activities was determined by a change in either duration or frequency of participation, as well as the addition or deletion of activities. An increase or decrease of illnesses refers to changes in frequency, while eating habits were quantified by changes in both quality and quantity of food consumed. Changes in smoking habits were measured by increased or decreased consumption, and sex habits by both frequency and quality of sexual activity. Changes in sleep habits were rated on the basis of better or poorer quality, as inferred from the average time it took to fall asleep, as well as degree of reported restlessness.

Chi square tests were calculated on the frequency of increases and decreases in each of the six categories. Only activities yielded a significant difference ($X^2 = 13.44$, $p < .01$); that is, Group Exercise increased activity levels significantly more than both Groups Music and Meditation.

Five moods (anger, happiness, depression, psychological well-being, and lethargy) were included on the mood adjective checklist, with five adjectives describing each. Means were calculated for each adjective and are presented in Appendix E. Mean mood scores (see

Table 4

Percent Changes on the Life-Style Questionnaire

for Each of the Three Groups

	GROUP					
	EXERCISE		MUSIC		MEDITATION	
	Increase	Decrease	Increase	Decrease	Increase	Decrease
Activities	75%	0%	15%	35%	15%	25%
Backaches	6%	20%	10%	25%	10%	20%
Headaches	0%	31%	25%	30%	20%	30%
Eating	20%	0%	15%	5%	10%	10%
Smoking	0%	0%	0%	15%	10%	10%
Sex: Frequency	6%	0%	15%	0%	5%	20%
Enjoyment	6%	0%	0%	5%	0%	5%
Sleeping	38%	0%	15%	1%	10%	5%

Figure 4) were then computed based on the mean scores of each of their corresponding five adjectives. Differences for all groups were negligible across the three test sessions.

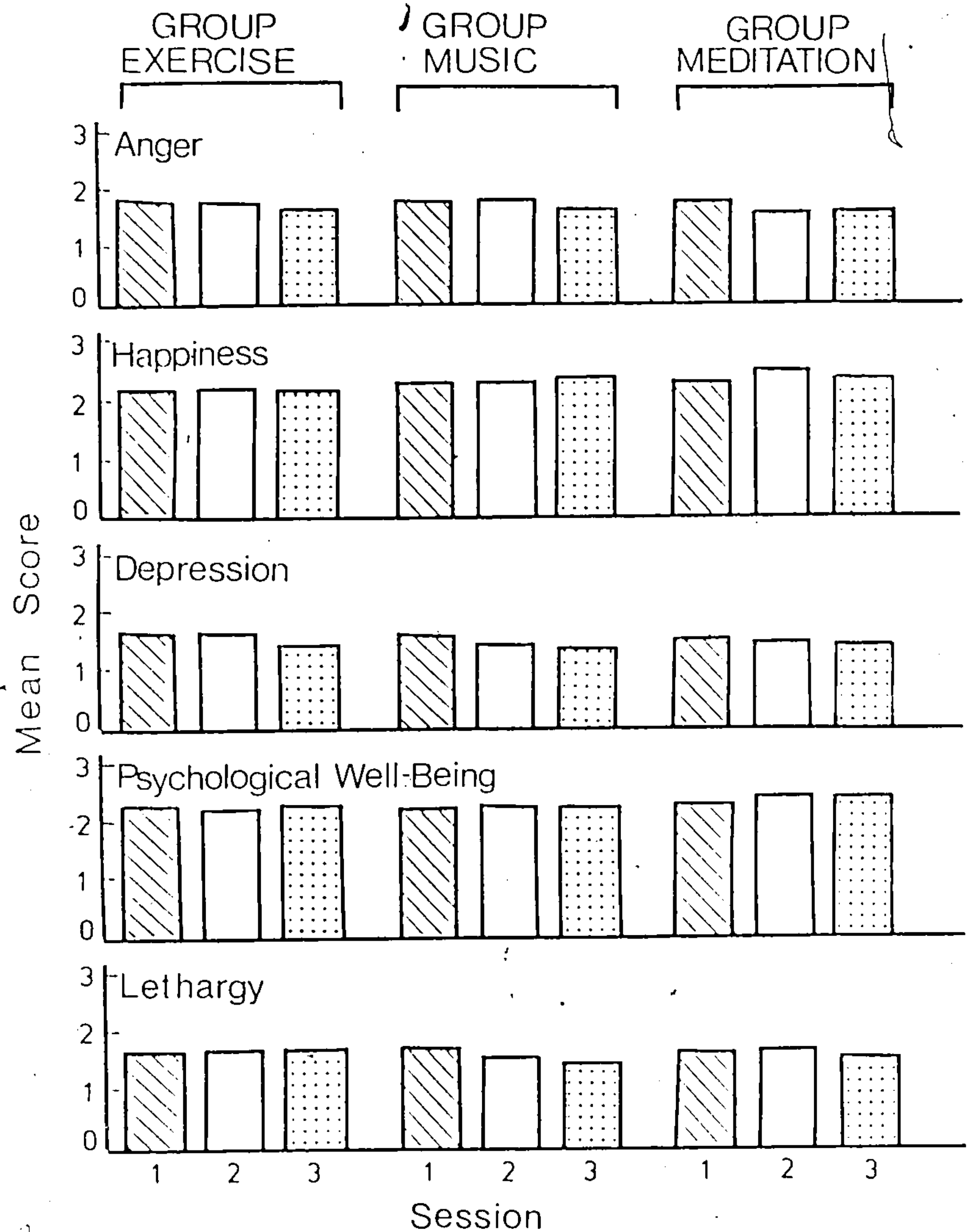

Figure 4. Mood Adjective Checklist: Mean Scores for Groups Exercise, Music and Meditation in Sessions I (\\), II ( ), and III (:::).

Discussion

In summary, two major results were obtained. Mean heart rate recovery times for Groups Exercise, Music and Meditation were almost identical in Session 1, but by Session 3 subjects in Group Exercise recovered significantly faster than the subjects in the other two groups. GSR lability ratios did not differ across the three groups initially, but ratios of Group Exercise decreased successively across Sessions 2 and 3 while those of the other two groups increased.

Changes in heart rate recovery time over the three test sessions indicate that physical training accelerated heart rate recovery from physical stress whereas neither meditation nor listening to music was effective. The finding that Group Exercise recovered faster from the step test in Sessions 2 and 3 also demonstrates their improvement in physical fitness level. That Groups Music and Meditation recovered at consistently slow rates in all three test sessions indicates that they did not improve fitness levels throughout the course of the study. The significantly lower basal heart rates of subjects in Group Exercise in Session 3 serves to further contrast their improved aerobic fitness to the static, poor fitness levels of Groups Music and Meditation throughout the study. These heart rate changes, therefore, support the hypothesis that exercise classes would improve cardiac efficiency. Given the strong correlations between the various physiological changes produced by physical training (Astrand & Rodahl, 1970), it may be inferred that subjects in Group Exercise may also have been experiencing improvements in other physiological systems, including a greater maximum oxygen uptake, and so on.

Although the monitoring of heart rate recovery time following a stepping task as an index of physical fitness was recognized by Schneider as early as 1920, relatively few recent studies have incorporated this measure. The present findings, however, demonstrate the reliability of heart rate recovery as a measure of physical fitness.

Changes in GSR lability ratios over the three test sessions indicate that aerobic training was also effective in accelerating autonomic recovery from emotional stress while meditation and music appreciation were not. The successively smaller GSR lability ratios of Group Exercise over the three test sessions indicate that as physical fitness improves so does autonomic recovery from emotional stress. The increasing lability ratios of Groups Music and Meditation, which indicate continued stress in response to the tasks, reflect their poor physical fitness levels. The finding that in Session 3 the lability scores on the first of the two stress-inducing tasks were significantly lower for Group Exercise than for both control groups may be interpreted as the exercisers having habituated more to the testing procedure. In other words, Group Exercise, which had less lability on the first test, still recovered significantly faster than the other two groups.

The present use of autonomic recovery as an index of psychological well-being illustrates the applicability of Cannon's (1932) theory of homeostasis (i.e., the body's ability to restore physiological balance following arousal). The use of GSR recovery ratios also supports Malmo's (1975) and Johansson's (1976) findings that individuals may be differentiated according to the rapidity with which they recover to baseline levels.

Comparisons of the physiological responses of Group Meditation versus Groups Music and Exercise suggest that meditation training failed to accelerate autonomic recovery from physical and psychological stress. Despite the claim that meditation has stress-alleviating qualities (Wallace, 1970), the meditators in this study exhibited poorer working and recovery heart rates, and an even greater autonomic response to emotional stress than before their meditation program. One unexpected finding was that although their basal heart rates decreased somewhat in Session 3, the change was not statistically significant. This could possibly be explained by the fact that all subjects were asked to stand before the step with "eyes closed and empty minds" at the time basal heart rates were being monitored; that is, Group Meditation may have become more adept than the other two groups at inducing a quick state of relaxation. These findings suggest that meditation may be effective in producing situational and transitory states of relaxation, while the relaxing effects of exercise may be considered more durable.

Life-style changes obtained in this present study were similar to those reported by Heinzelmann (1975). The significant increase in the exercisers' activity levels demonstrates that they developed an overall interest in participating in sports. Informal observation revealed that several of them joined a tennis club and partook in regular tournaments, two added recreational swims to their daily schedules, and a group arrived at the gymnasium one hour before the fitness classes to play badminton, basketball and other group sports. That Groups Music and Meditation reduced activity levels could be attributable to the fact that more of these subjects were working full-time. Having classes in the early evening may have conflicted with their usual free time for recreational activities.

Although other life-style changes were not significant, Group Exercise experienced the smallest increase in illnesses as compared to the control groups, slept and ate better, and also engaged in more enjoyable and frequent sexual activity. These findings are congruous with the claim (Cogan, Note 6; Morgan, 1968) that exercise enhances feelings of well-being and generally improves the quality of one's life. Changes in mood were both negligible and unsystematic for all three groups. This failure to replicate Radloff and Helmreich's (1968) findings could be due to the fact that in the present study, responses from the experimental group were compared to those from control groups. Radloff and Helmreich performed repeated measures on an experimental group only, assuming that a control group would provide similar reports on successive administrations of the mood adjective checklist.

Due to a longstanding belief that women experience mood and behavior changes, and also diminished efficiency during phases of their menstrual cycle, most studies on physical-psychological relations have involved male subjects only. However, Kopell, Lunde, Clayton and Moos (1969), investigating cyclic variations in autonomic measures of arousal, found that GSR did not vary significantly with phases of the menstrual cycle. Pierson and Lockhart (1963), measuring simple reaction time and movement time, also found no significant differences over the menstrual cycle. The finding that females did not differ from males in their response to stress in this present study provides further support for the inclusion of women as subjects in future research.

Several unforeseen problems were encountered at various stages of this study. Group Meditation had to change the location of their classes twice within the first week of the experiment. This may have diminished the enthusiasm of many of the subjects and also may have interferred with the meditation instruction. As well, informal observation indicated that subjects differed markedly in their proficiency at inducing a meditative state: some committed themselves thoroughly, while others appeared restless and bored. This latter finding was reflected in erratic and consistently low class attendance.

The Stroop color-word test presented unexpected problems as well. Several subjects did not speak English as a first language, making the reading task more difficult for them. As well, the Stroop appeared to be less stressful for a few subjects because of prior exposure to it.

Even though the step test has been considered the best submaximal measure of physical fitness (Margaria, 1967), it too presented difficulties. Some subjects found it hard to maintain the rapid speed of stepping and to synchronize themselves to the beat of the metronome. Others tended to trip or found it more difficult to straighten their backs and knees as they neared exhaustion. The height of the step also appeared to interfere with the performance of shorter subjects. Although Keen and Sloan (1958) found no relationship between height and leg length and the ease with which subjects climb the step, it is suggested that the step be adjusted for shorter persons.

Although the present study demonstrated that the physically fit recover faster from stress than the unfit, the use of contrived tasks prevents the extension of these findings to real life situations. Because almost all previous studies used experimentally-induced stressors, it is suggested that future research measure autonomic reactions during real life stressors, such as examinations or medical surgery, to determine the effectiveness of exercise in reducing stress.

Whereas the majority of studies on physical-psychological relations have allowed subjects to select their treatment group (e.g., Folkins, Lynch & Gardner, 1972) or have chosen people already participating in some physical activity (Hammett, 1967), this present study experimentally manipulated fitness level. This overcame not only the problems of self-selection, but also the limitations set by correlational designs by permitting directional statements about the influence of physical fitness on psychological functioning. As well, this present study employed an objective measure to assess emotional reactivity. This avoided the interpretive difficulties encountered with the subjective paper-and-pencil tests typically employed in previous research. The inclusion of a meditation treatment as a control for subjects' expectations of both physiological and psychological changes further distinguishes this study from earlier ones. Hence, the present findings provide more conclusive evidence than previous correlational reports for the interrelationship between physical and psychological functioning.

In conclusion, this study demonstrates the effectiveness of physical training in accelerating autonomic recovery from emotional stress. Because psychosomatic (stress-related) ailments are developed when the physiological reactions to stress (e.g., elevated heart rate and blood pressure) are sustained for long periods of time (Selye, 1974), the present findings imply that the physically fit may be less susceptible to psychosomatic ailments. Whereas the fit would recover quickly to normal levels of functioning, the physically unfit would continue to function at elevated levels, thus making heavy demands on the various bodily systems. Continued exposure to stressors would most likely result in the development of stress-related ailments in the unfit. Physical training might not only protect individuals from developing psychosomatic disorders, but it might also reduce occurrences of psychosomatic symptoms in the clinically diagnosed. This would suggest the need for research on the effect of a training program on psychosomatically-ill patients.

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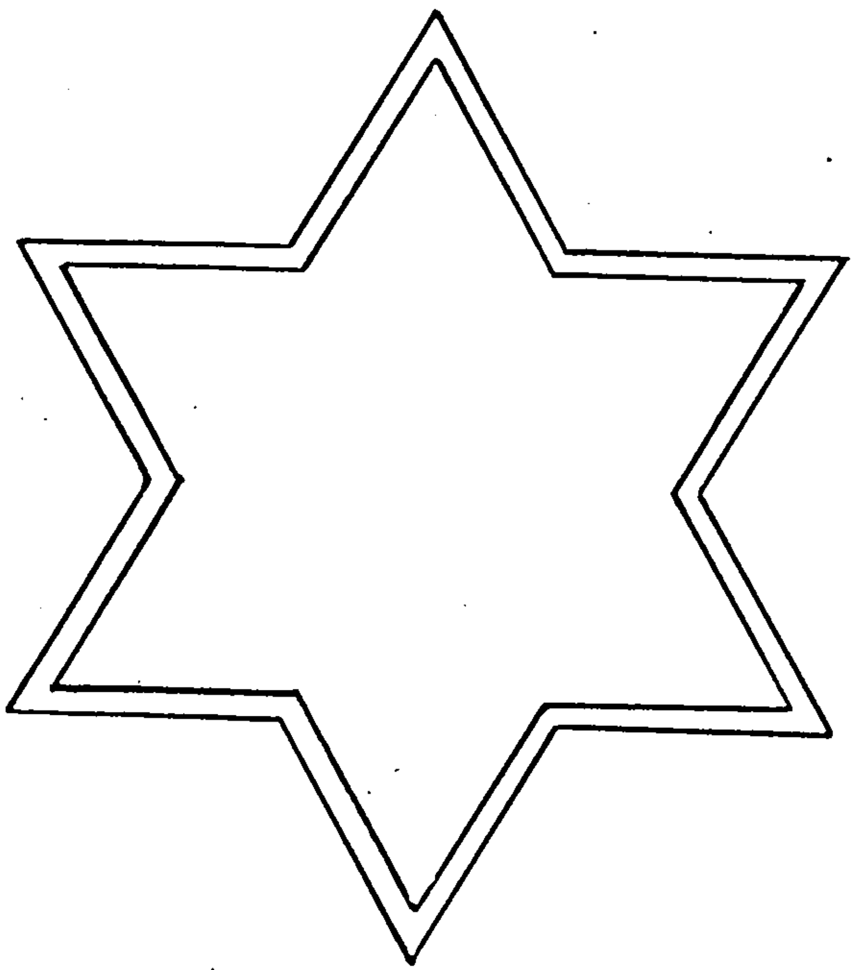
Appendix A

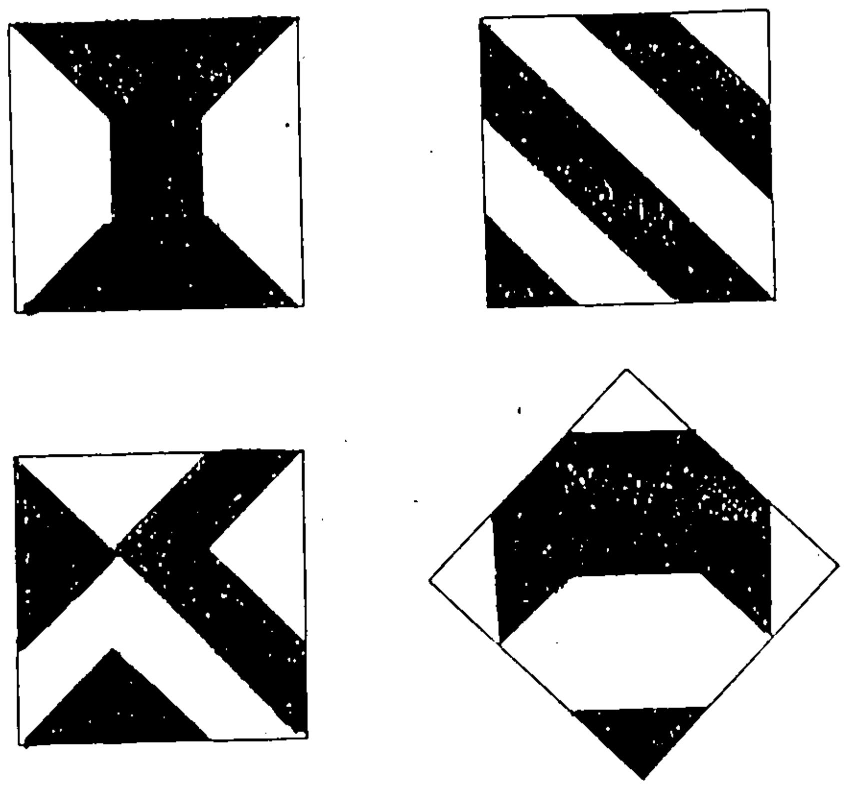
Diagrams of the Stress-Inducing Tasks

Mirror Star-Tracing Task



Appendix A (continued)

Block Design



Appendix A (continued)

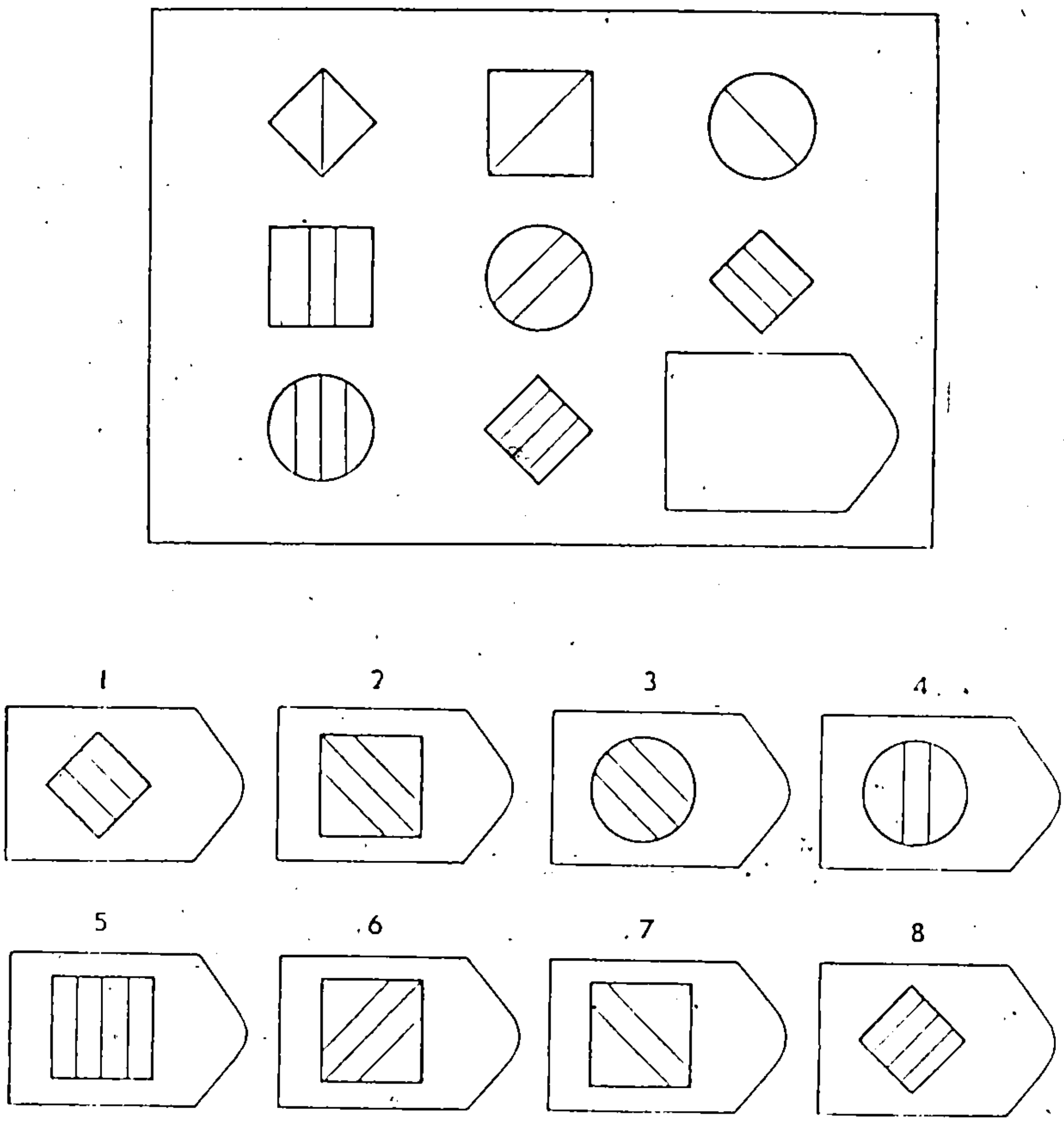
Digit Span

Practice Trials: a) 9-3-7-2 b) 6-2-8-5-1 c) 4-7-3-9-2-6

1)	6-1-6-2-8-3	24)	9-3-7-4-1-8-6	47)	2-7-3-6-9-4-1
2)	1-5-2-9-6-4	25)	2-6-4-9-5-3-8	48)	6-4-7-3-9-2-5-1
3)	7-3-1-8-4-9	26)	4-1-8-5-2-9-3-5	49)	4-1-5-8-2-6-3-9
4)	5-9-6-2-7-3	27)	2-6-3-7-1-8-4-5	50)	5-9-2-8-3-7-9
5)	7-4-8-3-5-9-1	28)	3-7-9-4-8-2-6	51)	7-2-8-5-9-3-1
6)	2-9-6-1-8-3-7	29)	3-7-5-8-2-6-1-7	52)	9-5-4-2-9-3-8
7)	5-2-4-9-3-6-8	30)	9-3-6-2-8-5-1-6	53)	2-8-5-1-4-9-6-3
8)	4-7-3-8-1-5-2	31)	4-7-5-1-9-6-3-7	54)	6-2-8-3-7-9-4-1
9)	9-6-5-7-2-8-1	32)	6-2-5-3-8-1-4	55)	8-4-7-2-9-6-3-1
10)	3-6-1-9-2-7-4	33)	7-3-9-5-1-4-6	56)	6-2-5-9-1-8-4-7
11)	5-3-6-9-7-8-2	34)	8-3-7-2-5-9-4	57)	9-4-7-3-1-8-2-6-5
12)	8-1-6-2-5-9-3	35)	5-9-7-2-6-3-1-8	58)	4-1-6-8-3-7-2-5-9
13)	2-7-4-1-8-3-6	36)	4-7-9-3-1-5-2-6	59)	2-5-8-3-9-2-6-4
14)	4-9-6-3-5-7-1	37)	3-8-1-5-7-2-9	60)	5-2-8-1-3-9-4-7
15)	5-8-3-6-9-2-7	38)	1-5-2-9-6-3-8-7	61)	3-7-4-9-6-1-5-2-8
16)	7-4-9-2-5-1-6	39)	9-3-2-8-3-1-7-6	62)	7-9-5-2-8-3-6-1-4
17)	3-8-2-7-1-5-9	40)	2-5-1-6-4-9-3	63)	2-8-5-9-1-4-7-3-6
18)	8-3-7-4-9-2-5-1	41)	5-8-2-7-3-9-6	64)	8-5-2-6-9-4-1-3-7
19)	4-9-6-1-7-3-8-5	42)	7-3-8-2-5-9-6-4	65)	1-6-9-2-7-5-8-4-3
20)	3-1-9-2-7-4-8-6	43)	5-1-8-4-7-2-6-9	66)	5-8-2-7-4-9-3-1-6
21)	9-6-3-8-5-1-7-2	44)	9-4-1-6-8-3-7-2	67)	4-9-7-1-6-3-8-4-2
22)	4-7-3-1-6-2-9-5	45)	4-9-3-1-6-8-5	68)	3-1-9-6-2-8-5-7-4
23)	8-2-5-9-3-6-4	46)	1-5-9-6-3-7-2		

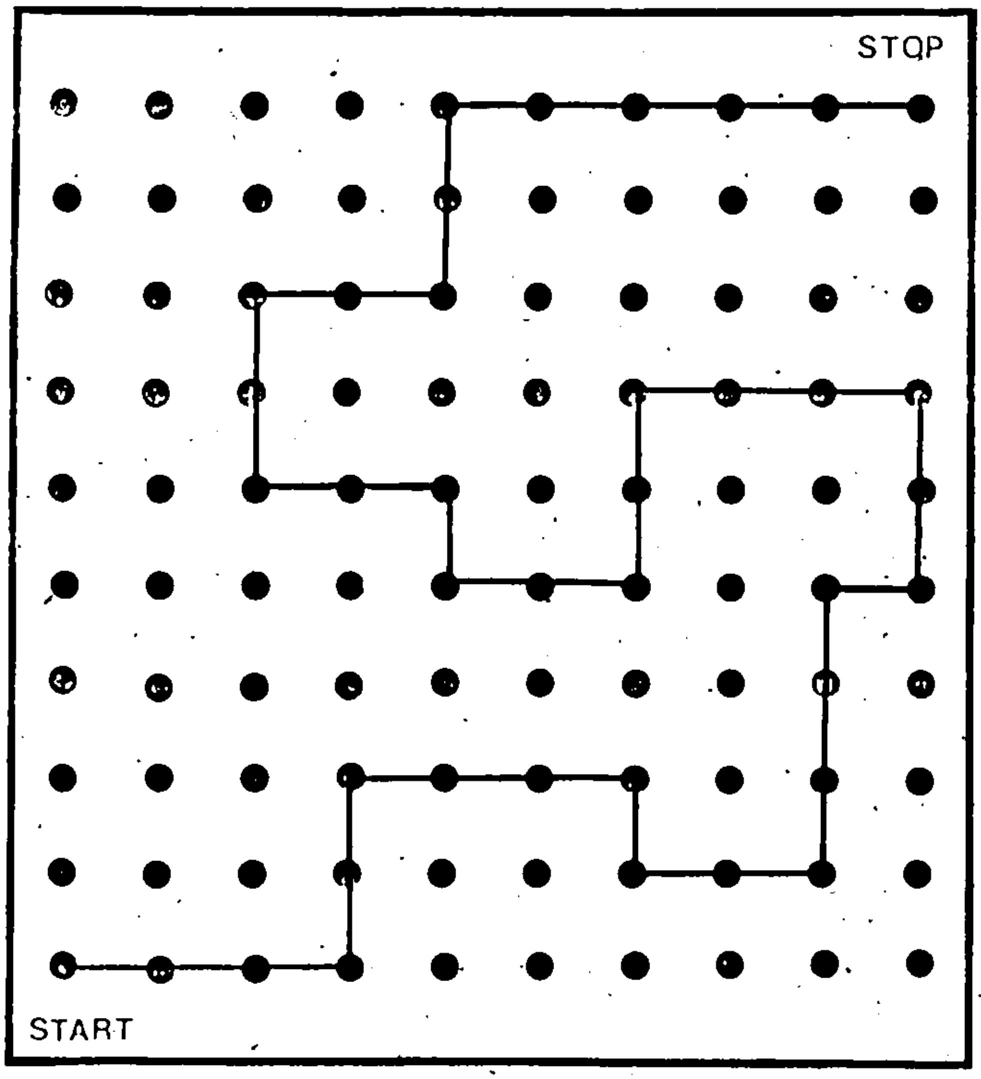
Appendix A (continued)

Raven's Progressive Matrices



Appendix A (continued)

Bolt Head Maze



Appendix B

Life-Style Questionnaire

Personal History

All information on this questionnaire will be kept strictly confidential.

PLEASE PRINT ALL YOUR ANSWERS CLEARLY

Name ____

Sex: Male ____________ Female ____________

Age ____________________

Married __________ Single _______ Separated ______ Cohabit ______

Mother Tongue ______________

Language Most Often Spoken ________________

Level of Education ____________________

Occupation __________________________

Height ______________________________

Weight (to be filled in by Examiner) __________

Appendix B (continued)

PHYSICAL HEALTH HISTORY

1. Do you suffer from any chronic illnesses? (Please specify). ____ ____.

2. Do you have a heart condition? (Please explain) ____.

3. Do you suffer from asthma? Yes ________ No ________.

4. Do you suffer from bronchitis? Yes ________ No ________.

5. Do you have rheumatism? Yes ________ No ______. If so, where? ____.

6. Do you have arthritis? Yes ______ No ______. If so, where? ____.

7. Do you have a hernia? Yes ________ No ________.

8. Do you have a "trick knee"? Yes ________ No ________.

9. Have you had any surgery in the past year? Yes ________ No ________. If so, for what? ______________________.

10. Are you free from postural defects? Yes ________ No ________. (Please specify). ____.

11. When was your last medical check-up? ______________________.

Appendix B (continued)

Please answer the following questions on the basis of your life-style over the past month.

1. How much time did you spend on each of the following activities?

a) Running ____________ f) Calisthenics ____________

b) Swimming ____________ g) Tennis ____________

c) Cycling ____________ h) Soccer ____________

d) Squash ____________ i) Reading ____________

e) Weight Lifting ______ j) Watching T.V. ____________

k) Other ____________ ____________ (Amount)

____________ ____________ (Amount)

2. Did you ever take the stairs rather than the elevator?

Yes ________ No ________

3. Did you ever get off the bus before your designated stop?

Yes ________ No ________

4. Have you suffered from:

a) Headaches /____/____/____/____/ 1 never — 5 often

b) Backaches /____/____/____/____/ 1 never — 5 often

c) Colds /____/____/____/____/ 1 never — 5 often

5. How often did you get sick? ____________

6. How often did you seek medical attention? ____________

7. Have you taken medication? Yes ________ No ______ Quantity ______

8. What did you usually eat for the following meals:

Breakfast ____________

Lunch ____________

Supper ____________

Appendix B (continued)

9. Did you eat between meals? Yes_____ Snacks consisted of________
No______ ____________________________

10. Approximately how much of the following did you consume daily?
   a) Coffee_________
   b) Tea____________
   c) Alcoholic beverages___________
   d) Drugs (marijuana, hashish, etc.) ____________

11. Did you smoke? Yes _________ Amount __________
No __________

12. How often did you engage in sexual activity? ____________________

13. Did you find sex:
   a) Exciting_________
   b) Satisfying________
   c) Unsatisfying______

14. I usually slept _____________ hours a night

15. How long did it usually take you to fall asleep?_______________

16. Was your sleep generally restless and disturbed? Yes_______ No_____

17. I was generally up ______ times during the night.

18. Did you usually wake up feeling refreshed?
Never______ Sometimes_______ Usually ______ Always_______

19. Did you ever take daytime naps? Yes_______ Frequency______
No _______

20. How often did you take sleeping pills?_________________________

Appendix B (continued)

Below is a list of words describing different kinds of moods and feelings. Indicate how characteristic each word is of how you have felt over the past month by placing 1, 2, or 3 after each word.

1 - NOT AT ALL 2 - SOMEWHAT OR SLIGHTLY 3 - MOSTLY OR GENERALLY

1. Raging ______
2. Angry ______
3. Grouchy ______
4. Impatient______
5. Annoyed______

11. Miserable______
12. Sad______
13. Depressed______
14. Despairing______
15. Low ______

6. Wonderful______
7. Fine ______
8. Calm ______
9. Happy ______
10. Contented______

16. Energetic______
17. Lively ______
18. Alert ______
19. Restless______
20. Active______

21. Drowsy______
22. Lazy ______
23. Weary______
24. Sluggish______
25. Inactive ______

Appendix C

Basal (B), Working, and Recovery (Rec.) Heart Rates

GROUP EXERCISE

Subject	Session 1				Session 2				Session 3			
	Minutes				Minutes				Minutes			
	B	1st	2nd	Rec	B	1st	2nd	Rec	B	1st	2nd	Rec
SL	100	160	185	2.0	97	153	164	1.5	96	127	162	1.3
MB	50	90	105	8.0	78	90	144	1.5	77	55	147	2.0
LM	84	-	144	1.7	103	73	158	6.2	89	66	124	0.6
PO	98	115	152	4.5	64	105	117	1.2	75	85	136	1.3
MW	85	110	141	1.5	88	88	134	0.7	83	98	140	1.5
JB	72	60	139	8.0	79	110	145	3.2	65	95	143	8.0
MD	85	75	136	8.0	80	120	126	3.0	85	100	134	1.4
JS	75	90	120	3.0	79	101	138	1.5	74	100	133	2.3
KM	100	65	160	3.5	97	78	163	3.6	98	65	151	3.0
JW	107	136	145	8.0	96	60	133	6.0	99	70	132	4.5
EL	84	110	146	5.0	75	65	129	4.0	74	108	131	3.0
MT	95	123	165	8.0	105	116	162	6.0	98	145	165	3.7
CF	88	130	148	8.0	98	84	148	7.0	86	100	144	8.0
HM	98	138	148	5.0	97	105	139	2.2	76	120	147	8.0
KB	70	65	126	8.0	66	57	119	1.0	84	84	125	0.8
RH	73	98	137	2.0	90	80	139	1.2	80	68	133	1.5
KG	90	124	144	4.0	111	140	166	2.7	78	130	143	4.2

Appendix C (continued)

GROUP MUSIC

Subject	Session 1				Session 2				Session 3			
		Minutes				Minutes				Minutes		
	B	1st	2nd	Rec	B	1st	2nd	Rec	B	1st	2nd	Rec
SN	97	102	147	3.5	106	70	158	6.0	87	101	153	8.0
PS	106	135	159	1.2	94	110	145	1.2	97	100	140	1.0
GT	65	68	131	8.0	99	95	143	2.0	63	100	130	8.0
BL	73	109	134	4.0	54	92	105	1.7	68	81	120	8.0
GW	88	73	145	8.0	76	76	152	8.0	84	81	142	8.0
JW	65	74	120	8.0	80	94	129	8.0	80	99	123	8.0
PM	80	84	120	1.5	70	80	144	3.1	75	81	145	2.7
MS	76	118	180	8.0	95	84	185	8.0	105	110	180	8.0
DH	105	112	139	2.0	100	60	142	8.0	104	84	146	6.1
JP	110	125	167	4.0	96	77	158	3.5	98	91	161	8.0
BP	98	120	138	0.5	80	93	129	0.6	76	65	139	1.1
BF	75	64	144	8.0	76	78	126	2.0	76	84	137	8.0
MW	100	112	150	5.5	96	116	150	1.5	93	94	147	2.5
KB	56	105	138	8.0	74	120	143	8.0	84	128	150	8.0
RB	63	111	124	8.0	60	100	126	2.5	70	134	146	1.7
MA	102	84	170	8.0	95	107	163	6.0	98	140	170	1.7
AF	84	60	136	4.2	84	67	153	8.0	85	55	168	8.0
AB	87	106	147	1.2	87	75	143	1.2	89	75	155	1.5
FR	85	109	158	8.0	100	87	167	8.0	90	86	143	7.1
ES	116	122	163	4.0	98	77	151	8.0	109	70	161	4.7

Appendix C (continued)

GROUP MEDITATION

Subject	Session 1				Session 2				Session 3			
		Minutes				Minutes				Minutes		
	B	1st	2nd	Rec	B	1st	2nd	Rec	B	1st	2nd	Rec
MHe	86	128	140	8.0	82	80	166	8.0	94	130	167	8.0
CC	70	85	156	8.0	114	120	172	2.7	75	85	148	8.0
GR	100	106	181	3.0	89	146	180	4.7	87	135	165	7.0
FA	85	120	156	3.2	84	100	143	4.2	84	120	143	3.7
SW	72	78	131	8.0	78	100	157	8.0	70	83	150	8.0
SI	93	90	157	8.0	85	100	159	8.0	80	70	159	8.0
KL	95	115	159	8.0	99	100	163	3.5	100	111	167	8.0
KM	98	101	160	5.0	82	120	184	8.0	75	78	178	8.0
LP	95	130	153	6.5	83	117	158	8.0	77	127	151	8.0
LD	94	120	163	1.5	120	84	183	3.0	76	60	153	8.0
LG	81	125	146	7.0	87	125	158	6.0	96	120	158	4.2
CB	71	90	130	1.7	76	144	147	4.2	70	136	147	3.0
RL	78	74	137	8.0	119	125	156	2.0	98	140	150	8.0
SK	83	140	157	2.2	78	143	159	8.0	95	145	149	2.2
MHa	88	100	149	8.0	91	95	162	8.0	95	102	163	8.0
OP	112	130	173	4.2	94	70	165	7.0	97	117	163	6.2
MA	103	150	149	1.5	90	105	144	2.0	90	121	138	2.0
RR	87	98	136	8.0	88	96	147	8.0	79	78	145	8.0
BM	62	136	142	1.5	65	120	140	2.5	85	133	164	4.2
MK	76	90	136	0.8	76	87	125	0.8	81	98	145	1.5

Appendix D

Raw GSR Lability Scores and Ratios for the Two

Stress-Inducing Tasks Administered in Each Test Session

GROUP EXERCISE

Subject	Session 1			Session 2			Session 3		
	Test			Test			Test		
	First	Second	Ratio	First	Second	Ratio	First	Second	Ratio
SL	168	145	.46	143	136	.48	248	176	.41
MB	119	124	.51	270	209	.43	138	159	.53
LM	126	120	.48	126	133	.51	195	135	.40
PO	125	126	.50	236	160	.40	148	123	.45
MW	127	124	.49	149	128	.46	147	123	.45
JB	160	128	.44	188	161	.46	331	195	.37
MD	164	159	.49	155	173	.52	184	172	.48
JS	193	304	.61	209	139	.39	167	142	.46
KB	143	149	.51	178	143	.44	156	129	.45
JW	133	132	.49	127	137	.51	123	120	.49
EL	141	119	.45	192	188	.49	144	136	.48
MT	154	156	.50	170	163	.48	211	182	.46
CF	115	126	.52	120	132	.52	120	119	.49
HM	154	138	.47	182	144	.44	221	175	.44
KM	307	138	.31	319	247	.43	159	157	.49
RH	278	256	.47	153	130	.45	203	167	.45
KG	129	128	.49	135	137	.50	127	123	.49

Appendix D (continued)

GROUP MUSIC

Subject	Session 1			Session 2			Session 3		
	Test			Test			Test		
	First	Second	Ratio	First	Second	Ratio	First	Second	Ratio
SN	134	136	.50	178	167	.48	167	133	.44
PS	124	132	.51	180	161	.47	162	156	.49
GT	124	137	.52	140	144	.50	123	129	.51
BL	159	138	.46	222	156	.41	146	153	.51
GW	134	134	.50	128	125	.49	121	130	.51
JW	152	226	.59	152	211	.58	147	149	.50
PM	119	120	.50	153	147	.49	147	181	.55
MS	127	130	.50	175	171	.49	127	132	.51
DH	137	132	.49	123	122	.49	144	159	.52
JP	173	248	.58	134	141	.51	134	148	.52
BP	120	120	.50	141	139	.49	137	151	.52
BF	148	152	.50	127	138	.52	127	137	.51
MW	144	121	.45	164	182	.52	163	197	.54
KB	183	154	.45	183	190	.50	195	238	.55
RB	145	126	.46	120	124	.50	134	138	.50
MA	172	129	.42	150	180	.54	132	151	.53
AF	122	139	.53	136	133	.49	136	132	.49
AB	224	189	.45	184	185	.50	136	147	.51
ER	137	139	.50	158	155	.59	122	122	.50
ES	135	125	.48	203	224	.52	185	170	.47

Appendix D (Continued)

GROUP MEDITATION

Subject	Session 1			Session 2			Session 3		
	Test			Test			Test		
	First	Second	Ratio	First	Second	Ratio	First	Second	Ratio
MHe	192	168	.46	161	190	.54	153	177	.53
CC	179	126	.41	206	185	.47	245	249	.50
GR	172	144	.45	179	228	.56	142	146	.50
FA	290	185	.38	165	192	.53	145	153	.51
SW	124	128	.50	174	185	.51	128	134	.51
SI	165	125	.43	124	126	.50	120	136	.53
KL	135	153	.53	166	160	.49	152	177	.53
KM	138	129	.48	128	132	.50	132	138	.51
LP	143	140	.49	132	136	.50	193	187	.49
LD	123	136	.52	131	140	.51	126	126	.50
LG	136	118	.46	186	158	.45	120	127	.51
CB	226	126	.35	125	149	.54	140	142	.50
RL	184	281	.60	126	134	.51	119	122	.50
SK	164	156	.48	159	165	.50	125	125	.50
MHa	123	118	.49	147	142	.49	140	164	.53
OP	159	150	.48	133	141	.51	160	140	.46
MA	199	168	.45	154	132	.46	150	200	.57
RR	132	108	.45	129	125	.49	128	127	.49
BM	121	120	.49	154	151	.49	154	149	.49
MK	192	156	.44	148	148	.50	175	181	.50

Appendix E

Mean Scores of Each Adjective Comprising the Mood Adjective Checklist

GROUP EXERCISE

	Session 1	Session 2	Session 3
ANGER			
Raging	1.31	1.38	1.38
Angry	1.69	1.88	1.81
Grouchy	1.81	1.63	1.56
Impatient	1.94	2.06	1.88
Annoyed	2.00	1.75	1.81
HAPPINESS			
Wonderful	2.06	2.19	2.25
Fine	2.50	2.31	2.44
Calm	2.56	2.56	2.31
Happy	2.19	2.38	2.38
Contented	2.25	2.31	2.25
DEPRESSION			
Miserable	1.56	1.50	1.31
Sad	1.81	1.88	1.75
Depressed	1.75	1.69	1.44
Despairing	1.44	1.38	1.19
Low	1.75	1.81	1.50
PSYCHOLOGICAL WELL-BEING			
Energetic	2.38	2.25	2.38
Lively	2.31	2.25	2.38
Alert	2.31	2.38	2.38
Restless	2.56	2.00	2.25
Active	2.31	2.38	2.44
LETHARGY			
Drowsy	1.69	1.69	1.81
Lazy	1.88	2.00	2.06
Weary	1.69	1.69	1.56
Sluggish	1.50	1.50	1.56
Inactive	1.50	1.50	1.63

Appendix E (continued)

GROUP MUSIC

	Session 1	Session 2	Session 3
ANGER			
Raging	1.20	1.20	1.05
Angry	1.95	1.90	1.80
Grouchy	1.65	1.75	1.50
Impatient	2.05	1.95	1.95
Annoyed	1.85	1.89	1.85
HAPPINESS			
Wonderful	1.90	2.10	2.15
Fine	2.55	2.60	2.55
Calm	2.65	2.40	2.45
Happy	2.30	2.30	2.65
Contented	2.30	2.35	2.40
DEPRESSION			
Miserable	1.40	1.25	1.25
Sad	1.75	1.65	1.60
Depressed	1.80	1.45	1.45
Despairing	1.15	1.10	1.05
Low	1.80	1.80	1.50
PSYCHOLOGICAL WELL-BEING			
Energetic	2.15	2.35	2.35
Lively	2.10	2.26	2.20
Alert	2.45	2.45	2.50
Restless	1.95	1.95	1.85
Aciive	2.35	2.50	2.40
LETHARGY			
Drowsy	1.70	1.65	1.50
Lazy	1.90	1.65	1.65
Weary	1.70	1.65	1.75
Sluggish	1.55	1.50	1.40
Inactive	1.50	1.40	1.40

Appendix E (continued)

GROUP MEDITATION

	Session 1	Session 2	Session 3
ANGER			
Raging	1.35	1.20	1.15
Angry	1.75	1.95	1.65
Grouchy	1.70	1.65	1.68
Impatient	2.00	1.80	1.85
Annoyed	1.95	1.37	1.75
HAPPINESS			
Wonderful	1.95	2.10	2.15
Fine	2.50	2.60	2.65
Calm	2.40	2.65	2.05
Happy	2.55	2.50	2.50
Contented	2.30	2.65	2.50
DEPRESSION			
Miserable	1.30	1.40	1.25
Sad	1.60	1.45	1.55
Depressed	1.80	1.65	1.45
Despairing	1.30	1.20	1.15
Low	1.75	1.79	1.75
PSYCHOLOGICAL WELL-BEING			
Energetic	2.25	2.35	2.35
Lively	2.35	2.40	2.35
Alert	2.65	2.85	2.70
Restless	2.05	2.05	2.20
Active	2.50	2.55	2.60
LETHARGY			
Drowsy	1.80	1.80	1.70
Lazy	1.85	1.80	1.70
Weary	1.70	1.65	1.55
Sluggish	1.60	1.75	1.45
Inactive	1.25	1.45	1.50

Appendix F

Standard Deviations for Heart Rate Recovery Times,

Basal Heart Rates, and GSR Lability Ratios

HEART RATE RECOVERY TIMES

	Session 1	Session 2	Session 3
Group Exercise	2.63	2.07	2.53
Group Music	2.87	3.01	2.93
Group Meditation	2.88	2.60	2.46

BASAL HEART RATES

	Session 1	Session 2	Session 3
Group Exercise	14.29	13.71	9.97
Group Music	17.31	14.34	12.91
Group Meditation	12.63	14.42	9.84

GSR LABILITY RATIOS

	Session 1	Session 2	Session 3
Group Exercise	.058	.041	.039
Group Music	.048	.032	.025
Group Meditation	.053	.026	.022

Appendix G

Summary of Tukey Post-Hoc Tests

HEART RATE RECOVERY TIMES (SESSION 3)

Mean differences	Group Exercise	Group Music	Group Meditation
Group Exercise = 3.26	–	2.26*	2.85**
Group Music = 5.52		–	0.59
Group Meditation = 6.11			–

BASAL HEART RATES (SESSION 3)

Mean differences	Group Exercise	Group Music	Group Meditation
Group Exercise = 83.35		3.20**	1.85*
Group Music = 86.55		–	1.35
Group Meditation = 85.20			–

GSR LABILITY RATIOS (SESSION 2)

Mean differences	Group Exercise	Group Music	Group Meditation
Group Exercise = 0.47	–	0.03**	0.04**
Group Music = 0.50		–	0.01
Group Meditation = 0.51			–

GSR LABILITY RATIOS (SESSION 3)

Mean differences	Group Exercise	Group Music	Group Meditation
Group Exercise = 0.46	-	0.05**	0.05**
Group Music = 0.51		-	0.00
Group Meditation = 0.51			-

GSR SCORES ON THE FIRST STRESS-INDUCING TASK (SESSION 3)

Mean differences	Group Exercise	Group Music	Group Meditation
Group Exercise = 177.76	-	33.51*	30.41*
Group Music = 144.25		-	3.10
Group Meditation = 147.35			-

* $p < .05$

** $p < .01$