A STUDY OF THE EFFECT THAT THE CONTROL OF MUSCULAR TENSION HAS ON THE LEARNING OF A NOVEL GROSS MOTOR SKILL

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We hereby recommend that the thesis prepared under our supervision by Marjorie C. Paben entitled "A Study of the Effect That the Control of Muscular Tension Has on the Learning of a Novel Gross Motor Skill"

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CHAPTER I

ORIENTATION TO THE STUDY

Introduction

A goal of physical education is to teach man to use his body in a way that contributes maximally to his health and well-being. This goal involves movement which can only be accomplished by the control of specific degrees of muscular tension. Steinhaus (34:3) states that muscular control, referring to the ability to distinguish between tension of the muscles that are necessary for an activity and of those that are not necessary, will separate the skillful athlete from the clumsy one. It is logical, therefore, that teaching a student to relax his muscular system properly is an important part of physical education. A tense muscle, characterized by non-resiliency or inelasticity, exhibits itself especially when one is in motion (29:27). According to Broer (3:375), unnecessary tension interferes with the smooth sequence of muscular action essential in coordinated movement. De Vries (11:51), in supporting this position, states that a decrement in performance may occur when nervous overflow results in the innervation of synergistic muscles.

Those who have used muscular tension control in research define this term as an accomplishment that ultimately results in a reduced level of tension in the skeletal musculature (34:3). Scientific relaxation is a process of disciplined neuromuscular learning (18:42).

Edmund Jacobson, a Chicago physician, is credited with many of the significant contributions to the history of tension control programs. Jacobson's methodology has been a source of reference to the medical and psychological literature since his initial research at Harvard in 1908 (18:43). During World War II the success of Jacobson's program of progressive relaxation was noted when 15,000 Naval Air Cadets were trained to combat nervousness exhibited by pilots during flight (18:43). The inclusion of a tension control program into the regular curricula of an educational system was initiated at Beloit College in 1960 (18:43). Cosmo A. Cosentino began a similar tension control project in 1961 at an elementary school at Chicago Heights, Illinois (18:43). The success and ease of training the children have helped contribute to the growth and interest in tension control programs.

True relaxation in any muscle results in a complete absence of all contractions. Nerves to and from truly relaxed muscles are completely inactive (24:84). Normal activities, such as breathing, talking, and walking, employ complicated tension patterns in many muscles (24:95). To do away with tension permanently would result in doing away with living; therefore, the real purpose of muscular relaxation programs is to be able to control the amount of muscular tension and/or the degree of muscular relaxation in a volitional manner (24:95). Rathbone (28:514) states that no one should be better prepared to teach conscious relaxation than the physical education instructor, who understands the muscles. No one should be more anxious to relieve tension because the teacher of physical education is interested in motor skills and total health.

Statement of the Problem

The proposed investigation entailed the comparison of learning a novel gross motor skill by an experimental group and a control group comprised of fifteen subjects each. The novel gross motor skill involved the use of a ball attached to a paddle and the non-dominant arm. The experimental group learned to control muscular tension, measured by quantitative electromyography, in the wrist and forearm flexors and extensors. The comparison was made on the basis of achieving a preselected level of ability. On the basis of the statistical findings a conclusion was reached, stating whether general control of muscular tension aids in learning a specific gross motor skill.

Definitions and Explanation of Terms

For the purpose of clarification, the following definitions and/or explanation of terms are stated below in the manner in which they are used throughout this study:

A. Relaxation: " . . . is a neuromuscular accomplishment that results in a reduction of tension in the skeletal musculature (34:3)." Relaxation was measured through quantitative electromyographic techniques.

B. Tension: " . . . is overt muscular contraction caused by emotional state or by increased effort (9:168)."

C. Electromyograph:

> . . . an instrument which measures and records muscle action potentials. It is basically an amplifier which receives current conducted from electrodes (22:577).

Quantitative electromyography, the technique used in this study, involves the integration of electrical potentials electronically and the conversion of the analogue recording to a digital readout.

D. Gross Motor Skill:

> . . . patterns of body movement involving complex motor coordination which achieves desired results with minimum expenditure of physical energy. . . . gross motor skills refer to those related to large muscle activity (4:365).

E. Novel Skill: A new gross motor activity. One that has either never been previously performed, or one that has been rarely performed so that the initial performance level is equal to the performance of those who never have executed the activity.

F. Learning:

> Learning is the process by which an activity originates or is changed through reacting to an encountered situation, provided that the characteristics of the change in activity cannot be explained on the basis of native response tendencies, maturation, or temporary states of the organism (e.g., fatigue, drugs, etc.) (2:2).

Purposes of the Study

The general purpose of the study was to determine the effect that the control of muscular tension had on the learning of a novel gross motor skill. Specifically the investigator proposed to:

A. Develop a program designed to enable selected subjects, the experimental group, to control the degree of muscular tension in the wrist and forearm flexors and extensors of the non-dominant arm. The degree of muscular tension control was measured by means of quantitative electromyography.

B. Test the hypothesis that there will be no difference between the experimental group and control group used in this study in their achievement of a preselected level of ability in a novel gross motor skill.

Delimitations of the Study

The proposed study was subject to the following delimitations:

A. Two groups of women volunteer subjects were comprised of fifteen each. These subjects were unskilled and did not have experience in tournament play in any of the racket sports.

B. The experimental group and the control group were equated through random selection from the thirty volunteer subjects.

C. The experimental group participated in the muscular tension control program.

D. Both groups did not practice the novel gross motor skill outside the designated learning sessions.

E. The measurement of muscle action potential was dependent upon the investigator's ability to obtain valid and reliable electromyographic recordings.

F. The selection of the novel gross motor skill involved the use of a ball attached to a small paddle. The skill is based upon upward and/or vertical contacts of the ball to the paddle.

G. Time for each trial session was selected upon the basis of fatigue and desirable motor learning procedures for simple motor skills. This time for each trial was selected by means of preliminary testing.

H. Selection of the achievement level of the novel gross motor skill was made upon the basis of preliminary testing.

I. Data determined the learning ability of the novel gross motor skill by the experimental group and control group.

Summary

Present literature reveals that the use of tension control programs in the field of physical education is relatively new. The purpose of this investigation was to study the effect that the control of muscular tension had on the learning of a novel gross motor skill. The gross motor skill was the use of a paddle-ball apparatus.

In Chapter I, information was presented that related to the potential value of muscular tension control and movement efficiency. Definitions and/or explanation of the terms, purposes of the study, and the delimitations of the study also were included in this chapter.

Chapter II reviews research reports and studies related to the present investigation.

CHAPTER II

RELATED LITERATURE

Introduction

The physical educator, like all educators, is always searching for new or better teaching techniques to enhance the process of learning. The curriculum of physical education as stated by Frederick (18:42) evolves around the efficiency of movement and what this efficiency means to the individual. Frederick (18:42) further states that our total concern is not only movement, but non-movement as well. Cary (5:220) continues this concept by saying that participants in athletic activities should be taught how to use only those muscles needed as well as how each motion contributes to the total task of which the muscles are a part. Training for a more economical use of the body, such as in physical education, should emphasize the recognition of muscular tension and methods of relaxation. Such an emphasis frequently produces a realization of a student's ability to produce contraction in some muscles while releasing others. The lack of ability to maintain a partial relaxation when not in motion results in unnecessary motion, in a loss in the accuracy of movement, and a loss of timing in the physical involvement of participation (5:220).

Kinesthetic Perception

The skeletal musculature, comprising forty to forty-five per cent of the body weight, is both sensory and motor in function (34:4). Fibers in the muscles carry impulses from sense organs. The sensory fibers appear in Pacinian corpuscles, free endings, and muscle spindles, which along with tendon organs, respond to stretch or tension. Together, these sense organs create muscle sense known as proprioception or kinesthesia (34:4). The muscle spindle is able to adjust its sensitivity to tension by the shortening or lengthening of slender intrafusal muscle fibers found in the spindle. Stimulation is received by these intrafusal fibers from gamma nerve fibers that belong to a small fiber motor system, separate from large alpha motor fibers. Impulses, generated by pressure or tension in the muscle, pass over large sensory fibers into the spinal cord, where numerous connections are made. Those connections or fiber tracts ascend to the thalamus and activate neurons that carry impulses to the cortex. In the cortex, the tension sensations are perceived, localized, and interpreted. Also at this level, the perceptual experiences provide information concerning weight, movement, resistance, and depth discrimination.

The nerve impulses from a tense muscle, upon their entrance to the cord, may facilitate cell bodies of a variety of neurons that originate at this level of the spinal column. Impulses interpreted as pain are thus relayed. In comparison, a relaxed muscle carries no facilitory impulses, which in turn account for a lower sensitivity to pain. Therefore, the stimulation of the sense organs in a relaxed musculature is reduced (34:9). The facilitating effects of the source are reduced, initiating a decrease in nerve center activity. All activity under the influence of the nervous system is then progressively reduced.

Studies in Relaxation and Tension

Relaxation, analyzed by Steinhaus (34:3), is a neuromuscular attainment resulting in a reduction of tension in the muscular structure of the skeleton. Relaxation in relation to activity means operating at maximum efficiency with minimum effort (5:220). Cary (5:221) indicated that tension results in lost motion and awkward, inaccurate reactions. Similar conclusions were made by Ryan (31:113) when he tested college students on a motor learning task that involved balancing on the pivoted platform of a stabilometer. Ryan concluded that increased tension impaired performance of a difficult motor task, but the rate of learning was independent of the state of tension for either difficult or easy skills.

Gregg (20) undertook a study to determine whether changes in generalized tension accompany change in proficiency of psychomotor tasks. Two experiments were used, both of which employed an arm-hand steadiness task and a tapping-aiming skill used to evaluate the difference. One of Gregg's experiments involved subjects practicing both tasks for five consecutive days. A second experiment by Gregg attempted to produce a decrement in the proficiency of the performance on the psychomotor tasks by requiring the subjects to carry out work that would fatigue specific muscle groups. A high-gain biological amplifier was used to measure muscle-action potential. Gregg concluded that increases in generalized tension, as related to the steadiness task, appeared to accompany a performance decrement. In comparison, a decrease in generalized tension appeared to accompany an improvement in the tapping task.

Stauffacher (33) undertook a study concerned with the effect of varying degrees of induced muscular tension upon the rate of learning. Subjects were instructed to grasp weights suspended over pulleys. While supporting these weights, the subjects were to memorize non-sense syllables and reproduce them by spelling. There were four conditions of muscle tension: (1) no tension; (2) one-forth tension; (3) one-half; and (4) three-forths tension. Although the results were not significant, Stauffacher found that a certain amount of muscular tonus causes a facilitation of learning. The increase in learning occurred when the amount of tension was somewhere around one-half of the subjects' maximum point. Lesser or greater amounts gave little or no facilitation.

Research conducted by Courts (8) and Freeman (17) also indicated that the more complex the performance or skill, the earlier tension will show inhibitory effects. Easier tasks were found to be facilitated with tension. Forest (15) conducted a study in which he used electromyographic readings of ten subjects while they performed simple postural variations. One channel of an electromyograph was attached to the right forearm one-half the distance between the lateral humeral epicondyle and styloid process of the ulna, while the other channel recorded from above and below the point of the chin. Forest concluded that a deceleration in the rate of work output was associated with an increase in tension.

Russell (30) undertook a study in which he concluded that a condition of relaxation is superior to a condition of tension with respect to accuracy of tossing balls at a designated target. Lazaras, Deese, and Osler (26) indicated that stress and anxiety in learning usually impair both verbal and perceptual motor performances. Similar results were found in research conducted by Bean (1), who implied that subjects tested under stress conditions will require more trials to reach a criterion of mastery and will make more errors during the memorization of non-sense syllables.

Haverland (21) studied the effects of relaxation upon certain aspects of motor skills. Subjects were divided into three groups, each of which was assigned a different treatment. The control group received no experimental treatment, while the conditioning group received training in Danish gymnastics for forty minutes twice a week. The third group received instruction in the Jacobson technique of relaxation twice a week for forty minutes. Tension measurements were recorded by the electromyograph. Haverland concluded that there were significant differences between the means of changes in performance of the three groups. It was also found that relaxation techniques, as suggested by Jacobson, may result in improved performance in certain areas of motor skill involving smooth, coordinated, precise movements.

As seen by the previous studies, many results have pointed out that tension inhibits performance to a degree. But, other studies, such as the one conducted by Freeman (16), revealed that certain levels of tension act as a factor that contributes to the facilitation of mental work. Freeman also adds, though, that it may become an inhibitor of precise performance. A similar conclusion was developed by Castaneda and Lipsitt (6), who stated that stress facilitated performance with respect to the learning of simple light-switch combinations.

Howell (23) employed a relatively simple motor task involving an arm movement in hitting a ball, reversing the direction to touch a key, and hitting a second ball. Howell concluded that the group given electric shock to produce tension and motivation exhibited a significantly greater increase in speed of motor performance.

Duffy (13) undertook a study to determine the relationship between the quality of a performance and tension of selected muscles in children. Graphic records were taken of the pressure upon dynamographs held in the hand during discriminative reactions to three kinds of pictures, one of which the subject was to respond to by closing a reaction key. Duffy concluded that an increase in skeletal muscular tension appears to represent an increase in excitation, caused from any type of stimuli. The more motivated an individual becomes or the more difficult the situation tends to be, the greater the muscular tension or the subjects' effort to adjust. Findings of this experiment, too, revealed that high degrees of muscular tension were found to be associated with a performance of poor quality. It was assumed that high tension tends to be disruptive and that very low tension probably is characterized by lack of alertness or effort.

Evans (14) investigated the influence of relaxation techniques upon the level of tension in college women before and after activity in physical education classes. Evans concluded that the average college student may be taught to recognize fatigue due to hypertensions and to utilize methods of reducing its effects.

Lyons and Lufkin (27) designed a study to determine by means of electromyography whether ten lessons in relaxation, spaced over five weeks, would significantly lower the muscular tensions of college women. Twenty-eight different sets of muscles were included during the ten fifty minute lessons. The increase in relaxation was measurable but not to a significant degree.

Studies in Electromyography

Many studies have used the electromyogram in testing muscle action potential in various areas of the body. Gardner and O'Connell (19) prepared an informative paper to explain the use and operation of the electromyograph which records electrical changes occurring in the muscle immediately prior to and during contraction. Close, Nickel, and Toss (7:1221), in questioning the validity of electromyographical readings when applied to the measuring of muscular tension, assert that a numerical readout of action potentials, with established threshold values, adds significantly to the information gained from a conventional electromyogram, for use in muscle-function analysis and locomotion studies. The aggregate action-potential count of a contraction would then be more likely to be proportional to the work performed by a muscle (7:1207). Wilcott and Geeken (36) concurred with these conclusions when they disclosed an essentially linear relationship between the force of muscle pull and the integrated mean of the electromyograph for female subjects, with a slightly curvilinear relationship for male subjects.

Jacobson (25) undertook a study to investigate periodic variability of tension in college women, using the electromyograph to determine the degree of tension. Jacobson hypothesized that there would be a difference in the range of variability in the tension of two groups of subjects classified according to high tension and low tension. Prime muscle movers of the neck, shoulder, elbow, hip, and knee were tested. Jacobson concluded that the high tension group varied in tension more significantly than the low tension group.

Summary

The cited research has shown that tension does affect performance and learning in various ways, depending upon the skill, whether mental or physical, and the conditions under which the task is being performed. The consensus favors the view that a complex skill may be inhibited by muscular tension and that an easy task may be facilitated. When tension becomes detrimental, the individual probably has the capability to recognize this tension and in turn can attempt to eliminate and/or reduce its effects. Methods of relaxation have been shown to alleviate negative results of muscular tension, especially when such tension becomes inhibitory.

In measuring or recognizing tension, the electromyograph has become an important instrument although its validity is still undergoing much research. Electromyographical studies have indicated that tension produced by a muscle during voluntary contraction is proportional to the electrical activity of that muscle. A linear relationship between the force of muscle pull and the integrated mean of the electromyograph for female subjects is purported to exist by several investigators.

Chapter III will present the procedures followed in the development of this investigation.

CHAPTER III

PROCEDURES OF THE STUDY

Introduction

The present investigation sought to determine the effect that the control of muscular tension had on the learning of a selected novel gross motor skill. Quantitative electromyography was utilized in distinguishing the extent of muscular relaxation. The study entailed the use of two groups, each comprised of fifteen college women. The experimental group was given instruction in relaxation and tension control while the control subjects were given no instruction in either of these areas. Both groups were then given the paddle-ball apparatus, the instrument used in the selected novel gross motor skill, and were instructed to reach a criterion level of performance as determined by a pilot study.

Preliminary Procedures

Information was surveyed, studied and assimilated from available documentary sources of data pertinent to all phases of the study with special emphasis upon techniques of relaxation, tension control and electromyography. A review of literature revealed many opinions as to the relationship of tension and of relaxation to learning and motor performance. It was decided to confine this investigation to specific muscle groups related to the skill and to concentrate on muscular relaxation and tension control of these areas only.

Instrumentation for the Relaxation and Tension Control Programs

Equipment utilized in this study consisted of an Integrating Bioelectric Monitor, electronic counter, Oscilloscope, Audio-Frequency Function Microvolter, Low Frequency Function Generator, and Biopotential Skin Electrodes. The monitor is a voltage-measuring instrument with changeable gains and band widths which make it adaptable to any AC bioelectric phenomena. The electromyographic monitor included a built-in ohm meter, calibration signal, and an audio output to feedback the level of muscle activity of the subject. The monitor setting used in this study was as follows: High Pass hz, 10k; Low Pass hz, 1.0; and Full Scale, 1.0. In order to eliminate any auditory cues the audio output was not used. The E & H Instrument Company produced the Biopotential Skin Electrodes that were employed in the testing of each subject.

The Low Frequency Function Generator and Audio-Frequency Microvolter were used to calibrate the monitor. The EMG monitor was calibrated each day prior to the teaching session and immediately following the testing session.

The oscilloscope, connected to the monitor, was useful in presenting a visual representation of muscular activity and, more specifically, in observation for any artifacts that might occur. The counter displayed measurements on a four-place neon column readout.

Before the electrodes were applied, the area over the muscle group being tested was cleansed with alcohol and abraded with sandpaper. The adhesive collars were applied to the electrode which was then filled with the electrolyte gel. The electrodes were placed over the muscle group, in accordance with Davis (10), with the ground electrode being placed on the dominant arm near the wrist bones.

The impedance of the subject was then tested with the value recorded for a one-second period. All subjects had to have less than 500 ohms impedance before testing continued. The oscilloscope was checked for artifacts during the impedance measurement.

Selection of a Novel Gross Motor Skill

The skill selected was to be one that had never been previously performed or one that had been rarely performed so that the initial performance level was equal to those who never had executed the activity. It was also decided that the non-dominant hand would be used to help insure novelty. The paddle-ball was selected and approved by the thesis committee as appropriate for the study.

Selection of Muscle Groups

The muscle groups tested were selected flexors and extensors of the wrist and forearm. On the basis of kinesthetic analysis the wrist and forearm flexors and extensors were found to be of major importance in the performance of the paddle-ball apparatus by the non-dominant arm of the subject.

Selection of Subjects

The subjects for this investigation were thirty volunteer students enrolled in physical education classes during the first summer term of the 1967-1968 school year at the Texas Woman's University. The subjects accepted for the study were unskilled and had no prior experience in tournament play in any of the racket sports. The Table of Random Numbers was used to select students for either the experimental group or the control group. An initial test was given to all of the subjects for the purpose of determining the homogeneity of the group by means of Bartlett's Test of Homogeneity (12:275). The test of homogeneity of variance was calculated for both the number of trials and the number of total hits during the initial test session. The homogeneity of variance demonstrated that both groups were equal in a population represented by the sample.

Development of Relaxation and Tension Control Program

The objectives of a program in muscular tension control were established. They entailed:

A. The development of an awareness of muscular tension in the forearm and wrist flexors and extensors.

B. The development of a skill in releasing tension, therefore, making relaxation easier.

C. The development of an ability to produce specific amounts of muscular tension upon request as measured by quantitative electromyography. The amounts of muscular tension requested in all cases were forty per cent and twenty per cent of the subjects' maximal tension point. These percentage values of the maximum tension each subject could attain were selected empirically with the consent of the thesis committee.

Specific procedures used in the relaxation program were set up, paralleled to those employed by Jacobson (24:76). Each session of the program was comprised of fifty minutes, with each subject in the experimental group having at least five periods of work.

During the first two periods, the electromyograph, its auxiliary equipment and the program objectives were explained in detail to the subjects. The electrodes were attached to the non-dominant arm, and the subject was instructed to lie on her back with her eyelids closed. She was then asked to raise her non-dominant arm and clench her fist. During this phase the feeling of muscular activity throughout the entire arm was to be noted by the subject. The arm was allowed to fall limply, while the fingers were slowly uncurled. The tension and relaxation phases were repeated at least twice with the remainder of the measurement period used to try to obtain total electrical silence in the selected muscles as determined by the electromyograph. All four muscle groups were measured in this manner during the first two periods.

The beginning of the third period was devoted to rest. The subject was then, upon a signal, asked to tense the muscles in her arm as much as possible. This "all out" effort was continued for ten seconds and repeated three times. A maximum mean value was calculated, and forty per cent and twenty per cent of this mean value were determined to give standard potentials. The subject was then asked to tense the muscle slowly until the forty per cent standard potential was reached. The investigator gave commands to start and stop the activity. The subject was asked to concentrate on that point of tension when the signal "stop" was given. This procedure was repeated four times and constituted the practice trials. During the following four repetitions the subject was given the command to start and asked to give the signal "stop" when she felt she had reached the standard forty per cent tension level. This constituted the test trials. The practice and test trials were repeated three rounds for both the forty per cent and twenty per cent level of tension. The subject was considered to be successful in her attempt to reproduce the standard tensions if she was within ten per cent of the selected tension levels. The subject was asked to relax several minutes and at the conclusion of the period was asked to reproduce both selected tension levels without any practice trials. This complete procedure was repeated for the third and forth periods for all the muscles involved.

The fifth session was devoted to relaxation and the reproduction of the two standard potential amounts with few, if any, trials. When the subject was able to maintain, in the select muscles, a constant relaxation point that was within thirty microvolts of total electrical silence, and to accurately reproduce the standard potential measurements, she was ready to learn how to manipulate the paddle-ball apparatus, the use of which was the basis for the novel gross motor skill. During the learning period each subject was tested at least once in order to check relaxation level and the maintenance of muscular tension control.

Collection of Data

The control group and experimental group met separately during the learning periods. Each group was oriented to the mechanics and operation of the paddle-ball apparatus. The ball was to project upward from the paddle with a full extension of the connecting rubberband. Each hit or series of consecutive hits constituted a trial. The subject's partner was to record the number of hits for each trial completed during a time of one minute and forty-five seconds. This time period was determined by preliminary investigation as satisfactory to eliminate the effects of fatigue upon learning and performance. Cratty (9:154) states that a performance decrement does occur during sustained activity. Each subject performed with the same paddle-ball apparatus each session.

The control group met and practiced once a day for the one minute and forty-five seconds. The practice was both massed and distributed. The student practiced without rest for the time set for each session, with an interval between sessions. Singer (32:191) states that leading physical educators believe short, frequent performances are more profitable than long sessions crowded into a short time span. The subjects were instructed not to practice at any other time. One limitation was unavoidable in that the students began testing two days before a holiday period and continued practicing at home. This practice was recorded by the performers in the standard manner. Once they returned to the University, they met as a group until each had reached the criterion level.

The experimental group, upon completion of the relaxation and muscular tension control program, was allowed to begin its learning sessions. Massed-distributed practices of one minute and forty-five seconds in duration were arranged once a day. The group continued throughout the program utilizing the same piece of equipment and partner each time. The members of the experimental group were considered finished when they had reached the criterion level of mastery.

The criterion level was established at twenty consecutive hits. Preliminary research had been conducted in the criterion level of skill mastery with consideration given to the study by Trussell (35:342) on predicting success in learning a skill. Anyone who had reached or surpassed this point was considered to have learned the skill.

The data collected from each subject consisted of the total number of trials per session and the total number of hits per trial and per session, both up to the point of success in meeting the criterion level.

Analysis of Data

The data collected were treated in two different manners. The first treatment was concerned with the number of trials taken to meet the criterion level by both groups, while the second treatment dealt with the total number of hits taken to meet success by both groups. In both cases the data were totaled for each group with the mean, standard deviation and standard error calculated. Both treatments were subjected to a *t*-test to determine any significance of the difference in learning between the control and experimental groups.

Summary

In Chapter III the investigator presented the procedures followed in the development of the investigation. The selection of muscle groups, the novel gross motor skill, and the subjects were reviewed along with the procedures followed in the relaxation and muscular tension control programs as suggested by Jacobson. Operational procedures were discussed with respect to the EMG. The process of learning the novel gross motor skill was discussed in relation to practice sessions and mastery level. The data were analyzed in terms of the number of hits and the number of trials taken to meet the criterion level. A *t*-test of significance was used to evaluate the differences in learning and performance.

Chapter IV contains the presentation of the findings from the data collected.

CHAPTER IV

RESULTS AND ANALYSIS OF THE DATA

Introduction

The results and analysis of the data collected are presented in this chapter of the thesis. The interpretation of the data is presented in relation to the hypothesis that guided the development of this investigation. The hypothesis stated that there would be no difference in the achievement of a preselected level of ability in a novel gross motor skill between the experimental group and control group used in this study.

Analysis of Group Homogeneity

Table 1, page 29, illustrates the status of group homogeneity in relation to the total number of hits executed during the initial test of the novel gross motor skill. The number of consecutive hits for each trial was totaled for every subject in both the control group and the experimental group. The sum of the scores was subjected to Bartlett's Test of Homogeneity. The V value of .1307 did not approach the amount needed for significance at the .05 level.

TABLE 1

INITIAL TEST: TOTAL NUMBER OF HITS WITH RESPECT TO THE SIGNIFICANCE OF THE VALUE OF BARTLETT'S TEST OF HOMOGENEITY

Group	Number of Hits	V	df	P*
Control	352	.1307	1	n.s.
Experimental	341			

* V value required for significance with 1 df: .05 level = 3.81

The same procedure was followed in comparing the groups with respect to the number of trials taken by each subject during the initial test session, illustrated by Table 2.

TABLE 2

INITIAL TEST: TOTAL NUMBER OF TRIALS WITH RESPECT TO THE SIGNIFICANCE OF THE VALUE OF BARTLETT'S TEST OF HOMOGENEITY

Group	Number of Trials	V	df	P*
Control	349	.7625	1	n.s.
Experimental	348			

* V value required for significance with 1 df: .05 level = 3.81

Data Analysis

Data of the subjects' ability to learn the paddle-ball apparatus were collected. Both the number of consecutive hits per trial and the number of trials performed to reach the criterion level of mastery were recorded. These data are recorded in the appendix, page 39. Table 3, depicts the total number of consecutive hits performed by the subjects in both groups to reach the criterion level. The scores of each subject were totaled and added to either the control group or the experimental group. The mean of each total group score was calculated as was the standard deviation and standard error. The results were submitted to a *t*-test which yielded a *t* value of 4.21. This value was significant at the .01 level.

TABLE 3

SIGNIFICANCE OF THE DIFFERENCE BETWEEN THE TOTAL NUMBER OF HITS TAKEN TO REACH THE CRITERION LEVEL BY THE EXPERIMENTAL GROUP AND THE CONTROL GROUP

Group	Total Number of Hits	Mean	S.D.	S.E.	df	*t* value	
						t	P*
Control	10,554	703.6	133.65	34.53	28	4.21	.01
Experimental	9,115	607.67	100.34	25.92			

* *t* value required for significance with 28 df:
.05 level = 2.05
.01 level = 2.76

The mean and standard deviation were also calculated for the number of total group trials to reach the skill level of mastery. After a t-test was calculated, the t value of 6.41 was derived, as exhibited by Table 4. This score was also significant at the .01 level.

TABLE 4

SIGNIFICANCE OF THE DIFFERENCE BETWEEN THE TOTAL NUMBER OF TRIALS TAKEN TO REACH THE CRITERION LEVEL BY THE EXPERIMENTAL GROUP AND THE CONTROL GROUP

Group	Total Number of Trials	Mean	S.D.	S.E.	df	t value	
						t	P*
Control	4,297	286.5	76.55	19.78	28	6.41	.01
Experimental	3,291	219.4	64.95	16.78			

* t value required for significance with 28 df:
.05 level = 2.05
.01 level = 2.76

The results of the t-test by either process indicated that the relaxation and muscular control programs were of value in the success of reaching the criterion level of skill mastery. Uncontrollable variables were found to be as follows: the interruption of the skill learning by summer holidays, the inability of the experimental group to begin the skill learning at the same time as the control group, and the difficulty of combatting individual or daily tensions such as examinations and personal problems during the relaxation and tension control program.

Summary

The data of the present investigation were collected with regard to the number of trials and number of hits taken to reach a criterion level of skill mastery by subjects in a control group and an experimental group which experienced a program of relaxation and tension control. The mean, standard deviation, and standard error of each group total in trials and hits were calculated, and a *t*-test was performed to determine the significance of the differences between the scores of both groups in relation to the number of trials and the number of hits. Both calculations yielded a significant difference at the .01 level.

Chapter V will include a summary of the entire study. The finding and conclusion of the study will be drawn according to the results of the data analysis. Implications of the finding and recommendations for future studies will also be presented in Chapter V.

CHAPTER V

SUMMARY, CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS FOR FUTURE STUDIES

Summary of the Investigation

Movement is an essential part of living for all organisms. An objective of physical education is to develop efficient movement for effective living. Broer (3:375) states that the smooth sequence of muscular action, essential for coordinated movement, is interrupted by unnecessary tension. Many investigators, in studying learning and movement efficiency, have found that a decrement in performance is usually accompanied by excessive muscular tension. Other studies have shown that relaxation, when effectively applied, has resulted in an improved performance. In light of the probable effects of relaxation on performance, it was the purpose of the present investigation to study the relationship of relaxation and the control of muscular tension to the learning of a novel gross motor skill involving the use of a paddle-ball apparatus with the non-dominant arm.

The research design involved a control and an experimental group. The experimental group learned relaxation and muscular tension control in the wrist and forearm flexors and extensors as measured by quantitative electromyography. A comparison was made on the basis of achieving a preselected level of ability, twenty consecutive hits of the paddle-ball apparatus with the non-dominant arm. On the basis of the statistical findings a conclusion was drawn as to whether relaxation and control of muscular tension aided in the learning of the specific novel gross motor skill.

Finding of the Study

The hypothesis that guided the present investigation stated that there would be no difference in the achievement of a preselected level of ability in a novel gross motor skill between the experimental group and control group used in this study. This hypothesis was rejected.

Conclusion of the Study

As a result of the statistical findings of this investigation, it can be concluded that the program in relaxation and muscular tension control was of value in the learning of the novel gross motor skill, involving the use of a paddle-ball apparatus. The experimental group learned the novel gross motor skill quicker than the control group. The difference in the learning rate of the skill, favoring the experimental group as compared to the control subjects, was statistically significant.

Limitations of the Study

The following limitations were established with regard to the present investigation:

A. Summer holidays interrupted the design of the study in that it became necessary for the control group to follow the set learning procedures at home for four days. This meant that the actual practice by each control subject was not known by the investigator. Each subject recorded her own scores during this period. It is assumed that each subject followed the correct procedures.

B. The experimental group had not completed the relaxation and muscular tension control program in the expected time and, therefore, was not able to begin the learning procedures with the control group. The experimental group was thus four days behind the control group in learning the skill.

C. While conducting the relaxation and muscular tension control program, the investigator found it difficult to combat individual tensions which resulted from examinations and personal problems.

Implications for Physical Education

One of the stated purposes of physical education is to teach efficient body movement. The methods used to teach skills are varied and dependent on the student and teaching situation. It behooves the physical education teacher to experiment with various methods conducive to effective motor learning. The present investigation has shown a difference in learning a novel skill by two groups, one of which was exposed to a program in relaxation and muscular tension control. The tension control program aided in a quicker learning of a novel gross motor skill.

No one should be better prepared to teach a program of relaxation than the physical educator because of his knowledge of anatomy, physiology, and kinesiology, and his avowed interest in relieving tension. As a relatively new area of inclusion in the physical education curriculum, relaxation and muscular tension control suggest new horizons for efficient motor learning. Teachers of physical education should continue to explore this field and further determine its effectiveness in learning skills.

Recommendations for Future Studies

The following suggestions have been recommended for future investigation:

A. The effect of relaxation and muscular tension control upon the learning of a specific sports skill such as floating in the water.

B. The relationship of a student's skill in a specific sport to the learning of relaxation.

C. The effect of learning relaxation upon the academic achievement level of the student.

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APPENDIX A

TABLE 5

THE NUMBER OF TOTAL HITS AND TOTAL TRIALS
ACHIEVED BY SUBJECTS IN EACH GROUP
DURING THE INITIAL TESTING PERIOD

	Control Group		Experimental Group	
Subject	Trials	Hits	Trials	Hits
A	26	27	28	22
B	25	22	24	13
C	17	37	22	21
D	16	19	22	8
E	20	17	20	9
F	24	14	26	34
G	20	19	28	13
H	16	14	19	23
I	26	16	26	24
J	24	38	25	42
K	26	31	17	9
L	25	25	27	31
M	26	42	25	26
N	32	20	19	30
O	25	11	20	36
Total	349	352	348	341

TABLE 6

THE NUMBER OF TOTAL HITS AND TOTAL TRIALS ACHIEVED BY SUBJECTS IN EACH GROUP UPON COMPLETION OF THE CRITERION SKILL LEVEL

	Control Group		Experimental Group	
Subject	Trials	Hits	Trials	Hits
A	405	824	246	724
B	219	629	275	551
C	254	968	274	713
D	294	615	175	494
E	329	741	284	585
F	317	818	252	798
G	203	519	226	753
H	344	717	194	627
I	336	723	278	586
J	78	372	278	596
K	354	714	296	490
L	301	773	107	584
M	262	725	172	417
N	257	761	114	582
O	344	655	120	615
Total	4,297	10,554	3,291	9,115

APPENDIX B

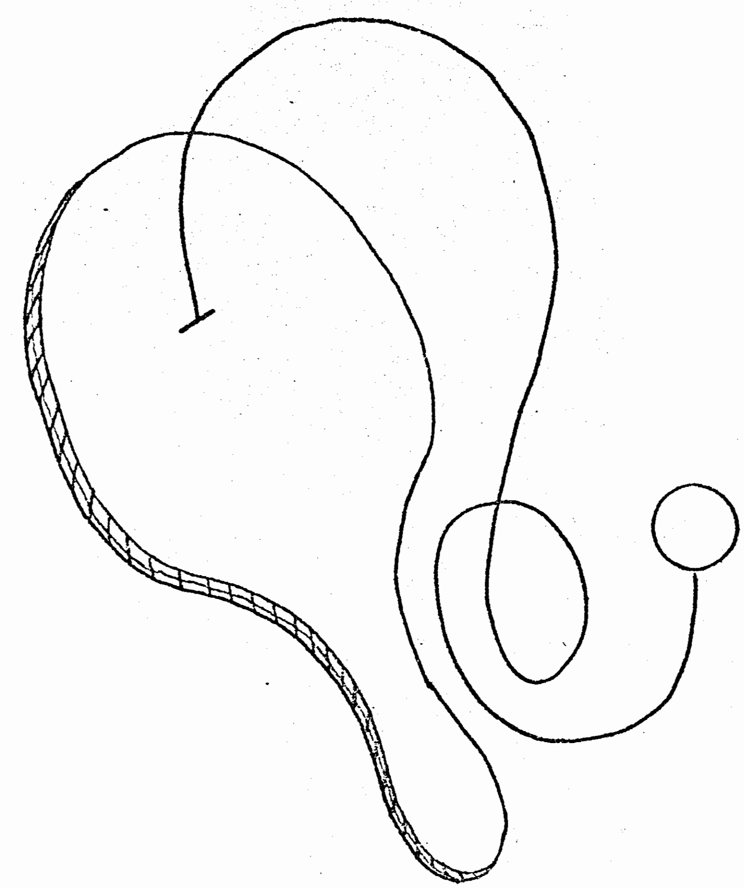

Plate 1. The paddle-ball apparatus used in the novel gross motor skill. The rubber-band connecting the ball to the paddle was approximately twenty-five inches long.

APPENDIX C

NAME ____________________

GROUP ____________________

DORMITORY ____________________

PADDLE NUMBER __________

SESSION ____
(time 1:45)

Trial	No. of Hits	Trial	No. of Hits
1		16	
2		17	
3		18	
4		19	
5		20	
6		21	
7		22	
8		23	
9		24	
10		25	
11		26	
12		27	
13		28	
14		29	
15		30	

Plate 2. The scorecard used during the learning of the novel gross motor skill.

APPENDIX D

FORMULAE UTILIZED IN THIS STUDY

THE FORMULA FOR BARTLETT'S TEST OF HOMOGENEITY OF VARIANCE (12:375)

$$= \frac{2.3026}{C}\left[(N-k)\log_{10} V_w - (n-1)\log_{10} V_i\right]$$

where $C = 1 + \frac{1}{3(k-1)}\left[\sum \frac{1}{n-1} - \frac{1}{N-k}\right]$

THE FORMULA FOR STANDARD DEVIATION (37:63)

$$= \sqrt{\frac{\sum (x_i - \overline{X})^2}{n}}$$

THE FORMULA FOR STANDARD ERROR (37:161)

$$= \frac{\text{Standard deviation}}{\sqrt{n}}$$

TESTING DIFFERENCE BETWEEN MEANS
(37:483)

$$= \frac{M_1 - M_2}{\sqrt{\dfrac{(S_1)^2}{N_1-1} + \dfrac{(S_2)^2}{N_2-2}}}$$