AN ELECTROMYOGRAPHIC STUDY OF THE RELATIONSHIP BETWEEN RELAXATION ABILITY AND CHANGES IN THE PERFORMANCE OF A MOTOR AND A MENTAL SKILL UNDER INDUCED TENSION

A DISSERTATION

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CHAPTER I

INTRODUCTION

Excessive neuromuscular tension may result from fears and anxieties as well as from over-activation of muscle groups. This kind of tension is found increasingly among persons of all ages, occupations and socioeconomic levels. According to Dunbar, "the inability to relax is one of the most widely spread diseases of our time and one of the most infrequently recognized" (31:570). In twentieth century America man is constantly confronted with tension-producing events over which he has no voluntary control.

Relaxation training is concerned with alleviating and controlling neuromuscular tensions which arise within the human body in response to various physiological and psychological stimuli. In the early part of the present century Jacobson developed a program of relaxation techniques known as "Progressive Relaxation," which has continued to be recognized by medical doctors and psychologists as a reliable method for teaching neuromuscular relaxation (27:3-8).

Progressive Relaxation is a program that attempts to develop skill in relaxation through increasing the kinesthetic awareness of changes in muscle tonus. Jacobson states that

> After you have recognized contraction in a muscle group, you practice at relaxating it completely. You learn to recognize contraction in the various parts of your body in a certain order. The large muscles are studied first, because the sensation therefrom is most conspicuous. As you relax a given part, you simultaneously relax all parts that have received practice previously (27:81).

The ability to relax neuromuscularly, like other motor skills, requires much practice to perfect.

The skillful performer of gross motor skills attempts to produce the most efficient and the most effective movements possible during the execution of a given task. The conventional view of efficiency relates to the amount of work accomplished in relation to the amount of energy expended to complete a task. Wells states that, "the greater the efficiency, the smaller the amount of wasted movement" (52:382). It is hypothesized that an individual who has developed the skill of relaxation can control neuromuscular tension by relaxing the muscles which do not contribute materially to the performance of efficient movement. When comparing the novice and the advanced performer in the performance of a gross motor skill, it is relatively easy to detect that one of the central differences in individuals is motor efficiency. In the skilled performer the agonists contract while the antagonistic muscles relax. The novice, in contrast to the skilled individual, is unable to select and isolate the appropriate muscle groups for a given task.

In the human organism, a complex network of physical and mental responses to the underlying stimuli is imposed by the environment when individuals perform motor and/or mental skills. Previous investigators have obtained confusing results when they studied effects of induced tension on mental and motor skills (21:146; 45:330; 3:227; 10:235;48: 26). The present investigation provided an opportunity to observe both the mental and motor performance of the same subject during induced tension.

Statement of the Problem

The problem of the study was to determine possible relationships between ability to relax and changes in the performance of a novel motor skill and a novel mental skill during induced tension on the part of three groups who had experienced different treatments for a period of six weeks. Psychological and physiological tension was induced by a verbal threat during the administration of the final tests. Psychological tension, as measured by the galvanic skin response and respiration rate, and neuromuscular tension in specific muscles, as measured by electromyographic techniques, were recorded before and after an experimental period of six weeks.

The study entailed the use of three groups, each containing sixteen female subjects. One control group participated in a program of body mechanics for a period of six weeks. A placebo control group took a sugar tablet daily for a period of six weeks. The experimental group received daily instruction and practice in Jacobson's techniques of relaxation for six weeks.

Rationale for the Study

The purpose of participation in programs of neuromuscular relaxation is to learn to control the amount of muscular tension. Basmajian, as well as Jacobson, has revealed that individuals can voluntarily control neuromuscular tension through learning to relax (3:230; 29:83). Efficient movement demands a specific amount of tension; however, unnecessary tension interferes with the smooth sequence of muscular action essential for coordinated movements. If individuals are to perform neuromuscular skills at an optimum level of efficiency, or to learn motor skills quickly, it follows that training in specific relaxation techniques may be needed to reduce unnecessary or negative muscular tension which limits efficiency.

In physical education classes the teacher of motor activities is confronted frequently with students who evidence excessive psychological and neuromuscular tensions. The physical educator who is concerned with the total aspects of learning motor skills should be better prepared to teach conscious relaxation techniques than any other educator (41: 469).

The present investigation was concerned with the relationship between the ability to relax and changes in the performance of a selected gross motor skill and a mental skill during induced tension. It was hypothesized that subjects who were capable of controlling neuromuscular tension could reduce tension during the performance of selected skills to a greater extent than subjects who had not learned neuromuscular relaxation techniques and, therefore, their performance should enhance a higher level of efficiency than subjects not trained to control neuromuscular tension.

Today, the potential applications for education in tension reduction are unlimited. It is conceivable that physical and mental performance under stress can be facilitated if techniques of neuromuscular tension control are learned.

Definitions and/or Explanations of Terms

To contribute to a clear understanding of the problem, the following definitions and/or explanations of terms were established for use throughout the study.

Tension: The investigator accepted the definition of Cratty, who stated that tension "is overt muscular contraction caused by an emotional state or increased efforts" (12:219).

Relaxation: The investigator accepted the definition of Jacobson, who stated that, "relaxation is the minimum of tension in the muscles requisite for an act" (29:83). In this study, relaxation was measured by electromyographic techniques.

Galvanic Skin Response: The investigator accepted the definition by English, who stated that

> galvanic skin response is the resistance of the skin to the passage of an external electric current, or to the production of an external electric current, or to the production by the body of a weak current on the skin surface (19:174).

For the purpose of this study, the electrodes were placed on the middle finger of the non-preferred hand for the selected skills.

Novel Motor Skill: For the purpose of this study the investigator defined a Novel Motor Skill as one that has not been attempted before or has been performed with such infrequency that the initial performance of the skill equals that of someone who has never executed the movement. In this study, the novel motor skill was throwing darts at a target mounted on the wall at a distance of ten feet from the subject.

Mental Skill: The investigator defined mental skill for the present study as the ability to recall lists of randomly-ordered numbers. This skill was measured by the accuracy of each subject in the verbal recall of different sequences of nonsense numbers.

Induced Tension: The investigator defined induced tension as an external stimulus designed to prevent normal adaptation. In this study, induced tension was produced by a verbal threat. The amount of induced tension was measured by changes in the galvanic skill response and in the respiration rate.

Delimitations of the Study

The study was subject to the following delimitations:

A. Freshman women randomly assigned to three groups with a total of sixteen subjects in each group. All subjects were enrolled in the required physical education program of the Texas Woman's University during the spring semester of the academic year of 1969-1970.

B. Subjects were equated or matched with respect to the following variables: (1) lack of previous formal instruction in techniques of relaxation, (2) no previous formal instruction in techniques of memorization, (3) score on the Standard Aptitude Test and/or the American College Testing Program, (4) score on the Taylor Anxiety Test, (5) resting mean base level as recorded by electromyographic techniques, (6) mean neuromuscular tension level on the initial test of dart throwing, (7) mean neuromuscular tension level on the initial test of recalling nonsense sequence of numbers, and (8) score on novel motor skill.

C. Participation of an experimental group in a program of specific relaxation techniques for a period of one hour per day, five days a week for six weeks.

D. Participation of a control group in a program in which the subjects received one sugar tablet a day, five days a week for six weeks. The subjects were told that daily ingestion of the tablet would reduce neuromuscular tension.

E. Participation of a control group that received no scheduled instructions in techniques of relaxation and were provided no placebo. The control group received instructions in body mechanics for a period of six weeks.

Purposes of the Study

The general purpose of the study was to determine the relationship between the ability to relax specific muscle groups during the performance of a novel motor skill and a novel mental skill under induced tension. Specifically, the following null hypotheses were tested:

1. There is no significant difference between the placebo group, the exercise control group, and the relaxation group in their ability to throw darts accurately and to control neuromuscular tension during induced tension.

2. There is no significant difference between the placebo group, the exercise control group, and the relaxation group in their ability to control neuromuscular tension and their ability to recall nonsense numbers accurately during induced tension.

Summary

Neuromuscular relaxation is a learned skill that requires a kinesthetic awareness of residual muscle tonus.

A person who has identified the amount of tension necessary to perform a given task is usually better prepared to voluntarily control neuromuscular tension than one who is not successful in recognizing muscle tension. The skill of relaxation demands many hours of concentration before the learner can progress from conscious relaxation to situations where relaxation becomes habitual.

The purpose of this investigation was to determine the relationship between the ability to relax and changes in the performance of a selected motor and a mental skill during induced tension. It was believed that subjects who were capable of controlling neuromuscular tension could reduce tension during the performance of selected skills to a greater extent than subjects who had not learned to control neuromuscular tension; therefore, the subjects would perform the selected skills more efficiently than those subjects not trained to control neuromuscular tension.

Forty-eight female subjects were selected to participate in the study. One control group consisted of sixteen female subjects who participated in a program of body mechanics for a period of six weeks. A second control group consisted of sixteen female subjects who took a sugar tablet daily for six weeks. The relaxation group consisted of sixteen female subjects who received daily instructions in Jacobson's techniques of relaxation for six weeks.

Chapter II presents the review of literature which was found pertinent to this investigation.

CHAPTER II

REVIEW OF RELATED LITERATURE

Introduction

The success of the first accurate measurement of muscle tension by mechanical means is attributed to Edmund Jacobson, who in cooperation with the Bell Telephone Laboratories developed equipment that was sensitive enough to record voltage changes as low as a fraction of one-millionth of an electrical volt in human muscles (29:310). Jacobson, more than any other individual, has stressed the importance of neuromuscular tension control as a laboratory technique that is valuable in modern society. A review of the literature pertinent to the control of muscle tension reveals numerous research designs which have attempted to isolate specific relaxation techniques and the effects of induced tension upon muscle tension. To simplify the review of the related literature the following subheadings have been formulated: Studies in Relaxation and Studies in Induced Muscular Tension. All of the studies are presented in chronological order.

Studies in Relaxation

Prior to the development of adequately sensitive electrical instruments, Jacobson and Carlson (24:324) analyzed the intensity of the knee-jerk in fourteen subjects who were trained in specific techniques of relaxation as opposed to subjects not trained in relaxation. Jacobson and Carlson concluded that the knee-jerk action tends to diminish as the skill of relaxation is learned. The subjects trained in relaxation reported a decreased sense of tenseness during periods devoted to relaxation.

Jacobson (25:694) studied muscle action potential during various forms of mental activity. A string galvanometer was the instrument used to measure the muscle action potential during prescribed mental activity. The subjects were twenty females trained in the techniques of relaxation. Each subject was asked to lie down in a relaxed position with the eyelids closed and to engage in a specific mental activity, such as imagination. It was noted that a measurable increase in contraction occurred in the specific muscles of the body measured. Jacobson noted that during a particular mental activity, the muscles of a subject trained to relax remained inactive, except for those muscles specifically associated with the control of the eyes and mouth. Electrical records, along with subjective reports, indicated that during the Progressive Muscular Relaxation lessons, imagery and thinking processes dwindled and disappeared. Jacobson concluded that the relaxation of the specific muscle contractions normally present during a particular mental activity brings about the disappearance of that activity.

Jacobson (26:230) further explored the benefits of relaxation by comparing eight college subjects trained in relaxation with a similar number of subjects not trained in relaxation during resting levels of muscle tension. All of the subjects were tested on general muscular tension by means of a galvanometer on two different days for a period of thirty minutes. The only instruction given to the subjects in the untrained group was to relax as much as possible. The second group of subjects were given instructions in techniques of relaxation. Jacobson concluded that no subject in the untrained group achieved and maintained complete relaxation in the arm muscles during the thirty minutes; whereas, the subjects trained to relax produced a much lower level of tension for the same time period.

Ruesch and Finesinger (44:132) investigated the relationship between muscular relaxation, as measured by the electromyograph, and subjective feelings of relaxation as reported by the subjects. Electromyographic tracings of the flexor and extensor muscles of the arm were made on a series of thirty-seven patients with psychiatric and neurological diseases and on normal subjects while closing and opening the fist at different time intervals up to three seconds. The investigators reported that the greatest relaxation values were obtained when the interval between the movements was greatest. One-half of the subjects reported on the questionnaire that they could feel the relaxation intervals in their arms and fingers during the activity periods. The other subjects reported that they had no sensation in the arms and fingers.

Jacobson (28:98), using electromyographic instruments, examined the relationship between the ability of athletes and non-athletes, both trained and untrained, in techniques of relaxation. The subjects were twenty-one college students who were not participating in athletics and ten college students who were actively participating on a varsity team. At the beginning of the experiment each subject was instructed to bend his right arm immediately upon hearing a telegraph key click and then to relax the arm. Responses were measured and recorded by an amplifier galvanometer assembly. Jacobson concluded that as a group the athletes succeeded in relaxing a particular muscle group to a fuller and more sustained degree than did subjects untrained in relaxation. The athletes' success was generally inferior to that of those subjects specifically trained in techniques of relaxation. It was noted that some individual athletes attained levels of relaxation as low as the subjects who were trained in the techniques of relaxation.

Davis (13:451) measured the muscle action potentials of three limbs in two groups of subjects while they worked at multiplication and memorization of nonsense syllables. The subjects worked under normal conditions and under directions asking for total relaxation of the right arm during mental activity Davis noted that muscular activity increased progressively during work periods. No consistent relationship between muscle action potential and output of work was found under the experimental conditions when individual subjects were compared. Subjects showed more muscular activity in the body parts tested during mental work than during rest. It was found that instructions to relax the right arm during work produced a decrease of activity in that limb with similar but smaller decreases in the other segments of the body tested.

Using nonsense syllables as the learning task, Pascel (39:32) conducted experiments comparing recall under a state of normal tension (sitting in an easy chair) with recall under a state of induced relaxation (lying on a couch listening to five minutes of instructions on relaxation). Relaxation time was held constant at one hour and comparisons were made on the ability of twelve subjects to recall the nonsense syllables after one, five, and ten learning trials, respectively. Pascal concluded that subjects merely lying on the couch without instruction in relaxation showed no significant difference in recall over the experimental condition. Relaxation immediately after learning, instead of immediately preceding recall, also produced no significant difference over the control condition.

In 1943, Nerfeld (35:132) used techniques of relaxation as a method of reducing tensions in pilots who experienced nervous tension during missions of combat duty. Approximately 15,000 cadets received relaxation training from 100 Navy officers. The instructions were limited to three half-hour periods, three different days per week, for a total of twenty-six periods. The specific objective of the training program was to teach cadets to recognize their individual patterns of neuromuscular tension and to relax when necessary. A subjective rating scale was administered to each cadet after receiving instructions in relaxation. Upon the basis of the findings yielded by the rating scale, Nerfeld concluded that cadets trained to relax and control muscular tension had a lower fatigue-tension rating than those cadets who had not been taught techniques of relaxation.

Haverland (22) conducted a study to determine whether significant improvements in coordination, steadiness, or reaction time might be obtained by a six weeks training program using either Progressive Relaxation techniques or a specific physical conditioning program. The subjects were comprised of freshman and sophomore college women volunteers. One group was a physical conditioning class; a second group received training in Danish Gymnastics for forty minutes twice each week; and the third group received instructions in the Jacobson techniques of relaxation for forty minutes twice each week in addition to the required physical education program which met two forty minute periods per week.

Haverland found that the subjects receiving instruction in Progressive Relaxation techniques improved their performance significantly in reaction time and aiming tests, and very significantly in the tracing and steadiness items of the motor control tests. The physical conditioning group and the Danish Gymnastics group also improved their performance significantly on the tracing and steadiness items of the motor control tests. Haverland concluded that training in Jacobson's techniques of relaxation may result in improved performance in certain aspects of motor skills involving smooth, coordinated and precise movements and is to be favored over the other methods studied.

Watson (51) conducted a study to determine the relationship between athletic ability and the ability to relax in sixty-four undergraduate college women. Electromyographic techniques were employed to determine the level of muscle action potential in each of the selected subjects. Each subject's tension was recorded during discrete movements using the individual muscle groups. The subject was instructed to relax as much as possible and still complete the movement. Watson concluded that there was no significant difference in the ability to relax under specific conditions between the women who had high athletic skill and those who had low athletic skill.

Evans (20) conducted a study to determine the influence of techniques of relaxation on the level of tension in college women. The subjects were twenty-eight women in an experimental group who received instructions in relaxation and thirty-six women in a control group. Tension was measured with specific devices which determined the amount of knee-jerk present before and after participation in several motor skill tests. Evans concluded that there was no significant decrease in neuromuscular tension immediately after the motor skill tests in either the experimental or the control groups. When comparing the height of the knee-jerk before a volleyball skill test with the height of the knee-jerk nine minutes after the administration of the skill tests, there was a significant reduction in neuromuscular tension which favored the experimental group.

Benson (4) studied the effects of instructions in relaxation on eighty college students enrolled in beginning swimming classes; forty subjects were in the experimental group which received twelve weeks of instructions in techniques of relaxation. The other forty subjects were in a control group that had no instructions in relaxation. Benson found that relaxation training was an asset to beginning swimmers. Those subjects trained in relaxation not only developed skill more rapidly than the control group but also experienced a generally lower tension level as determined by subjective evaluation. In addition, all of the nonswimmers in the group who received relaxation instructions learned to swim a given distance, while only half of the subjects not given such instruction were successful in the same test.

Roney (43) studied the relationship between kinesthesis and relaxation by comparing the ability to perceive muscle contraction as measured by the kinesthetic tests of perception of effort and position, with the ability to relax specific muscle groups. A second purpose was to determine if the skill of relaxation could be taught and if so, could kinesthesis, as measured by the selected tests be identified as a factor in learning to relax. The components of kinesthesis selected for study were awareness of extent of muscular contraction in the arm, force of muscular contraction of the arm, arm static function, leg positioning, force of muscular contraction of leg, and thigh and leg static function. The tests were administered to fifty-eight college women at the beginning and at the end of a nine week experimental period. During the experimental period the subjects were divided into two groups; one group received instructions in Jacobson's techniques of relaxation, and the other group received no training in relaxation. Roney concluded that there was a slight relationship between total kinesthesis and total relaxation in the initial test scores for both groups; but this was not apparent in the final test results. The experimental group improved significantly in total relaxation, where the control group did not. Kinesthesis, as measured in this study, did not improve in either group. Roney concluded that it was not a factor in learning to relax. From a subjective viewpoint it was noted that the subjects in this study became more aware of muscular tension and developed positive changes in mental and emotional attitudes as a result of the relaxation program.

King (32) determined the effect of voluntarily induced relaxation in ten college women exposed to a psychological stressor. The experiment was designed to study neuromuscular and cardiovascular functioning under experimental conditions. The stressor consisted of trying to add figures while loud music played in the background. Measurements of steadiness, reaction time, pulse rate, and blood coagulation rates were recorded while the subjects were in a "normal" condition, following exposure to the stress condition for the first time and following exposure to the stress condition for the second time, when relaxation was the intervening variable. King concluded that there was no significant difference in the variables measured in the different conditions. King noticed that after the subjects were exposed to a stressor the pulse rate declined during the period of relaxation.

de Vries (15) analyzed the effects of a specific relaxation technique and two different types of stretching exercise programs which are commonly used as warm-up procedures upon subsequent motor performances in three different athletic events. The athletic events considered were: (1) 220 yard run, (2) 50 yard swim, and (3) the standing broad jump. de Vries hypothesized that the resistance offered by muscles antagonistic to the prime movers in motor performance can be minimized through preliminary stretching and/or relaxing techniques to an extent which will result in improvement or subsequent motor performance. The subjects were eleven members of the track team, sixteen male members of a class in advanced swimming, and twenty-one members of a class in corrective physical education. No statistical evidence was found to demonstrate that either the stretching programs or the specific relaxation program had a unique value as a warm-up procedure for running a 220 yard run, swimming a 50 yard race, or for performing in the standing broad jump. de Vries concluded that there was no evidence that the resistance offered by muscles antagonistic to the prime movers in motor performance can be minimized through preliminary stretching and/or relaxing techniques to an extent which will result in measurable improvement of subsequent motor performance.

Steinhaus and Norris (49) noted that neuromuscular tension, as measured by electromyography, could be reduced substantially in college students and older people, and that significant decreases in both systolic and diastolic blood pressure could be obtained after an instructional period of eight weeks in techniques of relaxation. In addition to pre and post tests, the subjects were also tested several times during each day to determine level of tension at specific time intervals. Upon the bases of the data obtained, Steinhaus and Norris found that a period of eight weeks was required to successfully apply Progressive Relaxation techniques when taught two days per week. It was noted that tension levels had a tendency to increase during the day. The investigators found that the majority of the subjects taught to relax had positive concomitant effects such as changes in temperament, ability to fall asleep more quickly, reduction of headaches and sensitivity to pain, and improved disposition, as measured by subjective ratings.

Calleja (8) observed the effect of relaxation training on cognitive performance under stress. The hypothesis studied was that relaxation training and cognitive functioning would be related through their common connection with anxiety. Relaxation training was placed within the general context of a concept of anxiety as a form of emotional arousal with neuromuscular and cognitive consequences. The word "cognitive" was applied to: (1) a verbal maze task and (2) a perceptual task. Sixty-four patients from neuropsychiatric wards were assigned to high or low anxiety groups on the basis of their scores on the Taylor Manifest Anxiety Scale. Half of each group was assigned to a stress-stimulus condition and the other half to a no-stress condition. The stress and no-stress groups were in turn subdivided into relaxation and no-relaxation subgroups. Callega concluded that relaxation directly affects the capacity to concentrate by preventing the intrusion of irrelevant responses and thereby allowing the person to focus on the task at hand.

Lyons and Lufkin (34:663) conducted a study to determine electromyographically whether ten lessons in relaxation, spaced over five weeks, would significantly lower muscle tensions in 257 college women. The subjects were subdivided into three groups. One group was given relaxation training and was tested over five weeks. The second group, which also received training in the techniques of relaxation, was tested over a five weeks period. The third group was a control group which received no training in relaxation but was tested in relaxation ability over the same period. Lyons and Lufkin concluded that the control of neuromuscular tension was significantly improved with ten hours of instructions extending over a five week period. Significant improvements, however, did not occur before the ninth session. The investigators noted that familiarity with the instrumentation or the factor of repeated measurements did not alter results nor did the time of day selected for the testing procedure.

Johnson (30) studied the effects of different stimuli and the passage of time on measures of two specific classifications of anxiety. It was hypothesized that measures of trait-anxiety (A-trait) would remain essentially constant over time and be unaffected by periods of relaxation and stress. In contrast, measures of state-anxiety (A-State) were expected to fluctuate over time, decline during relaxation periods, and increase in response to stress. Measures of A-trait and A-state were made from forty-eight male neuropsychiatric patients in two experimental sessions. In the first session, measurements of A-trait and A-state were taken before and after a relaxation period. In the second session, the third and fourth measures of A-trait and A-state were made before and after a period of relaxation. Following an interview period the experimental group was placed in a stress condition where they discussed their "most frightening" experiences, while those assigned to the control condition discussed neutral topics. During this time the fifth measurement of A-trait and A-state was made. Scores on trait-anxiety measures were essentially unaffected by either relaxation procedures or a stress interview. A small, but statistically significant, decline in Manifest Anxiety Scores over time was the only systematic change shown by the A-trait measures. The measures of state anxiety all declined significantly as a function of relaxation procedures, while scores increased significantly in response to the stress interview.

Perkins (40 investigated the effect of muscle relaxation and the suggestion of relaxation on the reduction of anxiety. Fifty-six female university students were assigned to one of four treatments: verbal statement suggesting relaxation as anxiety reduction, verbal suggestion of relaxation with a statement indicating no effect, control task with suggestion of anxiety reduction, and control task with suggestion of no effect. Stress was imposed by informing subjects that their emotional stability was being evaluated by their palmar sweating (PSI), word associations, and finger unsteadiness when responding to forty stimulus words in a Luria-type association-motor task. It was concluded that, as a whole, the study failed to demonstrate that muscle relaxation or suggestion of benefit are superior to a control task or suggestion of no benefit in reducing anxiety as measured by PSI and motor control. However, subjects receiving relaxation or positive suggestion of the value of relaxation perceived anxiety reduction in themselves more frequently than did subjects in the other conditions.

Brockberg (7) conducted a study to determine the effects of a training program in neuromuscular relaxation upon selected motor skills of thirty-one educable mentally retarded boys and girls between the ages of eleven and fourteen who were divided into an experimental and control group. The experimental group received instructions in the techniques of relaxation, while the control group received no training in relaxation. Electromyographic instruments were used to determine the tension levels of each subject during the selected tests. Scores were obtained on the following tests: Sequin form board, Health rail-walk, a maze from the Wechsler Intelligence Scale for Children, level of aspiration and two subtests from the Illinois Test of Psycholinguistic Abilities. Brockberg found no significant difference for either the control group or the experimental group in their ability to control neuromuscular tensions as a result of relaxation instructions. Although there was no significant difference between the two groups, it was noted that the experimental group tended to reduce tension following the relaxation training program to a greater degree than the control group.

Studies in Induced Neuromuscular Tension

Russell (45:330) undertook a study to determine the effectiveness of different degrees of neuromuscular tension in a specific skill. The study was restricted to accuracy as the criterion of efficiency and to tossing balls at a target as the specific motor skill. Three conditions of tension were employed: (1) moderately tensed, (2) natural, and (3) moderately relaxed. The subjects were placed in three groups of five men and five women each. Russell concluded that a condition of relaxation is superior to a condition of tension with respect to accuracy of tossing balls at a designated target.

Duffy (17:535) studied the relationship between quality of performance and tension in the skeletal muscles. The subjects were eighteen children approximately three years old. Graphic records were obtained from the pressure upon dynamographs held in the dominant hand during a tapping performance, and during discriminative reactions to three kinds of pictures. The experiment was repeated five times within a period of four months. Duffy concluded that poor performance was almost invariably accompanied by high tension. Good performance was accomplished with tension scores of various magnitudes, but most frequently with moderate or low tension scores. The quality of performance in discriminative reactions, but not in tapping, correlated rather closely with the smoothness of the tension tracing from the hand during the tapping performance. Duffy stated that excessive fluctuations in tension represented poor inhibition, but that lack of inhibition is a severe handicap in certain types of performance. It was noted that the degree of inhibition tends to increase with age.

Zartman and Cason (54:671) compared the time required to solve short arithmetical problems under normal conditions and the time required to solve the same problems when the subject exerted pressure between twenty-five and forty pounds with the right foot on a pedal apparatus. Each subject solved each problem under the two conditions, half of them doing a problem first under tension and later under normal conditions. The subjects were eighteen college students. Zartman and Cason concluded from the results of the experiment that increasing the tension of the right leg does not increase the efficiency of solving arithmetical problems.

Stauffacher (48:26) studied the effects of induced muscular tension on learning in forty graduate and undergraduate students. Each subject was given a preliminary test to determine the maximum amount of weight he could lift with one hand. During the experiment each subject gripped stirrup-handles, lifted a predetermined weight off of the floor, and maintained it suspended. At the same time an electrically driven memory drum, which advanced every two seconds, was used to expose the material to be learned. The material consisted of four lists of fifteen, three letter, nonsense syllables. The experiment was conducted under four conditions: (1) no induced tension, (2) one-quarter of the maximum weight tested, (3) one-half of the maximum weight tested, and (4) three-quarters of the maximum weight tested. Stauffacher suggested that there is a certain amount of muscular tonus which, when induced in the subject, will cause facilitation of learning. This degree of tension was approximately one-half of the individual's maximum. Lesser or greater amounts of induced muscular tension provided little or no facilitation in memorization of nonsense syllables.

Freeman (21:146) analyzed the effects of optimal muscular tensions for various performances on skills that utilized the upper part of the body for sensory input and motor output. The skill studied included finger oscillation, mirror-drawing, intensity limen for touch, eyelid reflex, and mental arithmetic. Kyomgraphic recordings were obtained on ten subjects in each of the selected tasks. The palmar skin-resistance was used to check upon the general excitation level of each subject. Freeman concluded that ability in mental arithmetic was seriously distorted by tension increments while sensory discriminations and reflex-responses were facilitated. The results indicated that a tension-load which was optimal for one type of activity may be detrimental to performance of a different character. In general, it was suggested that the more complex the performance, the earlier the tension increment will cause inhibitory effects.

Courts (10:235) investigated the relationship between the level of performance in memorization and various degrees of experimentally induced muscular tension. Muscular tension was measured in ten subjects by the amplitude of the knee-jerk as indicated by the amount of quadriceps tightening in response to the tendon-tap. Tension was induced by squeezing a Smedley hand dynamometer. Courts concluded that no evidence was available to support a differential effect of experimentally induced tension for good and poor memorizers.

The results indicated that both good and poor memorizers performed best under approximately one-fourth of the maximum tension when applied by the hand dynamometer.

Arnold (2:315) investigated a number of hypotheses concerning the degree of muscular tension with which individuals react to situations. Twenty-two students were asked to take a tapping test and to write shorthand from dictation which gradually increased in speed, while the pressure on the hands was recorded by a hymograph. Considerable individual differences were found between all subjects. Efficient performance was found by Arnold to be associated with greater recorded pressures in the right hand. An increase in tension was found to be inversely related to skill, intelligence, and average academic standing in school.

Courts (11:501) attempted to ascertain the influences of practice upon the dynamogenic effect of experimentally induced muscular tension in 240 male subjects. Fifty trials on a modified Koerth Pursuit Rotor under various degrees of tension induced by squeezing a dynamometer yielded the data. Courts found that as learning progresses, the facilitative influence of optimal degrees of tension increases to a maximum. The detrimental influence of excessive degrees of tension becomes more marked as learning progresses.

Adams (1:127) reported that induced tension did not facilitate performance in a two-handed task using matching rows of lights. The subjects were 160 basic airmen who depressed a stirrup to the floor while doing the matching task. The stirrup required zero, ten, twenty and thirty pounds of force to depress it. No difference in performance occurred under the conditions of induced tension. Adams concluded that the amount of movement required by the matching task may have made additional muscular activity less effective in improving performance than would have been the case in a less complex task.

Bourne (6:418) hypothesized that induced tension would not improve serial learning if there were a delay between study and recall. To induce tension each subject was presented a list of adjectives and then told to anticipate them in a presentation which might occur zero, thirty, sixty, 120 and 240 seconds later. Tension was induced in some of the subjects during learning, some during recall, some during both; while others had no tension induced. Bourne concluded that induced tension during recall was more effective in improvement of serial learning than tension during the learning task. As a longer period of time intervened, tension induced during recall became progressively superior to tension induced during the learning task.

Shaw (47:113) determined the effect of induced tension on the subject's ability to recall a list of randomized digits. Tension was induced by having the subject hold on to a weight by a cord running over a pulley. The total weight was the maximum of the subject's total pulling strength. This amount was decreased by one quarter increments of the maximum lift during the mental task. Shaw noted that the greatest facilitation occurred in those subjects who performed in a superior fashion on the initial test.

Ryan (46:111) tested the hypothesis that externally induced tension will facilitate performance on a relatively easy motor skill but will impair performance on a more difficult motor skill. Male college students were tested on a motor learning task that involved balancing for twelve trials on a stabilometer. The task was made easy for forty subjects by placing the stabilometer ten inches below the pivot and made difficult for eighty of the subjects by placing the stabilometer ten inches above the pivot. Half of the subjects performing the easy task were given electric shocks irregularly during the learning period to produce tension. Their performance or learning did not differ appreciably from the control subjects. Under the same conditions, except that the difficult task was used, the subjects given induced tension achieved the same amount of learning as the controls but showed poorer performance throughout the test. When the application of the tension-producing shock was delayed until the third trial, it produced a lesser amount of impairment in performance for that trial but full impairment for later trials. The results supported the hypothesis that increased tension impairs performance of a difficult motor task. Ryan stated that rate of learning is independent of the state of tension for either difficult or easy skills. The induced tension did not facilitate performance of the easy task.

Summary

When analyzing the related literature pertinent to the influence of relaxation and induced tension upon mental and motor performance, it becomes evident that numerous research studies present conflicting results. Some of the findings concerning relaxation and neuromuscular tension were based upon subjective ratings by the subjects or by the investigator which makes a valid interpretation difficult. Those investigators who measured muscle action potential by mechanical means found that neuromuscular tension can be decreased by specific instructions in techniques of relaxation. Edmund Jacobson was a pioneer in studying relaxation and in teaching individuals to relax and control muscular tension. Steinhaus and Norris (32) and Lyons and Lufkin (34:663) have contributed to the research in the area of relaxation training and have indicated the approximate number of lessons and the optimal time of day for a significant decrease in neuromuscular tension. Other investigators have concluded that reducing neuromuscular tension allows individuals to perform better in a variety of tasks than those individuals who are not able to control neuromuscular tension.

Studies based upon induced tension have produced disagreements in regard to the effects of induced tension upon learning and performance in both mental and physical skills. Zartman and Cason (54:671), Freeman (21:146), and Duffy (17:535) all found that induced tension did not facilitate mental performance, whereas Stauffacher (48:26) concluded that certain amounts of tension facilitated learning. In relation to motor performance Russell (45:330) and Courts (11:501) found that induced tension did not facilitate performance. Russell (45:330) concluded that conditions of relaxation were superior to conditions of tension when performing a specific motor skill.

Chapter III pertains to the procedures followed in this study.

CHAPTER III

PROCEDURES OF THE STUDY

Introduction

The purpose of the investigation was to determine the relationship between ability to relax and changes in the performance of a novel motor skill and a novel mental skill during induced tension. The study entailed the use of three groups, each comprised of sixteen college women. A control group participated daily in a six weeks program of body mechanics, a second control group took a daily placebo for a period of six weeks, and an experimental group received daily instructions in specific techniques of relaxation for six weeks. All of the subjects were tested for neuromuscular tension by electromyographic techniques before and after the experimental period which was conducted during the fall semester of 1969-1970.

Preliminary Procedures

Before definite procedures were determined, an analysis of all sources available concerning relaxation and control of tension was conducted. A careful review of literature revealed that several studies had been conducted in which investigators attempted to reduce and control neuromuscular tension by specific relaxation techniques similar to those techniques planned in the present investigation. The review of the literature revealed that no completed study duplicated the specific design of the present investigation.

Preliminary experiments were conducted with volunteers drawn from the same population as the sample to determine specific techniques for inducing neuromuscular tension. Experimentation with high frequency noise and electric shock proved unsuccessful in inducing tension during the performance of a motor and a mental skill. Subjects who were exposed to high-frequency sounds of eighty to ninety decibels quickly adapted to the noise. The adaptation was evident since no decrease in the specific motor and mental performance was apparent. An electric current produced by a muscle stimulator was then substituted in an attempt to induce stress in a quantifiable manner. The electrical activity created by this method interferred with the electromyographic recordings; moreover, the muscle had no influence on the performance of the tasks studied.

Because the methods described were not satisfactory for inducing tension, it was decided in consultation with the dissertation committee and with previous research, that a more common psychological method, a verbal threat, would be used as the method of inducing stress. The verbal threat consisted of telling the students they would receive a failing grade in the class in which the subjects were enrolled if their scores were not superior on the final test as compared to the initial test. None of the subjects were aware of the threat until the final testing period.

The galvanic skin response and respiration rate were selected as the phenomena to be measured to indicate if stress was present. According to Woodworth and Schlosberg, the galvanic skin response indicates the degree of activation of the autonomic nervous system (53:152). When the human organism is in a stressful situation, the level of activation of the autonomic nervous system increases and the level of skin resistance decreases. The galvanic skin response pre-amplifier measures precisely the difference in the level of activation of the autonomic nervous system during these specific changes. An irregular respiration rate of the human organism is another indication of tension. According to Rathbone (42:20), when the respiration rate becomes increased and irregular the tension level is also increased. Jacobson (29:28) also indicates that irregular respiration is one indication of tension. In the present study, respiration rate was measured by a pneumograph.

Administration of Pilot Study

Prior to the beginning of the investigation, a pilot study was conducted to determine accurate procedures to be followed throughout the study and to isolate specific muscles to be tested by electromyographic techniques. The subjects in the pilot study were volunteers, none of whom were used in the main investigation. During the pilot study a laboratory assistant, who assisted throughout the study, was taught to record data from the different electronic instruments.

To determine which muscle had the greatest action potential during the performance of the selected motor and mental skills, a preliminary investigation of the following muscles was conducted: upper and middle trapezius; anterior and middle deltoid; and posterior biceps and triceps. All of the muscles tested were on the dominant side of the body. Upon the bases of the findings, the triceps on the dominant arm was selected as the muscle with the greatest action potential while throwing darts for speed and accuracy. For the mental skill the masseter on the right side of the face was selected, which according to Nidever (37:83) is the best indicator of mental tension.

Selection of Instruments

The instruments used in this study were a Newport Laboratories Integrating Bioelectric Monitor (36:2), a Hewlett-Packard electronic digital counter (23:4), and an E and M Company Physiograph (18:1). The Integrating Bio-electric Monitor is a voltage-measuring instrument with switchable gain and bandwidth, which makes it adaptable to all AC bioelectric phenomena. The most valuable innovation embodied in the monitor is its ability to integrate data over precise time intervals--by means of voltage-to-frequency conversion, with pulse-counting in an accessory counter (36:1). According to de Vries (16:1), the integrating bioelectric monitor is the appropriate instrument for measuring the lowest possible electrical muscle action potential in a given muscle. The electronic counter, an instrument which, when attached to the monitor, is designed to present information in an easy-to-read, non-ambiguous, numerical display form (23:94).

The I.M.I. biopotential skin electrodes were used in testing all subjects (36:54). When all three electrodes were applied to the skin using disposable collors, the physiological transducers transformed biopotentials into electrical signals suitable for recording. The procedures for recording the data and the preparation of each subject for testing were standard and have been enumerated by Lovett (33:49).

The Physiograph was used to obtain accurate recordings on two different physiological phenomena simultaneously and continuously throughout the testing period (18:1). A pneumograph was utilized to obtain direct ink recordings of the subject's respiratory rate during the selected skills (18:9). The pneumograph was selected because of its ability to attach directly to the physiograph and because it gives a continuous record of respiration rate during a prolonged period of time.

The Taylor Manifest Anxiety Test was selected as a valid and reliable instrument for measuring degrees of anxiety (50:285). The Taylor Manifest Anxiety Scale was constructed from the anxiety statements of the Minnesota Multiphasic Personality Inventory. The Taylor Scale has been validated many times and has a coefficient of correlation with other similar tests of from .82 to .85. The Taylor Manifest Test was used in the preliminary period because the verbal threat, which was to be the method of inducing tension for all post experimental period testing, could not be used initially without invalidating the potential threat.

Selection of Skills

The present study entailed the investigation of the level of performance on a novel motor skill and a novel mental skill under induced tension. The novel motor skill and the novel mental skill were limited by two factors: (1) skills that were classified as novel to college women and (2) skills that could be performed in the laboratory while the subject remained attached to several different pieces of laboratory recording equipment.

Throwing darts at a stationary target was considered a novel motor skill for most university women students. Although many students had previously attempted this activity, none of the subjects had developed skill in dart throwing. The subjects participating in this study were not naive to the activity, but were unskilled performers.

The novel mental skill selected was the immediate verbal recall of lists of different sequences of randomly arranged numbers. The recall of nonsense numbers was utilized as the novel mental skill because of the meaningless relationship between different digits as opposed to possible acronyms of nonsense syllables. According to Conrod and Hille (9:1), the immediate memory span for college students is approximately eight digits in the recall of numbers. The nonsense numbers used were randomly selected from a table of one-digit numbers and placed in the sequence of recall.

Treatments Utilized in the Grouping of Subjects

The subjects in the investigation were forty-eight university women ranging in age from seventeen to twenty-one with a mean age of nineteen. All of the subjects were freshmen enrolled in a body mechanics class in the College of Health, Physical Education and Recreation at the Texas Woman's University, in Denton, Texas, which met five days a week for nine weeks during the fall semester of the academic year of 1969-1970. All of the subjects were selected upon the basis of having had no previous instruction in memorization and/or instructions in techniques of relaxation.

Orientation of Subjects

During the first day of the course, the subjects were told that they were part of an experimental study and that each subject would be required to take a pretest and post test using several different electronic instruments in the laboratory. Based upon the individual scores of the pretest, the subjects would then be randomly assigned to one of three groups. One group would receive daily instructions in body mechanics as scheduled. Another group would take a pill each day for six weeks. The subjects were told that the pill was to reduce neuromuscular tensions and that each subject would be approved to take the relaxant pill by the University Health Service prior to the experimental period. The third group would receive daily instructions in Jacobson's techniques of relaxation.

During the second day of classes the subjects were taken to the Human Performance Laboratory of the College of Health, Physical Education and Recreation at the Texas Woman's University where each piece of equipment to be used in the study was explained and demonstrated in detail. During the next class period the subjects were administered the Taylor Manifest Anxiety Test.

During the second week of the semester, each student was assigned a given hour to take the pretest in the Human Performance Laboratory. Prior to making the laboratory assignments, the investigator randomly assigned each subject to one of two different sequences of treatment. The first sequence consisted of an initial two minute period, at which time neuromuscular resting tension was measured in the triceps of the dominant arm. Following the two minute rest period, the novel motor skill was performed and data were collected with the bioelectric counter, the galvanic skin response preamplifier, and the pneumograph. At the end of the motor test, each subject was given a second two minute rest period, at which time resting tension of the masseter was recorded. At the end of the second rest period the novel mental skill was administered, and data were collected from the selected instruments. The second treatment was identical to the first treatment except that the mental skill was administered first and the motor skill second and both skills were preceded by a two-minute rest period. The purpose of these two sequences of treatments was an attempt to counterbalance and eliminate any influence of one particular procedure upon the other.

When the subject arrived at the laboratory, the investigator outlined the testing procedures. The subject was then asked to fill out a data card which appears in the Appendix on pages 113-4. The subject was then prepared for testing by abrading the skin in the areas selected for the electrodes. The exact position for each electrode was determined in accordance with the procedures established by Davis (14:18). The procedures for preparing the surface electrodes and calibrating the equipment were the same as those outlined by Lovett (33:51-52).

The pneumograph, which was attached to the first channel of the six channel physiograph, was connected around the rib cage of the subject. The galvanic skin response preamplifier was attached to a channel of the physiograph. The positive and negative electrodes of the galvanic skin response mechanism were placed on the third joint of the middle finger of the non-preferred hand. The positive plate was placed on the bottom and the negative electrode on the top. A piece of tape held the two electrodes in place during the experiment. The galvanic skin response preamplifier was calibrated for skin resistance and set on direct current. The paper speed of the physiograph was set at .25 cm per second. After the equipment was connected to the subject, she was asked to sit and relax as much as possible for two minutes. During the last minute of the two-minute rest period, the laboratory assistant recorded, from the electronic digital counter, the resting muscle action potential.

Novel Motor Skill

The novel motor skill consisted of throwing twenty-five darts at a dart board for speed and accuracy. In the pilot study conducted by the investigator, twenty-five darts were found to be an appropriate number to measure initial skill in dart throwing. Within this number of trials a significant degree of learning did not occur. The dart board was attached to a solid frame and placed at eye level ten feet from the subject. Accuracy was measured by the number of darts in the board at the end of the last throw. Speed was not recorded, but was emphasized in the verbal instructions as a means of increasing tension. No specific time limit was given but the subject was told to throw the darts as fast and as accurately as possible. The scoring system of the dart board was explained to each subject prior to the beginning of the practice throws. The scoring procedures and the dimensions of the dart board appear on page 115 of the Appendix.

Before the initial test began, each subject was given a warm-up period of ten practice trials at throwing darts at the target. After completion of the ten practice trials, the dart board was cleared and the subject was told to throw twenty-five darts for speed and accuracy. On the signal "ready go," the subject began to throw the darts. When the last dart was thrown, the subject took a seat with her back to the dart board. The subject's score was then recorded, and all of the darts removed from the board. At no time was the subject informed of her score on the dart throwing test. The electrodes were removed from the triceps of the subject's dominant arm. The procedures followed in cleaning the electrodes and preparing them for a different muscle group were in accordance with those described by Davis (14:15)

Novel Mental Skill

The novel mental skill consisted of immediate recall of a sequence of nonsense numbers. The test was comprised of a list of fifteen different arrangements of numbers ranging from five digits to twelve digits. The nonsense numbers were randomly assigned to the list in order to prevent any grouping of meaningful digits. Each subject was given a two minute rest prior to the novel mental test. During the last minute of the two minute rest period, the muscle action potential of the masseter was recorded from the electronic counter.

The subject was then shown eight practice cards, each of which had a different sequence of nonsense numbers. The subject was told that the practice cards were similar to the initial test but none were exactly the same. After the subject had looked at each of the practice cards, the novel mental skill test was administered. A copy of the practice numbers and the actual test can be found in the Appendix on pages 116-8. Each list of nonsense numbers was presented to the subject for a period of ten seconds. According to a pilot study during which different time periods were examined for immediate number recall, ten seconds was found to be a sufficient amount of time to visually view each nonsense number. At the end of ten seconds, the investigator turned the card over and asked the subject to verbally recall the exact sequence of numbers. When all fifteen groups of numbers were recalled, the investigator recorded the individual's score on the score card. The individual's score consisted of the total number of accurate digits recalled in the correct sequence of order. A copy of the score card is in the Appendix on pages 119-20.

After the administration of the preliminary tests the subjects were grouped in matched triplets according to the following data from the pretest: (1) subject's college entrance score on the Standard Aptitude Test and/or score from the Advanced College Testing Program. This was a means of equating intelligence, and these scores were selected because all freshmen had previously taken the test and scores were available for all possible subjects, (2) score on the Taylor Manifest Anxiety test, (3) resting mean base levels for the triceps and masseter muscles as recorded by electromyographic techniques, (4) mean neuromuscular tension level while performing the novel motor skill, (5) mean neuromuscular tension level while performing the mental skill, (6) score on the novel motor skill. Six one-way analyses of variance were computed to determine if there was any significant difference between the three groups for each of the above six variables. All F ratios were not significant at the .01 level of confidence; this finding indicated that all three groups were matched on the selected variables prior to the experimental period.

Experimental Period

The experimental period began on the third week of the semester. The control group that was treated with exercise met five days a week for six weeks in the gymnasium and received daily instructions in body mechanics. The control group receiving the placebo met daily in the gymnasium to receive an individual pill which was a sugar pill but was given to the group with the instructions that the pill was a neuromuscular relaxant. After receiving the pill each day, the control group was dismissed. The experimental group received daily instructions in the techniques of relaxation. The experimental group was sub-divided into three smaller groups containing five students in two groups and six students in another. The purpose of this subdivision was to allow for more individualized teaching techniques in the skill of relaxation. The sub-groups met in the Human Performance Laboratory where the subjects rested on individual mats during each period when instructions in relaxation were given.

Each week all members of the experimental group were tested electromyographically on the specific muscles that they had been taught to relax during that week. During the weekly testing periods each subject was asked to reduce neuromuscular tension on the command to relax. Subjects attempted to reduce the tension in the triceps or masseter to zero level. No time limit was given to the subjects, and each subject attempted to relax in a sitting position. During the testing sessions the electromyographic equipment served as a motivational device in that it allowed each subject to see her level of neuromuscular control as indicated by the electronic counter and also by auditory sound, which is an assessory component of the bioelectric monitor.

Treatment of the Data

At the end of the pretesting period individual means were computed for each subject on neuromuscular tension resting level, neuromuscular tension when performing a novel motor skill and neuromuscular tension level when performing a novel mental skill. A one-way analysis of variance was computed, on each of the raviables, to determine if there were any significant differences between the groups.

At the end of the experimental period, individual means were computed for the posttest scores on neuromuscular tension resting level, level of neuromuscular tension when performing the novel motor skill under induced tensions, and level of neuromuscular tension when performing the novel mental skill under induced tension. An analysis of variance, using a two factor mixed design with repeated measures on one factor, was then computed to determine if there was any significant difference between the pretest and posttest of the novel motor skill and the novel mental skill.

Coefficients of correlation were then computed between pretest and posttest scores for each of the three groups on the novel motor skill and on the novel mental skill. Correlations were also computed between mean resting level and mean levels on the novel motor skill and the novel mental skill, respiration rate and skin resistance. The significance of the correlations was tested at the .05 level of confidence. Upon the bases of the results, a conclusion was drawn concerning the ability to control neuromuscular tension under induced tension.

Summary

In the present investigation forty-eight subjects were administered a novel motor skill and a novel mental skill in the Human Performance Laboratory before and after an experimental period of six weeks duration. Electromyographic techniques were used to measure muscle action potential in the triceps and masseter. Simultaneously, a pneumograph recorded the respiratory rate and the galvanic skin response was recorded to determine autonomic nervous system reaction to stress.

Based upon the results of the pretest, the subjects were matched on six different variables and randomly placed in three different experimental treatments; one control group received daily instructions in body mechanics, a second control group received a daily placebo, and a third group was designated as an experimental group. The experimental group received daily instructions in specific relaxation techniques.

At the end of the six week experimental period, a posttest was administered which was identical to the pre-test except for the influence of a verbal threat to induce tension. The data were collected and treated statistically, using analysis of variance and correlation techniques. Upon the bases of the findings, a conclusion was drawn concerning the relationship between ability to relax and changes in the performance of a novel motor skill and a novel mental skill under induced tension.

Chapter IV contains the analysis of the data and the results related to the interpretation of the study.

CHAPTER IV

ANALYSIS OF DATA AND RESULTS

Introduction

In Chapter IV the results of the statistical analysis are presented in narrative and tabular form. The purpose of the present investigation was to determine the relationship between specific relaxation ability and changes in the performance of a novel motor skill and a novel mental skill under induced tension. The study entailed the use of three groups, each containing sixteen female subjects. One control group participated in a program of body mechanics for a period of six weeks. A placebo control group took a sugar tablet daily for a period of six weeks without engaging in any formal physical activity program and the experimental group received daily instructions and practice in Jacobson's techniques of relaxation for six weeks.

Quantitative measures of the following variables were collected from all of the subjects before and after an experimental period of six weeks: resting muscle action potential of the triceps, resting muscle action potential of the masseter, muscle action potential of the triceps during the novel motor test, score on the novel motor test, muscle action potential of the masseter during the mental test, score on the mental test, resting respiration rate, respiration rate during the motor test, respiration rate during mental test, galvanic skin response resting level, galvanic skin response during the mental test, and galvanic skin response during the motor test.

The data were treated statistically by analysis of variance; a two-factor mixed design with repeated measures on one factor. For each F ratio for which a significant difference was found at the .05 level of significance, the data were treated by the Duncan's Multiple Range test to determine which specific means differed significantly from the other means. To determine the relationship between all possible combinations of the different variables, the Pearson Product-Moment correlation was computed.

Presentation of the Data

Table 1, presented on page 54, indicates that no significant differences appeared between the groups on the resting galvanic skin response. There was a significant difference, at the .01 level of confidence, between the two trials. The data indicated that stress did occur when the verbal threat was induced in all three groups. Table 2, presented on page 54, illustrates the the means and standard deviations for each group on the resting galvanic skin response both before and after the experimental period.

TABLE 1

ANALYSIS OF VARIANCE FOR THE RESTING LEVELS OF THE GALVANIC SKIN RESPONSE

Source	df	SS	MS	F
Between All Subjects	47	51737248.958		
Between Groups	2	1485014.583	742507.292	.6649
Between Subjects Same Group	45	50252234.375	1116716.319	
Within All Subjects	48	41796050.000		
Between Trials	1	5985009.375	5985009.375	7.828**
Groups X Trials	2	1406368.750	703184.375	.920
Subjects/Groups X Trials	45	34404671.875	764548.264	
Total	95	93533298.958		

*P .05 = 3.20
**P .01 = 5.10

TABLE 2

MEANS AND STANDARD DEVIATIONS FOR THE RESTING LEVEL OF THE GALVANIC SKIN RESPONSE

	Initial Test		Final Test	
	Means	S.D.	Means	S.D.
Relaxation Group	1643.125	1689.514	837.500	269.548
Placebo Control Group	1397.500	1066.931	915.625	593.643
Exercise Control Group	1070.000	818.535	837.500	468.874

The means are as follows: relaxation group, 1643.125, 837.500; placebo control group, 1397.500, 915.625; exercise control group, 1070.000, 837.500. When analyzing the means from the initial test to the final test it appeared that the relaxation group experienced a greater degree of stress as recorded by the galvanic skin response than did either the placebo control group or the exercise control group. It should be noted that for the galvanic skin response the lower the score the greater the stress reaction.

Table 3, presented on page 56, reveals the results of the galvanic skin response during the motor skill test. The F value of 1.000 indicated that there was no significant difference between the groups on the final trial but that there was a significant F value, 9.149 between the initial test and final test scores. Based upon the results of the galvanic skin response before and after a verbal threat, it was concluded that in these subjects the verbal threat did present a stressful situation. The results revealed that all three groups performed differently on the final test as compared to the initial test; but that no one group was significantly different from the other two. Table 4, page 56, presents the means and standard deviations for each group on the galvanic skin response during the motor skill test. The means are as follows: relaxation group, 1620.687, 796.187; placebo control group, 1383.250, 878.000; exercise control group, 1054.937, 818.750. Analyzing the means of

TABLE 3

ANALYSIS OF VARIANCE FOR THE LEVEL OF GALVANIC SKIN RESPONSE DURING THE MOTOR SKILL TEST

Source	df	SS	MS	F
Between All Subjects	47	54362957.656		
Between Groups	2	1220370.431	610185.216	.516
Between Subjects Same Group	45	53242587.225	1183168.605	
Within All Subjects	48	39780588.500		
Between Trials	1	6481802.344	6481802.344	9.149**
Groups X Trials	2	1416740.821	708370.411	1.000
Subjects/Groups X Trials	45	31882045.335	708489.896	
Total	95	45217546.156		

*P .05 = 3.20
**P .01 = 5.10

TABLE 4

MEANS AND STANDARD DEVIATIONS FOR GALVANIC SKIN RESPONSE DURING THE MOTOR SKILL TEST

	Initial Test		Final Test	
	Means	S.D.	Means	S.D.
Relaxation Group	1620.687	1684.929	796.187	267.919
Placebo Control Group	1383.250	1098.515	878.000	595.582
Exercise Control Group	1054.937	789.522	818.750	468.703

the initial test and the final test, it appeared that the relaxation group experienced greater degrees of stress from the verbal threat than did either the placebo control group or the exercise control group.

Table 5, page 58, illustrates that no significant difference occurred between the three groups on the galvanic skin response during the mental test. A significant difference at the .01 level was noted between the initial and final trial, which indicated that measured stress did occur during the final test in all three groups. Table 6, presented on page 58, reveals the means and standard deviations for the galvanic skin response during the mental test. The data indicated that the relaxation group experienced a greater degree of stress than did either of the other two groups during the performance of the mental test. The means are as follows: relaxation group, 1295.187, 795.625; placebo control group, 1370.938, 881.687; exercise control group, 1050.500; 821.250.

Based upon the results of the galvanic skin response, it may be concluded that the verbal threat did impart stress to the selected subjects in all groups during a resting test, a motor test and a mental test.

Table 7, presented on page 59, depicts the data for the resting respiration rate. There was a significant difference at the .01 level of confidence between the initial test and the final test scores for all three groups. This

TABLE 5

ANALYSIS OF VARIANCE FOR THE LEVEL OF GALVANIC SKIN RESPONSE DURING THE MENTAL TEST

Source	df	SS	MS	F
Between All Subjects	47	52997344.958		
Between Groups	2	1186860.333	593430.167	.515
Between Subjects Same Group	45	51810484.625	1151344.103	
Within All Subjects	48	38496993.000		
Between Trials	1	6269970.375	6269970.375	9.137**
Groups X Trials	2	1348443.750	674221.875	.983
Subjects/Groups X Trials	45	30878578.875	686190.642	
Total	95	91494337.958		

*P .05 = 3.20
**P .01 = 5.10

TABLE 6

MEANS AND STANDARD DEVIATIONS FOR THE GALVANIC SKIN RESPONSE DURING THE MENTAL TEST

	Initial Test		Final Test	
	Means	S.D.	Means	S.D.
Relaxation Group	1295.187	984.132	795.625	270.108
Placebo Control Group	1370.938	1055.368	881.687	597.915
Exercise Control Group	1050.500	778.293	821.250	466.264

TABLE 7

ANALYSIS OF VARIANCE FOR THE
RESTING RESPIRATION RATE

Source	df	SS	MS	F
Between All Subjects	47	871.490		
Between Groups	2	161.396	80.698	5.114**
Between Subjects Same Group	45	710.094	15.780	
Within All Subjects	48	708.5		
Between Trials	1	326.344	326.344	46.133**
Groups X Trials	2	63.813	31.907	4.511*
Subjects/Groups X Trials	45	318.343	7.074	
Total	95	1579.990		

*P .05 = 3.20
**P .01 = 5.10

TABLE 8

MEANS AND STANDARD DEVIATIONS FOR THE
RESTING RESPIRATION RATE

	Initial Test		Final Test	
	Means	S.D.	Means	S.D.
Relaxation Group	20.625	2.712	26.562	3.656
Placebo Control Group	21.750	3.326	24.750	3.132
Exercise Control Group	19.625	3.887	21.750	2.750

finding seems to support the findings of other investigators that when a subject is exposed to a stressful situation the respiration rate tends to increase. Table 7 also reveals that there was a significant F value of 4.511 at the .05 level of confidence between the different groups on the final test, which could indicate that on the final test one or more of the groups was performing significantly different from the others.

Table 8, on page 59, presents the data of the means and standard deviations for the resting respiration rate. The means are as follows: relaxation group, 20.625, 26.562; placebo control group, 21.750, 24.750; exercise control group, 19.625, 21.750. According to the means from the initial test and the final test, the relaxation group had a greater increase in respiration rate than did either of the other two groups. The exercise control group had the smallest increase in the resting respiration rate which could be interpreted to mean that the difference found might be related to the level of physical fitness of these particular students enrolled in a body mechanics class during the experimental period.

Table 9, page 61, presents the Duncan's Multiple Range test for the resting respiration rate. According to the results of the range test, there was a significant difference between each of three groups compared two at a time on the final resting respiration rate. Because the groups

TABLE 9

TABLE OF DIFFERENCES FOR DUNCAN'S MULTIPLE RANGE TEST BETWEEN ORDERED MEANS FOR THREE GROUPS ON THE RESTING RESPIRATION RATE

GROUP I Relaxation Group	GROUP II Placebo Control Group	GROUP III Exercise Control Group
26.562	24.750	21.750

**P .01 = 3.889
*P .05 = 2.858

that were either trained to relax or led to believe they were receiving facilitating pills for relaxation did not reduce the respiratory rate as low as did the exercise control group under the stress situation, there is evidence that the difference could be attributed to a physical training effect. The test of respiration rate was designed to determine if stress was actually induced and not to investigate possible differences between the groups; therefore, further study of this phenomenon was not pursued.

Table 10, page 63, presents data concerning the respiration rate during the motor skill test. The F value of 28.252 indicated that there was a significant difference between the three groups on the respiration rate during the motor test. According to the data, it may be concluded that all three groups were in a stressful situation when comparing the initial group scores to the final group scores. Table 10 also indicates that there was a significant F value at the .05 level of confidence, 4.395, between the different groups on the final test scores.

Table 11, on page 63, presents the means and standard deviations for the initial and final test scores as follows: relaxation group, 27.937, 33.375; placebo control group, 27.500, 34.187; exercise control group, 27.582, 28.562. The means revealed that the lowest respiration rate during the performance of a novel motor skill during a stressful situation was obtained by the exercise control group.

TABLE 10

ANALYSIS OF VARIANCE FOR RESPIRATION RATE DURING THE MOTOR SKILL TEST

Source	df	SS	MS	F
Between All Subjects	47	863.958		
Between Groups	2	154.6455	77.323	4.905*
Between Subjects Same Group	45	709.3125	15.7625	
Within All Subjects	48	1334.000		
Between Trials	1	459.375	459.375	28.252**
Groups X Trials	2	142.9375	71.469	4.395*
Subjects/Groups X Trials	45	731.6875	16.260	
Total	95	2197.958		

*P .05 = 3.20
**P .01 = 5.10

TABLE 11

MEANS AND STANDARD DEVIATIONS FOR RESPIRATION RATE DURING THE MOTOR SKILL TEST

	Initial Test		Final Test	
	Means	S.D.	Means	S.D.
Relaxation Group	27.937	3.732	33.375	3.333
Placebo Control Group	27.500	3.905	34.187	5.854
Exercise Control Group	27.562	2.290	28.562	3.200

The relaxation group had the greatest increase in respiration rate during the performance of a novel motor skill which would indicate that the experimental treatment did not facilitate a lower respiration rate in the selected subjects when they were exposed to a stressful situation as compared to the subjects in the other two groups.

Table 12, on page 65, presents the results of the Duncan's Multiple Range test. An analysis of the range test indicated that there was no significant difference between the relaxation group and the placebo control group. The exercise control group exhibited a lower respiration rate under induced tension when performing a novel motor skill than did either of the other two groups. It was believed that under the conditions of the present study, a program of physical exercise was more effective in reducing respiration rate than specific instructions in relaxation training or the placebo effect. The respiration rate was used as an indicator of tension in the subjects with an increased rate suggestive of increase of tension.

Table 13, on page 66, presents the data collected from the respiration rate during the mental test. The F value of 2.785 indicated that there was no significant difference between the groups in the respiration rate during the mental test. There was a significant difference between the initial test and the final test scores as indicated by the F value 86.444. The difference indicated that stress

TABLE 12

TABLE OF DIFFERENCES FOR DUNCAN'S MULTIPLE RANGE TEST BETWEEN ORDERED MEANS FOR THREE GROUPS ON THE RESPIRATION RATE DURING THE MOTOR TEST

GROUP I Relaxation Group	GROUP II Placebo Control Group	GROUP III Exercise Control Group
33.375	34.187	28.562

**P .01 = 3.889
*P .05 = 2.585

TABLE 13

ANALYSIS OF VARIANCE FOR RESPIRATION RATE DURING THE MENTAL TEST

Source	df	SS	MS	F
Between All Subjects	47	567.406		
Between Groups	2	18.250	9.125	.748
Between Subjects Same Group	45	549.156	12.200	
Within All Subjects	48	1090.5		
Between Trials	1	688.010	688.010	86.444**
Groups X Trials	2	44.334	22.167	2.785
Subjects/Groups X Trials	45	358.156	7.959	
Total	95	1657.906		

*P .05 = 3.20
**P .01 = 5.10

TABLE 14

MEANS AND STANDARD DEVIATIONS FOR RESPIRATION RATE DURING THE MENTAL TEST

	Initial Test		Final Test	
	Means	S.D.	Means	S.D.
Relaxation Group	21.375	3.199	27.812	2.242
Placebo Control Group	21.937	3.268	28.125	3.568
Exercise Control Group	22.250	3.288	25.687	2.686

did occur in all three groups when a verbal threat was imposed on the subjects. Table 14, on page 66, presents the means and standard deviations for the respiration rate during the mental test. The initial and final means are as follows: relaxation group, 21.375, 27.812; placebo control group, 21.937, 28.125; exercise control group, 22.250, 25.687. The means for the initial and final scores for each group indicated that the exercise control group had a lower respiration rate on the final test than did either of the other two groups. The placebo group had the highest rate of respiration during a stressful situation. It was assumed that the exercise group who received daily instructions in body mechanics had a lower respiration rate because of an increase in the physical fitness level of the subjects.

In this study the two measures that were used to determine levels of stress were the galvanic skin response and the rate of respiration. From the results of these two measures taken before and after the introduction of a verbal threat it may be inferred that for all groups during the mental and motor tests, stress did occur as determined by the selected measurements.

Table 15, on page 68, presents the resting muscle action potential of the triceps. According to an analysis of the data, there was no significant difference between the groups in this measure on the final trial. There was a

TABLE 15

F VALUES FOR ANALYSIS OF VARIANCE ON RESTING MUSCLE ACTION POTENTIAL OF THE TRICEPS

Source	df	SS	MS	F
Between All Subjects	47	250251.656		
Between Groups	2	26706.687	13352.844	2.688
Between Subjects Same Group	45	223545.969	4967.688	
Within All Subjects	48	210823.500		
Between Trials	1	71672.438	71672.438	17.970**
Groups X Trials	2	11289.813	5644.907	1.410
Subjects/Groups X Trials	45	181301.093	4128.913	
Total	95	461075.156		

*P .05 = 3.20
**P .05 = 5.10

TABLE 16

MEANS AND STANDARD DEVIATION FOR THE RESTING MUSCLE ACTION POTENTIAL OF THE TRICEPS

	Initial Test		Final Test	
	Means	S.D.	Means	S.D.
Relaxation Group	3.625	5.035	2.937	5.261
Placebo Control Group	8.000	14.000	35.812	66.384
Exercise Control Group	17.812	22.486	71.812	142.6911

significant difference between the initial and final trials. The data may be interpreted as indicating that the verbal threat was successful in inducing stress on the measurement of the resting level of the triceps. No group performed significantly different on the final test trial. Table 16, on page 68, presents the means and standard deviations for the resting muscle action potential of the triceps. The means for the initial and final trial are as follows: relaxation group, 3.625, 2.937; placebo group, 8.000, 35.812; exercise control group, 17.812, 71.812. According to the initial and final means of the resting muscle action potential of the triceps, the relaxation group had a much lower mean on the initial test than the other groups and was least affected by the stressful situation. It was believed that the relaxation instructions improved the ability of the relaxation group to relax and control muscle tension under a stressful situation, but this belief was not verified statistically. The placebo control group and the exercise control group both evidenced a much greater increase in muscle tension from the initial test to the final test. Upon the bases of the analyses of variance presented in Table 15 and the previous cited evidence, it may be stated that stress did occur in all three groups on the final test trial. Accepting the statement that stress did occur in all three groups allows one to better interpret the means and standard deviations and to suggest that the relaxation group was better than the other two groups at controlling muscle tension during the stressful situation of a verbal threat.

Table 17, on page 71, illustrates the data collected from the muscle action potential of the triceps during the performance of a novel motor skill. There was no significant difference between the groups on the initial or on the final trial. The data may be considered as indicating that the verbal threat did not cause a difference between the muscle action potential of the initial trial and the muscle action potential of the final trial. It is imperative to note that no practice was allowed between the two tests during the six weeks experimental period; therefore the initial trial of the novel skill may have been as equally productive of tension as the final trial under the verbal threat.

Table 18, on page 71, presents the means and standard deviations on the muscle action potential of the triceps during the performance of a novel motor skill. The means of the initial and final tests are as follows: relaxation group, 744.875, 648.125; placebo control group, 401.187, 450.500; exercise control group, 606.750, 736.000. The results of the data may be interpreted as indicating that the relaxation group was the only group that had a lower mean on the muscle action potential on the final test than on the initial test. Even though the difference was not statistically significant, the amount of the difference may indicate that the relaxation

TABLE 17

ANALYSIS OF VARIANCE ON MUSCLE ACTION POTENTIAL
OF THE TRICEPS DURING THE PERFORMANCE
OF A MOTOR SKILL

Source	df	SS	MS	F
Between All Subjects	47	1937996.334		
Between Groups	2	1824361.896	912180.948	2.338
Between Subjects Same Group	45	17555607.438	390124.610	
Within All Subjects	48	9970182.000		
Between Trials	1	83898.376	83898.376	.400
Groups X Trials	2	452365.187	226182.594	1.079
Subjects/Groups X Trials	45	9433918.437	209642.632	
Total	95	29350151.334		

*P .05 = 3.20
**P .01 = 5.10

TABLE 18

MEANS AND STANDARD DEVIATION ON THE MUSCLE ACTION
POTENTIAL OF THE TRICEPS DURING THE PERFORMANCE
OF A MOTOR SKILL

	Initial Test		Final Test	
	Means	S.D.	Means	S.D.
Relaxation Group	744.875	751.620	648.125	525.469
Placebo Control Group	401.187	287.149	450.500	151.448
Exercise Control Group	606.750	722.115	736.000	499.032

treatment facilitated the lowering of the amount of muscle action potential from the initial test to the final test which theoretically should have been more stressful.

Table 19, on page 73, reveals that there was no significant difference between the groups on the initial or final test of the novel motor skill. The data indicated that the varying treatments had no significant effect on the test scores for each group. The specific skill of dart throwing may not have been the best motor skill to indicate improvement in the final test scores. Possible rationale may be that because a pretest, posttest design without practice in between the tests eliminates possible improvement in the novel motor skill. Another explanation could be that the amount of tension utilized by low skilled performers varies so greatly that significant changes could not be statistically noted with the limited sample size.

In the initial stages of the study, dart throwing was selected as a skill that most college women would not have been exposed to at a high skill level. The skill of dart throwing was performed in the laboratory while each subject was connected to various pieces of equipment. At the particular time of selecting the novel skill it was believed that dart throwing was an adequate skill for measuring performance under induced tension. In an attempt to identify significant differences the groups were all equated on the dart throwing test after the initial test results were obtained.

TABLE 19

ANALYSIS OF VARIANCE FOR THE SCORES OF THE NOVEL MOTOR SKILL

Source	df	SS	MS	F
Between All Subjects	47	10126.656		
Between Groups	2	141.437	70.719	.319
Between Subjects Same Group	45	9985.219	221.894	
Within All Subjects	48	71606.480		
Between Trials	1	364.260	364.260	.235
Groups X Trials	2	1368.397	684.199	.441
Subjects/Groups X Trials	45	69868.823	1552.641	
Total	95	18728.156		

*P .05 = 3.20
**P .01 = 5.10

TABLE 20

MEANS AND STANDARD DEVIATIONS FOR THE SCORES OF THE NOVEL MOTOR SKILL

	Initial Test		Final Test	
	Means	S.D.	Means	S.D.
Relaxation Group	34.937	16.276	33.062	9.303
Placebo Control Group	28.062	15.586	42.625	12.712
Exercise Control Group	32.875	12.429	31.875	11.952

It may be that the motor skill test did not produce significant differences between the groups on the final test because of the priority that is placed by our society upon motor and mental efficiency. The subjects seemed to respond to the mental test in the desired competitive manner, while the motor skill evoked less competitiveness and more apathy.

Table 20, on page 73, presents the means and standard deviations for the scores of the novel motor skill. The scores for the initial and final novel motor skill test are as follows: relaxation group, 34.937, 33.962; placebo control group, 28.062, 42.625; exercise control group, 32.875, 31.875. These data show that the placebo control group was the only group that had an improvement in the final score. The relaxation and exercise control groups had a decrement in ability on the final measure. The improvement of the placebo group would seem to indicate that the psychological effect that was fostered in the placebo group facilitated improvement in dart throwing that was greater than that which actually resulted from the physiological effects of relaxation training.

Table 21, on page 75, presents the resting muscle action potential of the masseter. The F value, 3.366, indicated that there was a significant difference at the .05 level between the initial and final test scores. The F value of 9.725 indicated that there was a significant difference at the .01 level of confidence between the groups

TABLE 21

ANALYSIS OF VARIANCE ON RESTING MUSCLE ACTION POTENTIAL OF THE MASSETER

Source	df	SS	MS	F
Between All Subjects	47	216620.240		
Between Groups	2	33816.584	16908.292	4.162*
Between Subjects Same Groups	45	182803.656	5062.304	
Within All Subjects	48	104297.500		
Between Trials	1	5177.344	5177.344	3.366*
Groups X Trials	2	29912.250	14956.125	9.725**
Subjects/Groups X Trials	45	69207.906	1537.954	
Total	95	320917.740		

*P .05 = 3.20
**P .01 = 5.10

TABLE 22

MEANS AND STANDARD DEVIATIONS ON THE RESTING MUSCLE ACTION POTENTIAL OF THE MASSETER

	Initial Test		Final Test	
	Means	S.D.	Means	S.D.
Relaxation Group	40.062	44.486	4.500	6.633
Placebo Control Group	28.562	17.197	92.500	138.133
Exercise Control Group	38.187	19.650	53.500	22.808

on the final trial. Table 22, on page 75, reveals the means and standard deviations for the muscle action potential of the masseter during the mental test. The means for the initial and final tests respectively are as follows: relaxation group, 40.062, 4.500; placebo control group, 28.562, 92.500; exercise control group, 38.187, 53.500. Accordingly, the mean scores of the relaxation group displayed the greatest decrease in muscle action potential during the resting period. This finding seems to suggest that the subjects who received instructions in techniques of relaxation did, in fact, learn to relax the masseter which is believed indicative of mental activity. The placebo control group and the exercise control group both had an increase in muscle tension from the initial test to the final test. The amount of increase in the placebo control group and the exercise control group as compared to the drastic decrease in the relaxation group would further support the concept that the relaxation group did learn to control tension in the masseter during a stressful situation and was able to demonstrate the control when the subjects were exposed to a verbal threat which did induce tension.

Table 23, on page 77, illustrates the data from the Duncan's Multiple Range for the significant F value between groups on the final trial of the resting muscle action potential of the masseter. The range test indicated that

TABLE 23

TABLE OF DIFFERENCES FOR DUNCAN'S MULTIPLE RANGE TEST BETWEEN ORDERED MEANS FOR THREE GROUPS ON THE RESTING MUSCLE ACTION POTENTIAL OF THE MASSETER

GROUP I Relaxation Group	GROUP II Placebo Control Group	GROUP III Exercise Control Group
4.500	53.500	92.500

**P .01 = 3.889
*P .05 = 2.858

there was a very significant difference between the relaxation group and the placebo control group on the final test scores of the resting muscle action potential of the masseter. There was no significant difference between the placebo control group and the exercise control group. The data indicate that the relaxation group had a very significantly lower resting muscle action potential level in the masseter than did either of the other two groups. Such an analysis supports the belief that instructions in relaxation do lower the muscle action potential when tension is induced by a verbal threat.

Table 24, on page 79, presents the results of the analysis of variance of the muscle action potential for the masseter during the mental test. The statistical analysis indicated that there was no significant difference between the three groups on the final test. There was a significant difference for all groups between the two trials. The difference is interpreted as relating to the influence of stress from the verbal threat.

Table 25, on page 79, reveals the means and standard deviations for the muscle action potential of the masseter during the mental test. The means for the initial and final tests are as follows: relaxation group, 115.750, 81.937; placebo control group, 145.437, 100.375; exercise control group, 168.812, 94.500. Accordingly, it appears that the exercise control group had the greatest decrease in muscle

TABLE 24

ANALYSIS OF VARIANCE ON THE MUSCLE ACTION POTENTIAL OF THE MASSETER DURING THE MENTAL TEST

Source	df	SS	MS	F
Between All Subjects	47	650719.906		
Between Groups	2	18553.000	9276.500	.660
Between Subjects Same Group	45	632166.906	14048.154	
Within All Subjects	48	761400.500		
Between Trials	1	62679.260	62670.260	4.08*
Groups X Trials	2	6958.584	3479.292	.226
Subjects/Groups X Trials	45	691762.656	15372.504	
Total	95	1412120.406		

*P .05 = 3.20
**P .01 = 5.10

TABLE 25

MEANS AND STANDARD DEVIATIONS FOR THE MUSCLE ACTION POTENTIAL OF THE MASSETER DURING THE MENTAL TEST

	Initial Test		Final Test	
	Means	S.D.	Means	S.D.
Relaxation Group	115.750	77.357	81.937	73.125
Placebo Control Group	145.437	128.874	100.375	66.725
Exercise Control Group	168.812	220.326	94.500	42.408

action potential during the mental test. Differences favoring the exercise control group suggest that exercise may be a factor in reducing mental tension. Subjective statements of physical educators, health educators and psychiatrists have proposed such a paradigm.

Table 26, on page 81, presents the data for the mental test scores when treated statistically by an analysis of variance. There was a very significant difference between the initial and final trials as well as a very significant difference between the groups on the final trial. Table 27, on page 81, illustrates the means and standard deviations for the scores on the mental test. The means for the initial and final test are as follows: relaxation group, 87.562, 97.062; placebo control group, 84.562, 70.625; exercise control group, 76.432, 82.375. It appears that the relaxation group had a better mean score on the final test than either of the other two groups.

Table 28, on page 82, indicates the results of the Duncan's Multiple Range test to determine which group was performing significantly different from the other two. The range test revealed that there was a significant difference at the .05 level of confidence between the relaxation group and the exercise group. There was no significant difference between the exercise control group and the placebo control group. The data may be interpreted as indicating that the relaxation group performed much better on the mental test of

TABLE 26

ANALYSIS OF VARIANCE ON THE MENTAL TEST SCORES

Source	df	SS	MS	F
Between All Subjects	47	9727.950		
Between Groups	2	2967.646	1483.823	9.877**
Between Subjects Same Group	45	6760.312	150.229	
Within All Subjects	48	3383.000		
Between Trials	1	294.000	294.000	6.06**
Groups X Trials	2	905.062	452.531	9.321**
Subjects/Groups X Trials	45	2183.938	48.532	
Total	95	13110.958		

*P .05 = 3.20
**P .01 = 5.10

TABLE 27

MEANS AND STANDARD DEVIATIONS FOR THE SCORES ON THE MENTAL TEST

	Initial Test		Final Test	
	Means	S.D.	Means	S.D.
Relaxation Group	87.562	7.193	97.062	9.079
Placebo Control Group	84.562	9.855	70.625	13.284
Exercise Control Group	76.432	7.705	82.375	9.584

TABLE 28

TABLE OF DIFFERENCES FOR DUNCAN'S MULTIPLE RANGE TEST BETWEEN ORDERED MEANS FOR THREE GROUPS ON THE MENTAL TEST SCORES

GROUP I Relaxation Group	GROUP II Placebo Control Group	GROUP III Exercise Control Group
97.062	79.625	82.375

**P .01 = 3.889
*P .05 = 2.858

learning to memorize numbers in a sequential order under induced tension, than did either of the two control groups. The subjects who received instructions in the Jacobson technique of relaxation performed better on the mental test during induced tension than the other two groups who received other types of experimental treatments. Therefore, it was concluded that relaxation instructions which concentrated on controlling muscle action potential of the masseter enabled the subjects to perform better on the mental test than those subjects who were not trained in techniques of relaxation.

All of the coefficients of correlation for the study are presented in tabular form and show the relationships that were significantly different from zero at the .01 and .05 levels. In Table 29, presented on page 84, the zero order coefficients of correlation between all of the tested variables in the relaxation group are presented. A significant coefficient of correlation at the .01 level of confidence was found between the following variables on the initial test: resting G.S.R. and G.S.R. during the motor skill test and G.S.R. during the mental test. A significant coefficient of correlation at the .05 level of confidence was the G.S.R. during the motor skill test and the G.S.R. during the mental test. The following relationships were significant at the .01 level: motor skill score and resting G.S.R., G.S.R. during the motor skill test and G.S.R. during the mental

TABLE 29

CORRELATIONS FOR THE DIFFERENT VARIABLES FOR THE RELAXATION GROUP

	Resting EMG Motor	Resting EMG Mental	EMG Motor Skill	EMG Mental Skill	Motor Skill Score	Mental Score	Resting Respiration	Respiration Motor	Respiration Mental	Resting G.S.R.	Motor G.S.R.	Mental G.S.R.
I Resting EMG Motor		.2654	-.0379	-.1624	.3727	.0679	-.5681	-.5518	-.2376	.1867	[illegible]	.0667
I Resting EMG Mental			-.0086	-.1471	.1268	-.0692	-.2297	-.3669	-.0396	.1759	.1799	.0136
I EMG Motor Skill				-.0949	.2586	.116	.2536	.4773	-.0420	-.2742	-.2695	.2762
I EMG Mental Skill					-.0925	-.1084	.0172	.0748	.0331	.1963	.1938	.3321
I Motor Skill Score						-.0658	-.1590	.3393	-.3236	.0159	.0126	-.0716
I Mental Score							-.2422	-.0706	-.2128	-.3932	-.3941	-.7071
I Resting Respiration								.5408	.3923	-.1196	-.1196	.3197
I Respiration Motor									.2371	-.1059	-.3671	-.1111
I Respiration Mental										-.2215	-.2309	.1118
I Resting G.S.R.											[illegible]**	.6926**
I Motor G.S.R.												.6890*
I Mental G.S.R.												

	Resting EMG Motor	Resting EMG Mental	EMG Motor Skill	EMG Mental Skill	Motor Skill Score	Mental Score	Resting Respiration	Respiration Motor	Respiration Mental	Resting G.S.R.	Motor G.S.R.	Mental G.S.R.
I Resting EMG Motor	-.2273	.0617	-.2355	-.0423	-.2716	.0100	-.3115	-.1568	-.3715	.2981	.3174	.3298
I Resting EMG Mental	-.3318	.6011	-.3446	.0838	-.3053	-.1741	-.3302	-.2669	-.4259	.0722	-.0692	-.1416
I EMG Motor Skill	-.1825	.1965	.6168	-.1846	.1085	.2914	.1225	.2159	-.0121	.0340	.0480	.0669
I EMG Mental Skill	-.0755	-.0813	-.2715	-.0740	.0117	.1075	.1627	-.3702	-.0507	-.0319	-.0516	-.0610
I Motor Skill Score	-.0175	.0722	-.1668	.1399	-.1555	.0927	-.0088	-.1309	-.2195	.2768	.2924	.2056
I Mental Score	-.0587	-.0175	.1192	-.5003	-.0201	.3956	.2089	.1893	.1460	-.1191	-.0937	-.0730
I Resting Respiration	.1297	.1910	.2075	.3143	.2400	-.0244	.3173	.3127	.2042	-.2115	-.1968	-.1907
I Respiration Motor	.3166	-.0138	.3636	.1776	-.0070	.0775	.1628	.0872	.1255	.0210	.0522	.0632
I Respiration Mental	.1135	.3501	.0727	.0473	.0853	-.0072	.1475	.2505	-.2603	.0090	-.0425	-.0611
I Resting G.S.R.	-.2263	-.0518	-.2561	.1227	.1948	-.3568	-.1206	-.2196	.0950	.0535	.0147	.0571
I Motor G.S.R.	-.2242	-.0569	-.2491	.1229	.1995	-.3568	-.1226	-.2243	.0952	.0465	.0393	.0518
I Mental G.S.R.	-.1975	.1219	-.2338	.1490	.3133	-.4379	.0100	-.0670	.1384	-.1161	-.1292	-.1247
F Resting EMG Motor		.1123	.0819	-.1170	.0766	-.1164	.1415	-.0313	-.1122	-.3024	-.2560	-.2382
F Resting EMG Mental			-.1472	-.1776	.5628*	-.1437	.1583	.0026	-.3839	.3740	-.4363	-.4772
F EMG Motor Skill				-.0582	-.0560	.1987	.0141	.2579	.0185	-.0007	.0209	.0607
F EMG Mental Skill					-.4911	.2041	-.2102	-.2414	-.2600	.3512	.3632	.3582
F Motor Skill Score						-.5909	.1624	.0153	.3511	-.6676**	-.7404**	-.7603**
F Mental Score							.3086	-.1391	-.4323	.1229	.1716	.1978
F Resting Respiration								.4412	.1121	-.1482	-.0572	.0495
F Respiration Motor									.3696	.2417	.2998	.3060
F Respiration Mental										-.2210	-.1700	-.1423
F Resting G.S.R.											.9766**	.9553**
F Motor G.S.R.												.9953**
F Mental G.S.R.												

**p < .01
*p < .05

I = Variables on the Initial Test
F = Variables on the Final Test

test. Also correlated at the .01 level of confidence were resting G.S.R., G.S.R. during the motor skill test and G.S.R. during the mental test; G.S.R. during the motor skill test and G.S.R. during the mental test. At the .05 level the only coefficient of correlation that was significant was the resting EMG prior to mental work and the mental test score.

Table 30, on page 86, indicates the zero order coefficients of correlation for the placebo control group. On the initial trial the following variables were related at the .01 level of confidence: EMG mental skill and resting G.S.R., G.S.R. during the motor skill test and G.S.R. during the mental test; resting G.S.R. and G.S.R. during the motor skill test and G.S.R. during the mental test; G.S.R. during the motor skill test and G.S.R. during the mental test. On the final test trial, there was a significant relationship between the following variables at the .01 level of confidence: resting EMG prior to the motor skill test and EMG motor skill; resting EMG prior to the mental test, and EMG mental skill; resting G.S.R. and G.S.R. during the motor skill test and G.S.R. during the mental test; G.S.R. during the motor skill test and G.S.R. during the mental test. At the .05 level the only relationship that was significant was resting respiration and respiration during the mental test. When correlating the scores from the initial test to the final test the following relationships

TABLE 30

CORRELATIONS FOR THE DIFFERENT VARIABLES FOR THE PLACEBO CONTROL GROUP

	Resting EMG Motor	Resting EMG Mental	EMG Motor Skill	EMG Mental Skill	Motor Skill Score	Mental Score	Resting Respiration	Respiration Motor	Respiration Mental	Resting G.S.R.	Motor G.S.R.	Mental G.S.R.
I Resting EMG Motor		-.1243	-.3648	.0130	.0847	-.0181	.1534	-.0065	-.2085	-.0800	-.0612	-.0811
I Resting EMG Mental			.3098	-.0292	-.0146	.0211	-.1079	-.1717	.1342	-.0161	-.0149	-.0192
I EMG Motor Skill				-.1214	-.2401	-.0025	-.3874	-.3621	.1784	.1521	.1321	.1100
I EMG Mental Skill					.1345	.0633	-.0901	.1180	-.0261	.6632**	.6819**	.6737**
I Motor Skill Score						-.1528	.3812	.1093	-.0158	.1139	-.1172	-.1111
I Mental Score							-.1075	-.1791	-.0121	-.0698	-.0579	-.0713
I Resting Respiration								.1330	.1020	-.1222	-.1242	-.1191
I Respiration Motor									-.1297	.1063	.1091	.1152
I Respiration Mental										.0306	.0199	.0276
I Resting G.S.R.											.9991**	.9998**
I Motor G.S.R.												.9997**
I Mental G.S.R.												
F Resting EMG Motor												
F Resting EMG Mental												
F EMG Motor Skill												
F EMG Mental Skill												
F Motor Skill Score												
F Mental Score												
F Resting Respiration												
F Respiration Motor												
F Respiration Mental												
F Resting G.S.R.												
F Motor G.S.R.												
F Mental G.S.R.												

	Resting EMG Motor	Resting EMG Mental	EMG Motor Skill	EMG Mental Skill	Motor Skill Score	Mental Score	Resting Respiration	Respiration Motor	Respiration Mental	Resting G.S.R.	Motor G.S.R.	Mental G.S.R.
I Resting EMG Motor	-.2023	.7183**	-.3401	.7091**	.1682	.1131	-.1346	.0189	-.1754	0.516	.0387	.0555
I Resting EMG Mental	-.1828	.3022	-.0688	.3326	.0867	-.3818	-.1135	-.0116	.1811	.0419	.0281	.0303
I EMG Motor Skill	.0458	-.2662	.2385	-.3283	-.0983	-.0112	.2285	.1863	.0551	.2705	.2723	.2767
I EMG Mental Skill	.2555	-.1232	.1252	-.0625	.1537	.1103	.2731	-.1798	-.1603	.5221*	.5011*	.5081*
I Motor Skill Score	.2881	-.1516	.2265	-.0666	.2256	-.1231	.1564	.0519	-.1889	-.2963	-.3004	-.3136
I Mental Score	-.3245	-.1386	-.1065	.0190	-.2322	.6661**	-.0521	-.2133	-.1556	-.0372	-.0368	-.0236
I Resting Respiration	-.1697	.1342	-.1712	.2882	.3628	-.5580	.2159	.3811	.3396	-.1737	-.1699	-.1842
I Respiration Motor	.0109	.2028	-.2528	.1765	.3638	-.1722	.2810	-.1517	.4260	-.1098	-.1142	-.1235
I Respiration Mental	-.0170	.1964	-.1112	.0751	.2370	-.3159	-.1297	-.1986	.3811	.0053	-.0217	-.0137
I Resting G.S.R.	.1102	-.1576	.0120	-.2465	.0291	-.0755	.1161	.1717	.1223	.7839**	.7720**	.7767**
I Motor G.S.R.	.0949	-.1611	.0231	.2416	.0150	-.0628	.1145	.1633	.1208	.7934**	.7826**	.7864**
I Mental G.S.R.	.1699	-.1594	.0353	-.2469	.0286	-.0761	.1161	.1645	.1261	.7862**	.7751**	.7768**
F Resting EMG Motor		-.1601	.6155**	-.1597	.1686	.1316	-.3070	-.1895	-.1537	-.2774	-.2946	-.2902
F Resting EMG Mental			-.2978	.9322**	.1399	-.1666	-.2413	-.0216	.0770	-.0460	-.0453	-.0461
F EMG Motor Skill				-.2371	.1816	.0311	-.3495	.0014	-.4234	-.1694	-.1824	-.1799
F EMG Mental Skill					.3561	.0634	-.3174	-.1083	-.1671	-.1120	-.1083	-.1107
F Motor Skill Score						-.2184	-.4037	-.0687	-.0251	-.3147	-.3361	-.3322
F Mental Score							-.0908	-.2457	-.6239	-.1462	-.1558	-.1276
F Resting Respiration								.4353	.5339*	.0525	.0747	.0618
F Respiration Motor									.0736	.0671	.0939	.0830
F Respiration Mental										.1008	.0954	.0902
F Resting G.S.R.											.9989**	.9992**
F Motor G.S.R.												.9996**
F Mental G.S.R.												

**P < .01
*P < .05

I - Variables on the Initial Test
F - Variables on the Final Test

were significant at the .01 level of confidence: resting EMG prior to the motor test and resting EMG prior to the mental test, and EMG mental skill; initial mental score and mental score; initial resting G.S.R. and final resting G.S.R., G.S.R. during the motor skill test, and G.S.R. during the mental test; and G.S.R. during the motor skill test and resting G.S.R., G.S.R. during the motor skill test and G.S.R. during the mental test; G.S.R. during the mental test and resting G.S.R., G.S.R. during the motor skill test and G.S.R. during the mental test. At the .05 level of confidence the following were significant: EMG mental skill and resting G.S.R. and G.S.R. during the motor skill test and G.S.R. during the mental test.

Table 31, presented on page 88, indicates the zero order coefficients of correlation for the exercise control group. On the initial trial the following coefficients of correlation were significant at the .01 level of confidence: EMG during the mental skill and the resting G.S.R., G.S.R. during the motor skill test and the G.S.R. during the mental test; resting G.S.R. and G.S.R. during the motor skill test and G.S.R. during the mental skill test; G.S.R. during the motor skill test and G.S.R. during the mental test. At the .05 level of confidence the following relationships were significant: resting respiration and respiration during the mental test. On the final test trial the following coefficients of correlation were significant at the .01 level of confidence: respiration

TABLE 31

CORRELATIONS FOR THE DIFFERENT VARIABLES FOR THE EXERCISE CONTROL GROUP

	Resting EMG Motor	Resting EMG Mental	EMG Motor Skill	EMG Mental Skill	Motor Skill Score	Mental Score	Resting Respiration	Respiration Motor	Respiration Mental	Resting G.S.R.	Motor G.S.R.	Mental G.S.R.	Resting EMG Motor	Resting EMG Mental	EMG Motor Skill	EMG Mental Skill	Motor Skill Score	Mental Score	Resting Respiration	Respiration Motor	Respiration Mental	Resting G.S.R.	Motor G.S.R.	Mental G.S.R.
I Resting EMG Motor		.4252	.0168	-.0117	.2830	.0372	-.4012	-.2782	.1519	[illegible]	.3122	.3155	.1221	.3117	-.0075	.1353	.0838	.0545	-.3908	-.4109	-.2410	.2170	.2139	.2073
I Resting EMG Mental			.3687	.0317	.3199	.2723	-.1679	-.1069	-.2676	-.0524	-.0809	-.0733	-.2031	-.0875	.0445	-.1132	.1091	.2239	-.5785	-.4905	-.6229	.2732	.2756	.2732
I EMG Motor Skill				-.1659	-.0770	-.0370	.0134	-.0167	.0206	-.1069	-.1251	-.1161	-.1830	.2369	.1040	-.1733	.0635	-.2693	-.3065	.3666	-.1181	.3755	.3764	.3722
I EMG Mental Skill					-.3201	.0371	.0671	.2289	.3395	.7488**	.7354**	.7301**	-.0891	-.0863	.0251	.0970	-.1740	-.1568	.1176	-.0395	.1782	.1742	.1738	.1821
I Motor Skill Score						-.2702	-.0212	-.3949	.1613	-.3002	-.2071	-.2775	.3361	.0848	.0367	.1639	.5131*	.0523	.1197	-.2228	-.0797	-.1343	-.1375	-.1381
I Mental Score							-.5412	-.5731	-.1285	-.0212	-.0601	-.0735	-.0505	-.0887	-.3069	-.1687	.2632	.1057	-.2072	-.1240	-.1312	.2428	.2510	.2436
I Resting Respiration								.1448	.5715*	.2260	.2535	.2572	-.0418	-.1120	.1161	.0803	.0326	.1111	.6109*	.1690	.5275*	.2546	.2448	.2575
I Respiration Motor									.1372	.1190	.1296	.1180	-.1857	.0532	-.0321	-.1669	-.3923	-.1395	.1910	.2296	.3231	-.0487	-.6505	-.6482
I Respiration Mental										.5910	.4190	.4246	.1893	.1158	.1048	.1181	.1170	-.0842	.2419	.2241	.3838	.2857	.2767	.2870
I Resting G.S.R.											.9953**	.9981**	.1005	.0512	.1371	-.0523	.0201	-.0481	.1774	.1137	.3146	.3924	.3873	.3931
I Motor G.S.R.												.9906**	.1112	.0156	.1575	-.0339	-.0337	-.0438	.2024	.1231	.3424	.3792	.3736	.3798
I Mental G.S.R.													.1175	.0509	.1639	-.0416	-.0165	-.0365	.2056	.1260	.3332	.3937	.3850	.3913
F Resting EMG Motor														.6411*	-.1384	.1747	.5043*	-.2977	-.0945	-.1921	.0155	-.1922	-.1967	-.1991
F Resting EMG Mental															.1054	.3329	.2998	-.3836	-.3597	-.0252	-.0913	.1028	.1026	.0966
F EMG Motor Skill																-.2102	-.0203	.3452	.0852	.1732	.2377	.3392	.3374	.3461
F EMG Mental Skill																	.2521	-.0857	-.0557	.0319	.2144	.0154	.0111	.0120
F Motor Skill Score																		.0718	.2120	.2027	.0201	.2238	.2241	.2201
F Mental Score																			.1766	-.0965	-.1678	.3960	.3939	.3985
F Resting Respiration																				.5271*	.5563	-.0218	.0269	-.0200
F Respiration Motor																					.7110**	.3357	.3360	.3361
F Respiration Mental																						.0192	.0168	.0213
F Resting G.S.R.																							.9998**	.9999**
F Motor G.S.R.																								.9998**
F Mental G.S.R.																								

**p < .01
*p < .05

I = Variables on the Initial Test
F = Variables on the Final Test

motor and respiration during the mental test; resting G.S.R. and G.S.R. during the motor skill test and G.S.R. during the mental test; G.S.R. during the motor skill test and G.S.R. during the mental test. At the .05 level of confidence the following coefficients of correlation were significant: resting EMG prior to the motor test and resting EMG prior to the mental test and motor skill score; resting respiration and respiration during the motor test. When correlating the scores from the initial test to the final test the following relationships were significant at the .05 level of confidence: initial motor skill score and final motor skill score; initial resting respiration and final resting respiration; resting respiration and respiration during the mental test.

The most significant coefficients of correlation in all three groups for the initial test trial, final test trial and the combination of the initial and final test trial were between the variables of resting G.S.R., G.S.R. during the motor skill test, G.S.R. during the mental test, and mental EMG and motor EMG.

Summary

Quantitative measures were collected on twelve variables on an initial test and six weeks later on a final test and then presented in narrative and tabular form. The data collected were treated by analysis of variance, two-factor mixed design with repeated measures on one factor.

The Duncan Multiple Range test and the Pearson Product-Moment correlation were also computed.

The results of the analysis of variance indicated that the measures that were employed to measure stress both before and after induced tension produced significant F values at the .05 level of confidence indicating that stress did occur as a result of the verbal threat. The analysis of variance indicated that there was a significant difference on the final trial on the resting respiration rate, respiration rate during the motor skill test, resting muscle action potential of the masseter, and mental test scores. When computing the Duncan's Multiple Range test between the group means for those variables that were significantly different on the final test, the relaxation group was found to be performing significantly "better" than the placebo control group and the exercise control group.

Coefficients of correlation were computed to determine if there was a significant relationship between the variables on the initial test, final test and between the initial and final test scores. In all three groups there was a significant relationship at the .01 level between the resting G.S.R., the G.S.R. during the motor skill, and the G.S.R. during the mental skill, the EMG during the motor skill and the EMG during the mental test. No other correlational relationships were found to be significantly greater than zero in all three groups.

Chapter V contains a discussion of the results relative to the hypotheses of this study along with conclusions and recommendations for future studies.

CHAPTER V

SUMMARY, FINDINGS, CONCLUSION, LIMITATIONS, DISCUSSION AND RECOMMENDATIONS

Introduction

The present chapter is a review of the study with the hypotheses presented and discussed. A conclusion to the study is drawn, and recommendations for future studies are suggested.

Summary

Neuromuscular relaxation is a learned skill that requires a kinesthetic awareness of residual muscle tonus. Jacobson and others have indicated that the skill of relaxation demands many hours of concentration before a learner can progress from conscious relaxation to situations where relaxation becomes habitual. It is believed that a person who has identified the amount of tension necessary to perform a given task may be better prepared to voluntarily control neuromuscular tension than one who is not successful in recognizing muscle tension.

The purpose of the present investigation was to determine the relationship between the ability to relax and changes in the performance of a selected motor skill and a mental skill during induced tension. The skills used were dart throwing for the novel motor skill and the recall of random numbers for the mental task. It was hypothesized that subjects who were capable of controlling neuromuscular tension could reduce tension during the performance of the selected skills to a greater extent than subjects who had not learned to control neuromuscular tension; therefore, the subjects would perform the selected skills better than those subjects not trained to control neuromuscular tension.

Evidence of conflicting results is reported in the related literature concerning the influence of relaxation and induced tension upon the performance of mental and motor tasks. Some of the findings concerning relaxation and neuromuscular tension were based upon subjective ratings by the subjects or by an investigator, which makes a valid interpretation difficult. Those investigations which employed instruments for measuring muscle action potential by mechanical means have found that neuromuscular tension can be decreased by specific instructions in techniques of relaxation.

Jacobson (29) was one of the earliest investigators to indicate that an individual could be taught to control neuromuscular tension and that an excess of tension could interfere with the subject's level of performance. Lyons and Lufkin (34:663) found that ten lessons extended over a period of five weeks was the minimum necessary for learning the skill of relaxation. Bensen (4), Roney (43), Evans (20) and Haverland (22), in independent studies, concluded that reducing neuromuscular tension allows individuals to perform better in a variety of tasks than those individuals who are not able to control neuromuscular tension.

Studies utilizing induced tension have similarly resulted in disagreement concerning the effects of such tension upon learning and performance in both mental and physical skills. Zartman and Cason (54:671), Freeman (21:146), and Duffy (17:535) found that induced tension did not facilitate mental performance, whereas Stauffacher (48:26) concluded that specific amounts of tension caused facilitation of learning. Russell (45:330) and Courts (10:235), in considering motor performance, found that induced tension did not facilitate performance. Russell (45:330) concluded that conditions of relaxation were superior to conditions of tension when performing a specific motor skill.

In the present study electromyographic techniques were used to measure muscle action potential in the triceps and masseter. Simultaneously a pneumograph measured the respiratory rate and the galvanic skin response was recorded to determine autonomic nervous system reaction to stress.

At the beginning of the experimental period all of the subjects were matched on the following variables: (1) score on the Standard Aptitude Test and/or the American College Testing Program, (2) score on the Taylor Anxiety

Test, (3) resting mean base level as recorded by electromyographic techniques, (4) mean neuromuscular tension level on the initial test of dart throwing, (5) mean neuromuscular tension level on the initial test of recalling nonsense sequence of numbers and (6) score on novel motor skill. The matched subjects were randomly divided into three treatment groups: an exercise control group received daily instructions in body mechanics, a placebo control group received a daily sugar tablet and a relaxation group received daily instructions in specific techniques of relaxation. At the end of a six week experimental period, a postest was administered which was identical to the pretest except for the influence of a verbal threat which was employed to induce tension.

Findings of the Study

The following findings were based upon the data obtained from the present study:

A. The verbal threat did produce stress in all three groups at the .01 level of confidence as measured by the galvanic skin response, pneumograph, and electromyographic techniques.

B. The relaxation group was able to control mental tension better than the placebo control group and the exercise control group when the subjects were exposed to a stressful situation. The difference between the groups was significant at the .05 level.

C. The relaxation group scored higher on the mental test under induced tension than did either the placebo control group or the exercise control group. The data were significant at the .05 level of confidence.

D. The exercise control group had a lower respiration rate during the influence of the verbal threat than did either the placebo control group or the relaxation group. The data were significant at the .05 level of confidence.

E. The experimental treatment that was given to the relaxation group did not have a significant influence in reducing neuromuscular tensions during the performance of the motor test, after the subjects were exposed to the verbal threat.

Discussion

The primary purpose of the study was to determine the relationship between the ability to relax and changes in the performance of a selected motor and a mental skill during induced tension. The hypotheses of the study are presented with a discussion of their meaning in view of the findings of the study.

A. There is no significant difference between the placebo control group, the exercise control group, and the relaxation group in their ability to throw darts accurately and to control neuromuscular tension during induced tension. The data indicated that relaxation instructions or general exercises were not contributing factors in reducing neuromuscular tension in the triceps and did not aid the improvement of performance of a novel motor skill. Based upon this study, the investigator failed to reject the hypothesis that there was no significant difference between the placebo group, the exercise control group, and the relaxation group in their ability to throw darts accurately and to control neuromuscular tension during induced tension.

B. There is no significant difference between the placebo control group, the exercise control group, and the relaxation group in their ability to control neuromuscular tension and their ability to recall nonsense numbers accurately during induced tension. The results of the statistical analysis revealed that there was a significant difference between the groups in their ability to control neuromuscular tension in the masseter and in their ability to recall nonsense syllables on the final test. When analyzing the data further, the statistical treatment revealed that the relaxation group was the group that was performing differently from the other two groups on the final mental test under induced tension. The study indicated that the relaxation treatment was the significant factor that enabled the subjects in the relaxation group to control neuromuscular tension as determined by a lower muscle action potential of the masseter than that of the other two groups. The final mental test scores revealed that the relaxation group performed better on the mental test than did either the placebo control group or the exercise control group. Therefore, the hypothesis that specific instructions in techniques of relaxation can lower the muscle action potential of specific muscles and in turn enable the individual to control muscle tension when placed in a stressful situation was supported. The investigator rejects the hypothesis that there was no significant difference between the placebo group, the control group, and the relaxation group in their ability to control neuromuscular tension and their ability to recall nonsense numbers accurately during induced tension.

Conclusion of the Study

It was concluded that subjects trained to relax and to control neuromuscular tension perform in a superior fashion on mental tasks under induced tension than do subjects not trained in techniques of relaxation. There was no statistical difference found between the groups on the novel motor skill which would indicate that the relaxation treatment was of no significant value in the performance of a novel motor skill test.

Limitations of the Study

The present study was subject to the following limitations:

A. The novel motor skill that was used in the study was dart throwing for accuracy. This skill was selected because most college women are not highly skilled in dart throwing; the skill allowed each subject to be connected to several pieces of equipment while they were performing the skill and the results could be quantified. It is surmised that the skill of dart throwing performed once at the beginning of the study and once again at the end of the study did not really allow for any skill to be exhibited and thus the performances were random in nature and could not illustrate superior abilities for any treatment. It may also be that the skill of dart throwing was not of sufficient importance for the college women subjects to desire more than a minimum level of performance on the final test when tension was induced by the verbal threat.

B. The verbal threat that was employed in the study was a possible limitation. The threat did produce measurable stress in all three groups. Even though the threat did produce stress, perhaps the threat was not great enough to interfere with the skill of dart throwing. A different stressor may be desirable.

Recommendations for Future Studies

The following recommendations are suggested for additional investigation:

A. Determine if there is any difference between the ability to relax and control muscle tension after specific instructions in techniques of relaxation in the highly skilled athlete while tension is being induced.

B. Conduct a study similar to the present one but select several novel motor skills to determine if the subject responds similarly in different motor skills under induced tension.

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APPENDIX

MEANS OF RAW SCORES FOR RELAXATION GROUP ON THE PRETEST

Resting EMG Motor	Resting EMG Mental	EMG Motor Skill	EMG Mental Skill	Motor Skill Score	Mental Score	Resting Respiration	Motor Respiration	Mental Respiration	Resting G.S.R.	Motor G.S.R.	Mental G.S.R.
14	24	351	101	47	87	18	25	24	1200	1100	1075
9	125	1844	45	41	94	22	26	23	1500	1475	1400
0	52	213	79	31	81	24	29	22	900	885	890
0	0	564	373	16	93	22	28	22	1300	1260	1272
0	20	253	64	46	87	18	29	15	750	730	725
0	0	485	46	22	88	23	32	28	500	490	495
4	35	1195	145	66	79	21	36	21	1900	1880	1875
2	0	2512	75	28	90	21	31	21	550	567	572
0	12	2277	128	50	103	24	33	20	500	497	450
0	20	317	104	49	87	21	28	22	950	935	920
0	156	484	157	33	81	20	27	24	1400	1394	1397
0	55	312	86	4	89	20	25	20	1500	1485	1475
15	79	293	118	42	88	16	20	16	7000	6983	1880
9	50	482	96	48	91	16	26	17	540	545	552
2	0	152	187	28	70	26	28	24	4700	4650	4700
3	13	184	48	8	93	20	24	23	1100	1055	1045

MEANS OF RAW SCORES FOR RELAXATION GROUP ON THE POSTTEST

Resting EMG Motor	Resting EMG Mental	EMG Motor Skill	EMG Mental Skill	Motor Skill Score	Mental Score	Resting Respiration	Motor Respiration	Mental Respiration	Resting G.S.R.	Motor G.S.R.	Mental G.S.R.
0	0	207	74	13	97	24	38	26	1500	1458	1450
0	26	530	60	45	101	30	36	25	600	575	560
0	0	584	333	16	108	24	31	26	1000	965	955
4	4	331	40	30	108	31	30	27	700	680	685
2	3	510	45	39	86	28	36	32	700	688	680
21	9	1003	52	38	86	26	35	28	600	580	590
4	3	574	173	28	99	26	30	27	1200	1175	1187
0	0	2565	60	28	106	26	36	27	1000	950	980
0	0	660	26	38	99	28	36	32	750	735	745
8	4	536	60	30	110	36	36	26	900	890	885
0	13	280	53	47	87	22	30	26	900	640	550
0	0	592	63	32	86	25	37	30	1000	988	985
0	0	340	97	33	92	24	30	28	1000	955	970
6	4	500	39	29	100	20	26	25	450	435	448
2	6	548	99	46	82	27	34	30	500	470	485
0	0	610	37	37	106	28	33	30	600	555	575

MEANS OF RAW SCORES FOR PLACEBO CONTROL
GROUP ON THE PRETEST

Resting EMG Motor	Resting EMG Mental	EMG Motor Skill	EMG Mental Skill	Motor Skill Score	Mental Score	Resting Respiration	Motor Respiration	Mental Respiration	Resting G.S.R.	Motor G.S.R.	Mental G.S.R.
16	18	306	200	37	71	25	22	21	1000	980	972
55	30	118	16	20	80	27	29	22	1000	950	965
5	3	154	33	13	84	25	30	21	1300	1265	1270
0	23	408	287	57	74	22	30	23	2300	2230	2260
0	15	408	71	20	76	22	29	20	900	880	895
0	17	443	81	28	13	22	34	19	1750	1730	1725
0	13	267	121	18	88	22	33	21	1200	1180	1190
0	48	307	135	40	89	20	30	16	550	540	535
0	30	428	86	50	97	26	27	20	500	490	485
0	50	1411	61	16	79	20	23	25	3400	3350	3300
0	77	348	115	18	82	23	29	30	600	580	590
8	20	537	67	15	110	15	22	22	1100	1050	1040
0	29	532	141	5	89	15	22	22	550	535	538
32	21	217	204	53	91	24	29	28	1210	1200	1200
5	36	191	70	42	78	20	22	21	600	582	590
7	27	344	579	17	92	20	29	20	4400	4590	4380

MEANS OF RAW SCORES FOR PLACEBO CONTROL GROUP ON THE POSTTEST

Resting EMG Motor	Resting EMG Mental	EMG Motor Skill	EMG Mental Skill	Motor Skill Score	Mental Score	Resting Respiration	Motor Respiration	Mental Respiration	Resting G.S.R.	Motor G.S.R.	Mental G.S.R.
72	48	506	66	47	70	21	44	25	550	522	522
2	585	314	325	58	81	23	36	27	1000	988	985
0	30	596	43	30	71	26	32	31	900	850	855
252	60	844	78	74	75	21	28	26	600	500	510
0	18	360	61	50	75	25	33	29	900	875	865
77	51	243	60	38	82	32	37	35	500	488	480
14	89	375	93	48	78	24	35	29	1000	980	980
0	91	567	110	37	88	23	33	22	500	475	460
8	39	482	77	44	82	30	44	28	200	192	180
0	35	558	52	35	66	28	47	30	1900	1875	1880
0	254	306	152	57	53	22	28	35	500	400	420
15	32	422	78	41	108	22	28	22	600	550	600
126	27	602	102	30	104	22	30	26	600	573	585
0	40	298	103	37	88	27	30	28	800	750	740
0	32	415	64	19	68	26	30	29	1500	1480	1475
7	49	320	82	37	85	24	32	28	2600	2550	2570

MEANS OF RAW SCORES FOR EXERCISE

CONTROL GROUP ON THE PRETEST

Resting EMG Motor	Resting EMG Mental	EMG Motor Skill	EMG Mental Skill	Motor Skill Score	Mental Score	Resting Respiration	Motor Respiration	Mental Respiration	Resting G.S.R.	Motor G.S.R.	Mental G.S.R.
9	75	2042	96	38	86	22	24	23	1200	1100	1150
6	20	249	120	42	64	26	28	27	1000	1090	1092
11	48	242	86	48	75	17	26	19	750	735	730
16	30	361	314	40	81	20	28	28	550	545	548
0	16	271	52	26	71	24	33	20	700	690	682
2	47	257	128	24	90	16	24	18	200	180	175
9	41	2811	82	28	67	19	30	22	400	392	390
69	91	859	133	59	73	13	26	20	600	595	597
0	36	443	52	19	75	22	30	22	550	545	542
10	24	266	103	42	84	20	26	19	1250	1220	1225
0	28	236	83	20	86	12	27	18	220	207	215
61	25	388	62	39	77	18	26	26	1800	1770	1775
60	42	953	90	16	82	18	27	22	1900	1890	1870
17	41	241	988	13	77	21	30	25	3600	3450	3400
6	20	249	120	42	64	26	28	27	1000	1090	1092
9	27	210	192	30	71	20	28	22	1400	1380	1325

MEANS OF RAW SCORES FOR EXERCISE

CONTROL GROUP ON THE POSTTEST

Resting EMG Motor	Resting EMG Mental	EMG Motor Skill	EMG Mental Skill	Motor Skill Score	Mental Score	Resting Respiration	Motor Respiration	Mental Respiration	Resting G.S.R.	Motor G.S.R.	Mental G.S.R.
0	63	1151	99	51	94	20	30	22	2000	1980	1980
0	53	2246	71	31	92	26	32	30	1000	980	995
142	30	515	116	49	73	21	29	28	400	390	390
244	76	474	183	45	83	22	30	27	1200	1185	1185
0	50	455	63	26	76	23	28	25	1000	985	980
6	23	666	46	20	92	20	24	23	300	290	297
0	72	640	62	24	59	20	33	27	600	585	580
34	53	654	96	27	87	18	20	20	700	680	678
0	48	914	55	30	92	21	28	25	600	575	585
0	29	192	83	49	91	29	33	28	800	780	775
6	64	388	70	25	78	20	28	22	400	395	390
546	118	753	120	50	73	20	26	25	600	575	570
0	38	816	80	20	93	20	31	27	1700	1680	1670
0	43	818	45	23	75	23	28	27	1100	1080	1095
171	31	440	140	23	80	25	28	26	300	260	285
0	65	654	183	17	80	20	29	29	700	680	685

STUDENT PRETEST DATA CARD

Name____________________ Social Security No.__________ Dorm__________

Group__________ Pretest Novel Motor Score__________ Respiration Rate__________

Pretest Novel Mental Score__________ G.S.R.__________

Resting EMG	Novel Motor Skill EMG		Resting EMG	Novel Mental Skill EMG	
Mean:		Mean:	Mean:		Mean:

STUDENT POSTTEST DATA CARD

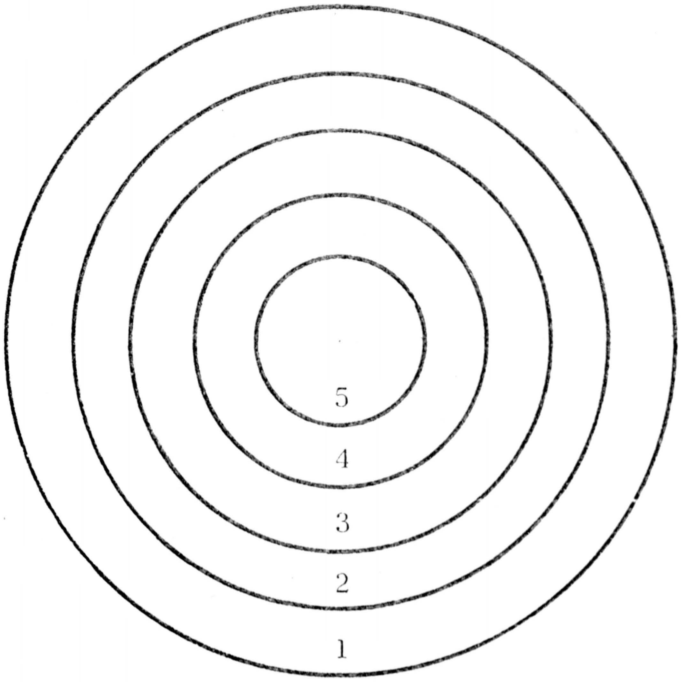
Name____________________ Social Security No.__________ Dorm__________

Group__________ Postest Novel Motor Score__________ Respiration Rate______

Postest Novel Mental Score__________ G.S.R.__________

Resting EMG	Novel Motor Skill EMG		Resting EMG	Novel Mental Skill EMG	
Mean:		Mean:	Mean:		Mean:

DART TARGET FOR NOVEL MOTOR SKILL



Scoring:

5 = 5 points
4 = 4 points
3 = 3 points
2 = 2 points
1 = 1 point

PRACTICE CARDS OF RANDOMIZED NUMBERS

1	7	4	2	8	3	6	0

9	2	8	4	1

3	2	7	8	4	0	6

2	7	5	3	8	6	7	1	0	6

8	1	0	6

8	2	5	4	9	7	0	1

4	7	5	9	3	2

8	3	7	5	1	0

PRETEST RANDOMIZED NUMBER TEST

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

POSTTEST RANDOMIZED NUMBER TEST

3	2	7	8	9	5	1	0

6	3	1	2	0

9	2	0	1	8	7	5	3	6

7	8	3	2	1	5

6	7	8	3	1	5	2	9	0	4

3	6	0	2	9

1	8	4	5	3	2	9

5	0	2	7	9	6	8	6	0	1

9	5	1	3	2	8	6	0

7	5	3	0	1

8	3	1	0	6	4

8	6	4	1	0	2	8	5	3

3	8	5	7	4	0	1

3	2	8	5	0	8	1	7	2

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

SCORE CARD FOR THE PRETEST RANDOMIZED NUMBER TEST

Name____________________ Group____________________

Score____________________

1. 473198
2. 02758139
3. 309526
4. 52614
5. 7821052
6. 81206582
7. 961098236
8. 108294765
9. 495380267
10. 40632104869
11. 70126
12. 7839230162
13. 10824
14. 628735806251
15. 4731905

SCORE CARD FOR THE POSTTEST RANDOMIZED

NUMBER TEST

Name______________________ Group______________________

Score______________________

1. 32789510
2. 63120
3. 920187536
4. 783215
5. 6783152904
6. 36029
7. 1845329
8. 5027968601
9. 95132860
10. 75301
11. 831064
12. 864102853
13. 3857401
14. 328508172
15. 683506243912