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RELAXATION MEASUREMENT OF NORMAL SUBJECTS

BY ELECTROMYOGRAPHY

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Presented to

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by

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ABSTRACT

Electromyographic records were taken from forehead and forearm muscle groups before and after a nine-hour relaxation training course conducted according to the theories of Dr. Edmund Jacobson. There was an experimental group (N=21) and a control group (N=20). Neuromuscular tension in the forearm was significantly reduced in the experimental group (N=21) of female elementary school teachers following the relaxation training course, while the control group remained stable. The training did not produce a significant change in forehead neuromuscular tension control.

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Chapter I

THE PROBLEM

Introduction

This investigation on the nature of neuromuscular relaxation was first stimulated through two separate experiences: a) It was observed that it was necessary for athletes to achieve relaxed upper bodies in middle distance running; and b) Neuromuscular relaxation literature has offered some interesting but subjective claims for certain types of relaxation training as outlined by Jacobson and others (14). The literaturehas also pointed out some objectively supported benefits which have been demonstrated with clinically tense patients. (12, 22). Very few studies have been reported, however, on these or other relaxation methods being applied to clinically non-tense subjects. This has led to speculation that if such training would benefit normal people, then it would have legitimate applications in school physical education programmes.

Purpose of the study

The purpose of this investigation is to determine whether or not Jacobson type relaxation training, which teaches the subject to identify when tension is present in a muscle, has a significant effect on the resting neuromuscular activity in normal people.

Rationale for study

The Jacobson programme emphasizes the reduction of tension through recognition of the patient "doing", and is detailed in Appendix E (page 60). As a normal human being can, by consciously and completely relaxing a muscle, abolish neuromuscular activity in it, analysis through electromyographical records will show conclusively the existence of a state of complete relaxation in normal human striated muscle at rest (1).

The general tone of muscles is determined by both the passive elasticity of muscular tissue and by active (though not continuous) contraction of muscles in response to stimuli arising in the central nervous system. (C.N.S.) (1). Thus, complete relaxation does not mean that there is no tone in skeletal muscles, but that variation in muscle tone is regulated by C.N.S. facilitation of the muscle spindles.

Muscle spindles lie parallel to the muscle fibres, and envelope a few fibres which are detached from the bundle of muscular fibres. Thus, contraction of muscle fibres reduces tension on the detached fibres and so decreases tension on the muscle spindles. The degree of tension in muscle spindles is relayed as afferent information to the cord, cortex, and other brain centres in order to provide for reflex action and to allow the C.N.S. to monitor body activity. In addition, the spindle falls under control of the gamma system which provides a facilitative function to increase the sensitivity of the muscle spindles to stretch. Tension can be increased or decreased by C.N.S. control to provide for muscle tonus at any given length and a resting muscle can exhibit tone even though there is no volitional or reflexive activity. Thus, the mechanism exists for a psychologically stressed or tense person to demonstrate, through C.N.S. action,high spindle facilitation and an excessive level of tonus. Though tonus is never absent in normal muscle, excessive tonus can be involved in the etiology of some nervous disorders. (1). It follows that relaxation "education" may have a beneficial therapeutic effect. Although the amount of effect that relaxation training will have on muscle tone is not certain, it can be said that cellular turgidity will not be involved and that the only direct effect will be on neural activity.

Hypothesis

Based on the foregoing rationale for a positive effect of relaxation training, it was hypothesized that twelve relaxation practice sessions spaced over a period of six weeks would significantly affect electromyographically identified muscular tonus in elementary school teachers. In particular it was the intention to discover whether or not the training would make any significant difference in the tonus of muscle groups in the forearm or forehead.

Definitions

The following terms have been operationally defined for use in this paper.

Relaxation means to reduce C.N.S. facilitory activity sufficiently so as to result in the generalized or localized cessation of electromyographically detectable muscular activity.

Differential Relaxation
(1) Mentally differentiating between muscles that are necessary for a particular action and those that are not.
OR
(2) Differentiating between strong and weak contractions of the active muscles and relaxing them as much as is consistent with doing the job in hand effectively.

Psychological Stress Basowitz's definition is used viz: "The organism's response to internal or external processes which reach those threshold levels that strain the organism's psychological integrative capacities close to or beyond their limits" (2).

Facilitation is the state of a neuron whose membrane is depolarized to any degree from its resting level thus making it responsive to lower intensity stimuli.

Muscle Spindles Function These are stretch receptors, enclosed in a tissue fluid and a capsule of connective tissue, which are innervated by sensory nerve endings. Within the muscle spindle are nerve endings of two types viz: a) Annulospiral endings which are terminals of large fibres arranged spirally around the muscle fibres. b) Flower-spray endings which are terminals of smaller, less myelinated fibres and end in spray like arborizations upon the muscle fibres. Both these receptors are arranged in parallel with muscle fibres so that they are stimulated when the muscle stretches.

Motor Unit This is the functional unit of striated muscle made up of the neuron, end feet, and all connected muscle fibres (since an impulse descending on the nerve axon causes all the muscle fibres in one motor unit to contract almost simultaneously) (1).

Electromyography is the means by which the change in electrical potential which accompanies the ionic shifts of depolarization is recorded. The electrical result is an electrical discharge lasting 5-8 milliseconds with a total amplitude measured in microvolts.

An Electromyograph is a high gain amplifier with a preference or selectivity for frequencies in the range of 10 to several thousand cycles per second.

Electromyogram is the pen recording produced by the electromyograph.

Recreation is a leisure time programme of activities directed at diverting the mind from everyday problems to more pleasant ones.

Tension Refers to the state of contraction in voluntary muscles and it can be identified by means of electromyography.

Tense Person One whose muscles show electrical activity when the person is trying to relax.

Normal Person One whose muscles show no electrical activity when he is trying to relax, and who is not psychologically stressed (as defined by Basowitz (2)).

Delimitations

The study was confined to female elementary school teachers (age range 19-55 years) from the Protestant Elementary School, Hull; Our Lady of Peace School, Ottawa; Pope John XXIII School, Ottawa; and the Vincent Massey School, Ottawa. The subjects were not randomly chosen, but were asked to take part in the experiment. Thus the conclusions only apply to this group of female elementary school teachers and no further inference can be made.

Limitations

The results are subject to interpretations which are affected by the following factors:

(a) The initial use of the electromyograph may have had a psychologically stressful effect on some subjects.

(b) It was not possible to control the attitude of each subject in the experimental group in response to treatments. By design, no "homework" was set but some subjects reported that they had done additional practice at home.

(c) It is possible that "outside" occurances (such as a relation's death) may have affected recordings.

(d) Pre-treatment experience may have affected the response and recordings.

(e) No pilot study was done to assess the effectiveness of the relaxation teacher's method.

Significance of the Study

In this study Bazowitz's definition of psychological stress (page 4) was used, because it is probably more readily understood by the normal subjects. Many of the subjects said they felt teaching to be a "stressful occupation", but no work could be found which had applied these methods to relieve their condition.

At this point it is the intention to discuss "stress" more generally and in the words of one of the world's leading authorities on stress. Dr. Hans Selye has said that stress is "prolonged combat of uncertain outcome" (34). He has taken stress as an entity that enters into the life process of all living creatures and has studied it objectively by the scientific methods of observation, analysis, and experimentation. It is inevitable in an approach so all-embracing that he should cast his net far wider than the stresses and stress diseases of clinical medicine. He has indeed tried to get away from the word "stress", and has talked of "a syndrome produced by diverse noxious agents". But he was driven back to the word, and has tried to find a definition that will embrace all its manifestations in man. A "stressor" is that which produces stress; i.e. heat, cold, heavy muscular work, worry, rage, or an attack by bacteria. Selye has defined stress as "essentially the wear and tear in the body caused by life at any one time" (34). He points out that, while stress is reflected by the sum of the nonspecific changes which occur in the body at any one time, the general adaptation syndrome (G.A.S.) encompasses all nonspecific changes as they develop throughout time during continued exposure to a stressor. The G.A.S. consists of three stages: the alarm reaction, the stage of resistance, and the stage of exhaustion. There is stress at any moment during these three stages, although its manifestations change as time goes on. Furthermore, it is not necessary for all three stages to develop before a G.A.S. can be spoken of. Only the most severe stress leads eventually to a stage of exhaustion and death. Most of the physical or mental exertions, infections, and other stressors which act upon man produce changes corresponding only to the first and second stages: at first the person may be upset and alarmed, but he gets used to them. Selye emphasizes that in the course of a normal human life, everybody goes through the first two stages many times. Even exhaustion does not always need to be irreversible and complete, as long as it affects only parts of the body.

On combating purely mental stress, Selye feels that <u>deviation</u> is particularly important (34). When concentration of effort in any one part of the body or mind is not very intense and chronic; milder types of deviation are quite often effective (sports, dancing, music, reading, travel, whisky, chewing-gum). These do not have to act primarily through the stress-mechanism and the pituitary-adrenal axis, but they always cause a decentralization of man's efforts, which often helps to restore a lopsided stress quotient toward normal - "something must be put in the place of worrying thoughts to chase them away" (34). Selye's G.A.S. embraces Bazowitz's definition of stress and this investigator believes neuromuscular relaxation training helps the teacher in her "stressful occupation".

Steinhaus feels it is appropriate to recommend that the teaching of neuromuscular relaxation should become a regular part of physical education (36). Those who have taught neuromuscular relaxation claim many psychological benefits which are generally subjective and consequently difficult to measure. However, it is possible to determine the physiological consequence of relaxation training programmes. But such investigations have not been conducted with female elementary school teachers who do not display clinical stress symptoms. Thus, this study has been designed to determine if relaxation training programmes have a significant effect on "normal" female elementary school teachers. The degree of effect will give some basis for deciding if they should be included or excluded in adult education programmes. Further, a significant effect might give the basis for inclusion in elementary and secondary programmes not so much for the immediate as for the long range implications.

Chapter II

REVIEW OF LITERATURE

General Introduction

The term relaxation is loosely defined in the current and past literature. For example, Pitkin (30) has stated that "you may relax by doing something different with your mind or body", and Rathbone (32) also confuses the word with recreation. But, even in the face of poor definitions, general public interest in relaxation has increased and was typified in an October 1968 article entitled "Art of Relaxation Practised" by Kain of the Ottawa Citizen. She points out how learning to relax rids the body of insidious muscular tension and says how wonderful it is to "feel relaxed and in control of yourself" (17).

Pioneers in the Area of Study

Numerous experiments have been done and claims put forward for the beneficial effects of relaxation. However, most modern studies in the area of relaxation are based on Dr. Edmund Jacobson's theories. Jacobson began his study of relaxation during his medical programme at Harvard University in 1918 and has maintained an active interest ever since.

Jacobson defines local or general relaxation as progressing toward completion if "it proceeds to a zero point of tonus for the part or parts involved" (9). He further defines differential relaxation to mean the absence of an unnecessary degree of contraction in the muscles employed for an activity while extraneous musculature remains flaccid. Jacobson has used these criterion to identify tension and develop a "training programme" which he applied successfully to treat patients who display excessive tension and nervous disorders (9,11,12,13).

Another eminent figure who has contributed extensively to the development of studies on relaxation is Dr. A.H. Steinhaus. He defines relaxation as a neuromuscular accomplishment which results in reduction of tension in the skeletal musculature (35,36). He has shown by experiment that even the so called normal tonus can, with practice in relaxation, be reduced to zero. Thus, Steinhaus says, relaxation means "zero activity" of the voluntary motor system. In this sense, playing golf or any other recreative sport is not a form of relaxation. Sport is instead a way of diverting the mind from everyday problems to more pleasant ones and, therefore, serves as a means of recreation. To Steinhaus, complete relaxation means relaxing all the muscles of the body as completely as has been shown to be possible in a non-tense person. He also gives a dual meaning to differential relaxation by stating that it means: 1) Mentally differentiating between muscles that are necessary for a particular action and those that are not; and 2) Differentiating between strong and weak contractions of the active muscles as much as is consistent with doing the job in hand effectively. Thus, in the interests of efficiency, Steinhaus feels differential relaxation should be practised continually in connection with every activity. In a lecture Steinhaus spoke of the fact that man himself creates the muscular tensions that stimulate his own proprioceptive system to keep him awake and aroused (37). Thus, in order to quiet his nervous system, he must reduce the stimuli he himself creates and this is reflected by his relaxation of skeletal musculature which in turn reduces proprioceptive input.

The skeletal musculature which comprises 40-45% of the body weight is both motor and sensory in function. The explanation of their sensory function is outlined in detail by Granit (8), while Steinhaus (34) gives an abbreviated but very adequate explanation. Their physiological views have been combined with those of Basmajian (1) and are outlined in the rationale, supra, pp. 2-3.

General Theories

Friedman does not agree with Jacobson's theory that mental relaxation is always associated with deep physical relaxation and, moreover, he considers that Jacobson's training in relaxation takes too long (6). Friedman's relaxation method is to inject a solution of methohexitone sodium into a patient's vein. He reports that his patients have all been cured of their anxiety disorders and have suffered no after effects because of the drug. However, his enthusiasm is not shared by Kraft (20) who is non commital, and Reed (33). Reed definitely prefers Jacobson's methods to the drugs for he says his patients do not like the drug injection (fearing the needle) and that it is too early to speculate on possible side effects.

The Claims made for Volitional Relaxation

The written works of Jacobson and Steinhaus make it possible to ennumerate the broad claims made for volitional relaxation. The training may produce:

1. 25-40% reduction in neuromuscular tension as measured by electromyography.
2. Significant reduction of previously elevated diastolic blood pressure.
3. Reduced insomnia.
4. Relief from nervous headaches.
5. Lower sensitivity to loud noises and noxious stimuli (including menstrual pain).
6. Reduction in nervous habits such as nail biting, excessive smoking, eating between meals, and involuntary muscle twitchings.
7. Elimination of annoying subjectively identified nervous symptoms such as sensations of a "rhythmic surging feeling".
8. An ability to reduce tense feelings in the urinary bladder.
9. An ability to "blank" the mind at will and stop internal talking or singing.
10. An ability to concentrate and increase mental efficiency by differential relaxation.
11. An ability to rest the mind briefly and return to a task with renewed energy.

12. Relief from some forms of stomach distress caused by nervous worry.
13. Reduction of worry, hypochondria, and dependant attitudes.
14. Better adaption to the conditions of life.

It must be noted that most of these beneficial claims are subjective in nature but they are reported after long experience.

Medical, Non-clinical and Sport Oriented Experiments

In the broad realm of medicine, "Jacobson type" relaxation is used by many clinicians. The importance of such applications is demonstrated by Covalt (4) who has stated that relaxation is one of the most important lessons anyone can learn, and by Kraus (21) who uses Jacobson's training methods in his application of therapeutic exercises. Functional justification for relaxation training is provided by Johnson and Spielberger (15) who have studied the effects of relaxation training on certain anxiety states and found that Jacobson's relaxation procedures produced a consistent decrease in systolic blood pressure and heart rate. In addition, various effects of the inter-relation of mental desensitization and relaxation on fear, anxiety, and various phobias havebeen investigated by Lomont and Edwards (22), Kondas (19), and Rachman (31). Generally they have found that the combined effects of relaxation and desensitization are greater than the separate effects.

Lyons and Lufkin report that skill in tension control was significantly improved in college women by a ten hour course of muscular training (24). Teaching and testing were done by the methods of Jacobson.

In the fields of athletics and sports medicine, Williams (38), Klafs and Arnheim (18), Morehouse and Rasch (27), and Percival (28) all refer to the psychological and physiological benefits of relaxation practices with athletes of many types.

Methods for judging the effectiveness of relaxation training

The subjective impressions of an experienced teacher may be of some value in judging the effectiveness of relaxation training. So also may be the patient's subjective impressions as demonstrated by Kondas when using a Fear Survey Schedule with 32 questions and a five point answering scale (19). However, it was Jacobson who first applied electrical measurement of the muscle voltage as a more direct and accurate way to evaluate patient progress in the control of tension. (10).

The literature and history of electromyography have been principally summarised by Joseph (16), Basmajian (1), and Jacobson (9,10). Their findings and the results of other investigations will be discussed here. In 1921 Jacobson, aided by the Bell Telephone Company, developed an application of the string galvanometer which could record voltage changes as low as "a major fraction of one millionth of a volt" in muscles. Voltage changes or physiologic action potentials occurring in the subject's forearm were detected by the terminals of a wire. This signal was then magnified 600 times and the vibrations recorded on moving photographic film. The extent of the vibrations was the resultant of voltages in the neighbourhood of the wire electrode and the more forceful contractions of the muscle fibres produced larger oscillations on the record. These basic principles still apply in modern equipment.

A typical example from Jacobson's earlier series of experiments can be summarized as follows (9):

An N of six males (three undergraduates, 18-25 years; three graduates, 28-30 years) untrained in relaxation were asked to relax as fully as possible for 30 minutes. Action potentials were monitored with electrodes attached to one forearm and recorded at a paper speed of 1½ inches per second. A switching mechanism in the recording system allowed 3 second recordings at 20 second intervals. Thus during a one half hour session for one subject, a photograph 20 feet long was produced containing 90 seconds of exposure. The results were then put in graphic form by measuring the height of each oscillation over the zero or "relaxation" base line. This result was expressed as peak voltage per unit of time, usually at 0.2 second intervals. But owing to the low selectivity of the equipment, it was necessary to cancel out artifact noise. This was done by subtracting the peak voltage in a similar unit of time during which a "short" was imposed across the amplifier input of the subject-apparatus circuit. Slight vertical vibrations recorded in this way represented the magnitude of artifact and thus provided data for compensation. The resultant was translated into microvolts through the use of standardized calibration inputs and the digital data was then plotted against time. His findings from one such experiment were that:

1. No subject maintained complete relaxation of the arm for the total 30 minute period.
2. One subject achieved approximately zero voltage 79% of the time and very slight voltage for 14% of the time ($<$ 0.3 microvolts). Therefore, his relaxation was practically complete for 93% of the time.
3. Five subjects relaxed completely for smaller periods of time ranging down to 20.2% of the time.

Jacobson assumed these results were "...... a fair specimen for an average group of persons not trained to relax but trying to do so".

Jacobson has also stated his results by expressing them simply as an average number of microvolts (9). This value represents the average magnitude of oscillation or mean peak voltage (Vm) during the 90 second measurement period of the test. The Vm of unselected students was $<$ 1.4 microvolts while the Vm of six "nervous" students tested later ranged from 1.46 to 8.0 microvolts. Therefore Jacobson concluded that his method enabled him to differentiate "nervous" from "unselected" students.

Loofbourrow has presented evidence to show that electromyographical amplitude parallels the amplitude of the mechanical force and that this is not so with experimental excitation (23). So in the measurement of relaxation by electromyography, a recording of the true electrical activity in the muscle is made since no experimental excitation is involved.

Gellhorn's studies of motor units reveal that action potentials are absent in completely relaxed muscles. But, a very slight voluntary or involuntary effort leads to the display of action potentials (7). This bears out Jacobson's theme of "This is you doing".

Broer and Houtz have done some interesting electromyographical examinations of sports skills (3). As a result, they stress that the magnitude of the action potential in one muscle can not be compared with that in another muscle. However, they say the relative magnitude of a single muscle can be studied at various times. This has important implications if attempts are made to quantify muscular response through electromyography.

Basmajian's book "Muscles Alive" represents an extensive treatise of the field of electromyography (1). In it he points out that motor end plates are located near the middles of muscle fibres so that when an impulse reaches the myoneural junction, a wave of contraction spreads outward from the centre over the length of the fibre. This results in a brief twitch of 1-2 milliseconds duration which is followed by a rapid and complete relaxation. During a twitch, a minute electrical potential is generated and dissipated into surrounding tissues and is followed by contraction. But the dispersion of impulse causes contraction of some fibres to be delayed several milli-seconds. Therefore electrical potential developed by the single twitch of all the fibres in a motor unit is prolonged to about 5-8 milli-seconds. Thus, Basmajian emphasizes that the following factors influence recording (1):

1. Generally the greatest amplitude of electrical potential is registered from the larger motor units. But this may be complicated by: the distance of the unit from the electrodes; the type of electrodes; and the type of equipment.
2. The twitch time may be relatively longer with advancing age because reactions are slower.

Jacobson, as a result of 50 years of experimentation, has shown that tense patients can be taught to relax away residual tension. Steinhaus, having studied Jacobson's methods and tried them himself, feels that in teaching the methods for alleviating residual tension, the profession of physical education would be entering a new phase. There is a good deal of medical evidence in favour of this type of relaxation training while not much evidence is reported against it. Electromyography has developed considerably during the last 50 years to greatly enhance the possibility of objective measurement of neuromuscular relaxation.

Chapter III

EXPERIMENTAL PROCEDURE

General Organisation

A control group and an experimental group were tested for electrical activity by the technique of electromyography. The experimental group was then given a course of relaxation training and, subsequently submitted to another electromyographical test. Comparisons were made to show whether or not the training made any significant difference between the two groups.

Selection of Subjects

The experimental and control subjects were personally contacted and requested to participate on a voluntary basis. (Appendix A, pp. 53-56). All subjects were female, English speaking elementary school teachers (age range 19-55 years; 23 married, 18 single) from the Ottawa-Hull area of Canada. It was assumed that both groups had approximately the same social-economic status and that they were all under similar working conditions. There was a treatment group of 21 (10 from the Protestant Elementary School, Hull; 11 from Our Lady of Peace School, Ottawa), and a control group of 20 women (9 from Vincent Massey School, Ottawa; 9 from Pope John XXIII School, Ottawa; 2 from the Protestant Elementary School, Hull).

Organisation of Time, Space, Personel and Equipment

By arrangement with the respective principals, the relaxation teaching was done at Hull Elementary School and Our Lady of Peace School between May 1, 1969 and June 9th, 1969. Each subject attended twelve 45 minute practice sessions during this period. The training took place in a quiet room immediately after the school children left at 3.30 p.m.

Electromyographical measurements were made in a quiet room at the University of Ottawa Department of Biology during the week preceding and the week following the training period. Approximately seven subjects per day were tested between 3.30 p.m. and 8.00 p.m.

Description of the Training Method

The subject learns to recognise when tension is present in a muscle and then to "let it go". The procedure is carried out systematically for all parts of the body. Full details are in Appendix E (page 60).

Description of the Test

The subjects were awake for the test. The equipment was serviced before each recording session by an experienced technician and all testing was done by the investigator. Adequate equipment which is applicable to Jacobson's forms of Electromyography is available in many commercial forms. But the use (and abuse) of technique and equipment has been very clearly outlined by Basmajian (1). However, Pinelli states that "...... our research in electromyography can only continue by adaptation, technical improvements, or discoveries of new phenomena" (29). This philosophy has been employed in the current study through the use of a widely distributed instrument, the Electronics and Medicine Physiograph Main Frame Assembly. (E and M Instrument Co., Inc., Houston). The basic housing of this recorder will accept the recording channels, accessory plug-in modules, power distribution, control, and monitoring circuitry suitable for electromyographic measurements.

The paper control unit was set at 0.1 cm/second so that over 30 minutes of testing 1.8 metres of paper per subject was produced and a time signal was recorded every 60 seconds. Maximum sensitivity of the Hi-Gain Preamplifier (Part No. 93-300-70) exceeds 30 microvolts per centimetre of Physiograph pen deflection. Internal calibration signals of 100 microvolts or one millivolt may be either injected through the subject during a recording or applied directly to a baseline. In addition, the amplifier has a high rejection ratio for in-phase signals such as 60-cycle interference which permits operation under normally adverse conditions and is thus well suited to this type of experiment.

A passive envelope type integrator for electromyography was used to enable an average line of the physiograph pen deflections to be drawn. The area underneath this integrated curve was cut out for comparison purposes. As some areas were very small, the paper areas were weighed on a tension balance (sensitive to 1/10,000 gram) and subsequently converted to square millimetres. As only one integrator was available, the forearm lead was integrated for the first 15 minutes and the forehead lead was integrated during the last 15 minutes. The percentage of relaxation time during the 30 minutes was calculated from the Physiograph pen deflections. (See Figure I, page 23 and Plates I-III, pp 24-26).

The electrodes (E and M Co.) were pure silver discs encased in a soft plastic cover and had a three foot lead of shielded wire which terminated in a standard 0.081 inch diameter phone tip plug. The plastic cover provided a large self contouring surface for adhesion, and held the electrode from direct contact with the skin. The electrodes were attached to the subjects with adhesive washers and use was made of E and M electrode jelly to lower the electrical resistance and minimize disturbance from movement artifact. The Physiograph, chair, and subject were each grounded seperately in an effort to reduce 60 cycle noise. No effort was made to control line current or to isolate the subject and equipment from radiated noise.

Key

A	Chair
B	Pre-Amplifiers
C	Physiograph and Pen Recorders
⏚	Grounding

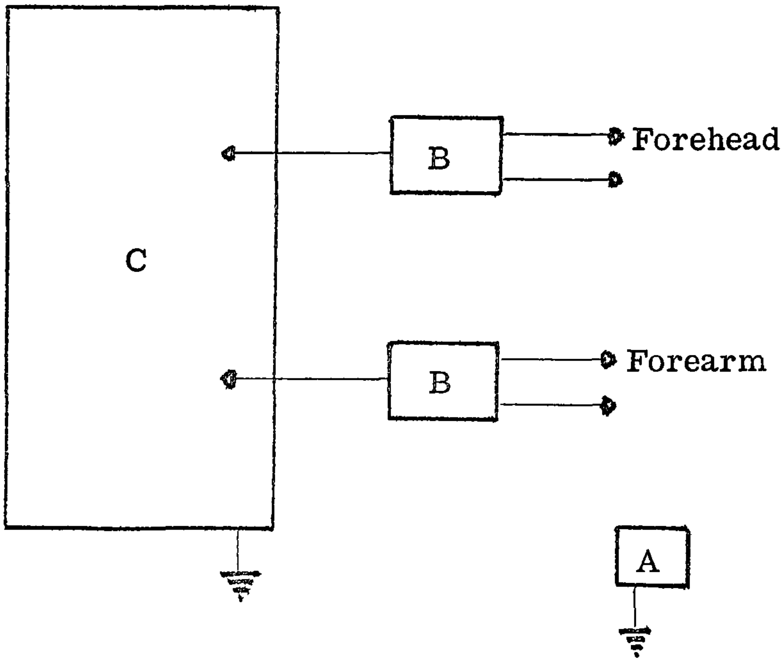

FIGURE 1:

ELECTROMYOGRAPHIC WIRING DIAGRAM

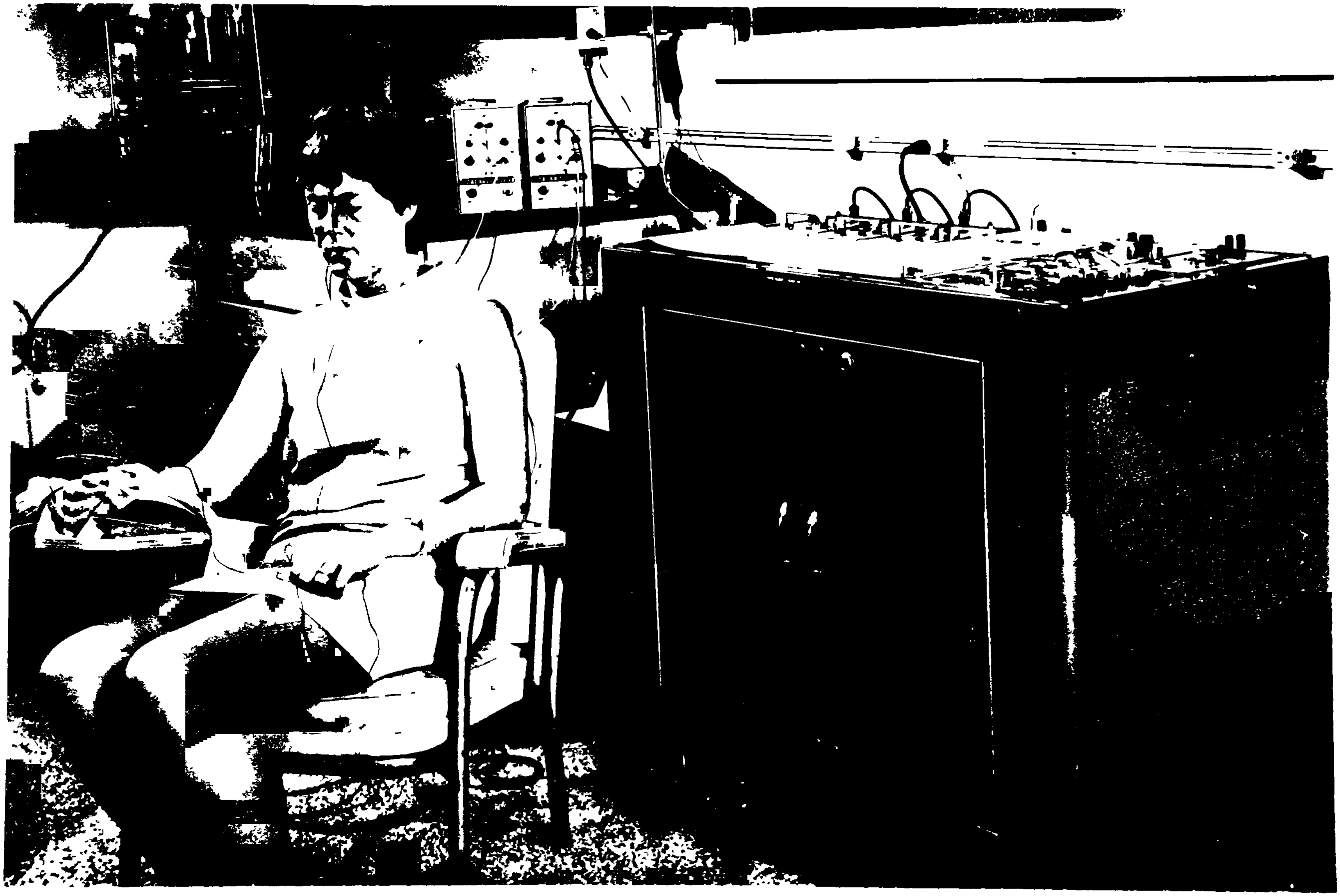

FIGURE 1 THE ELECTROMYOGRAPHIC EQUIPMENT AND A SUBJECT

PLATE II ELECTRODE CONNECTIONS

PLATE III ARM ELECTRODE CONNECTION

Test Implementation

The electrodes were attached to the subject's right forearm (extensor digitorum) and forehead (frontalis). These points were located by palpation. The forearm has been used by other investigators (e.g. Jacobson, Lyons and Lufkin) as these muscles are not normally concerned with posture, are less likely to be affected by movement artifact, and are thought to reflect tension in the hands (9, 24). To further decrease the possibility of movement artifact a cradle and cushion were provided for the forearm to rest in. (Plates I-III, pp. 24-26)

The forehead was chosen as the second site because it is not concerned with posture; has been used by Jacobson, Lyons and Lufkin; and Malmo et al have shown experimentally the superiority of the frontalis muscle tension in discriminating tense patients from normal people (25, 26). It should be noted, however, that there is some conflict here. De Vries et al, when calculating the effects of sauna baths on the neuromuscular system, found the electrical activity in the elbow flexor group was reduced by 42% when measured 20 minutes after a sauna bath while no comparable decrease occurred on the control day. The activity of the frontalis, on the other hand, rose after the sauna but the rise was not significantly different from the changes on the control day (5). This investigator felt, however, that this isolated contradiction was not sufficient reason not to use the frontalis muscles as a site because in saunas, while the body is relaxed, the face is often voluntarily creased and rubbed because of the heat. This creasing and rubbing may have contributed to De Vries' findings.

Reliability of the Instruments and Investigator

Basmajian has stated that surface electrodes are convenient and can be applied with reasonable success after little experience. They provide no discomfort to the subject and can be used in pairs over the belly of the muscle to localize pick-up. The disadvantages relate to electrode movement with moving subjects and to non-selectivity when applied to deep muscles (1). These conditions were minimized in this study by controlling the subjects activity (use of chair and arm rest), choice of electrode, and because the muscles to which the electrodes were applied were near the surface of the skin.

Basmajian describes electromyographic systems as basically high gain amplifiers with a selectivity range for frequencies in the range of 10 to several thousand cycles per second (1). Their main disadvantages are that they may be influenced by amplifier noise, general non-muscular tissue noise and movement artifact. But, although pen writing recorders may not be adequate for quantitative work: they are most convenient, least wasteful, easily serviced, and efficient for experiments involving qualitative analysis. Thus, as this was an experiment of identification rather than quantification, these disadvantages were of no consequence.

Before beginning experimentation, the investigator spent 50 hours of pilot study working with the Physiograph under expert instruction. The object was to become experienced in operating the Physiograph and in interpreting the results obtained from average subjects (usually university students), and to ascertain the reproducibility of results on the electromyograph. There was no significant difference between the first and second recordings. Details of this project and statistical analysis are recorded in Table 1 (page 30) and Appendix H. In addition, the investigator's understanding was enhanced by personal correspondence with Dr. J.V. Basmajian, Dr. E. Jacobson, and Dr. A.H. Steinhaus.

Table 1

PILOT PROJECT

	Subject	Rec. 1	Rec. 2	X diff	$x=(X-M)$	x^2	t
FOREARM TENSION	1	89.06	298.44	-209.38	-161.46	26,069.33	-0.59 N.S.
	2	76.56	32.81	43.75	91.67	8,403.39	
	3	135.94	114.06	21.88	69.80	4,872.04	
FOREHEAD TENSION	1	23.44	95.31	-71.87	-19.79	391.64	-2.43 N.S.
	2	23.44	98.44	-75.00	-22.92	525.33	
	3	53.13	62.50	-9.37	42.71	1,824.14	
PERCENTAGE TIME RELAXED (FOREARM)	1	97.33	97.09	0.24	-0.26	0.07	3.33 N.S.
	2	97.92	97.17	0.75	0.25	0.06	
	3	94.25	93.75	0.50	0.00	0.00	
PERCENTAGE TIME RELAXED (FOREHEAD)	1	99.33	99.42	-0.09	-0.31	0.10	1.1 N.S.
	2	98.67	98.50	0.17	-0.05	0.00	
	3	97.75	97.17	0.58	0.36	0.13	

$.95^{t}2=4.30$

Chapter IV

RESULTS

Electromyograph Results

Measurements were carried out as explained in Chapter III but the "noise" interference was so variable as to make it necessary to change amplifier gain during the test. Calibration signals were not entered after a change in gain and no quantitation of magnitude was attempted. Quantification was limited to simple identification of action potentials from which relaxed versus unrelaxed times could be determined. The latter results are reported in Tables 2-4 and Figures 2-5, (pp. 32-38). Details of statistical calculations relating to this data are in Appendix F (Tables 6-7, pp. 67-69).

In order to find at what point the difference occured, the original results were subsequently analysed in 7.5 minute sections and these results are summarized in Table 5/ Figure 6 (pp. 41-42) and detailed in Appendix G, pp. 71-82.

The subjects' subjective observations are also recorded (pp. 43-44) in an effort to add information to the objective results.

Table 2

Percentage of Time Relaxed in Forearm and Forehead Muscle Groups before and after Relaxation Training in the Experimental Group. (N=21)

Subject	Age	% Time Relaxed (Forearm)			% Time Relaxed (Forehead)		
		Pre	Post	Difference	Pre	Post	Difference
1	55	94.17	99.83	5.66	100.00	100.00	0.00
2	31	89.72	99.67	9.95	95.28	99.67	4.39
3	25	69.11	91.94	22.83	91.28	100.00	8.72
4	43	97.11	99.67	2.56	97.44	100.00	2.54
5	22	31.39	99.17	67.78	92.00	99.97	7.97
6	27	98.67	100.00	1.33	100.00	100.00	0.00
7	51	96.56	92.00	-4.56	100.00	99.83	-0.17
8	22	96.00	98.83	2.83	96.95	99.72	2.77
9	52	91.56	99.33	7.77	99.34	100.00	0.61
10	47	89.33	99.89	10.56	100.00	100.00	0.00
11	19	99.50	98.72	-0.78	99.17	99.99	0.82
12	27	94.66	99.98	5.32	100.00	99.98	-0.02
13	55	64.83	99.28	34.45	100.00	99.89	-0.11
14	27	58.17	99.98	41.81	100.00	100.00	0.00
15	32	96.28	99.50	3.22	96.44	100.00	3.56
16	22	96.78	100.00	3.22	96.67	100.00	0.33
17	20	98.50	100.00	1.50	99.50	100.00	0.50
18	20	93.67	100.00	-6.33	99.00	100.00	1.00
19	29	97.34	99.99	2.65	100.00	100.00	0.00
20	20	98.17	100.00	1.83	98.50	99.95	1.45
21	37	99.44	100.00	0.56	100.00	100.00	0.00
	M=35.52	M=88.14	M=98.94	M=10.80	M=98.31	M=99.95	M=1.64

Table 3

Percentage of Time Relaxed in Forearm and
Forehead Muscle Groups of the Control
Subjects. (N=20)

Subject	Age	% Time Relaxed (Forearm)			% Time Relaxed (Forehead)		
		Pre	Post	Difference	Pre	Post	Difference
22	24	94.78	94.44	-0.34	95.00	97.61	2.61
23	28	96.72	98.56	1.84	89.17	95.95	6.78
24	31	89.89	86.33	-3.56	84.67	79.50	-5.17
25	50	99.56	95.22	-4.34	99.61	99.56	-0.05
26	27	64.22	77.89	13.67	97.50	99.17	1.67
27	20	93.39	96.00	0.61	97.22	97.33	0.11
28	28	98.89	95.06	-2.83	100.00	95.22	-4.78
29	39	95.89	98.44	2.55	99.33	100.00	0.67
30	19	98.06	100.00	1.94	98.95	100.00	0.05
31	41	97.56	93.50	-4.06	99.33	98.33	-1.00
32	22	99.22	98.00	-1.22	94.28	99.67	5.39
33	23	98.17	96.50	-1.67	99.72	98.83	-0.89
34	28	92.06	95.95	3.89	98.82	98.11	-0.71
35	23	95.00	87.72	-7.28	90.78	98.56	8.22
36	26	95.00	96.33	1.33	99.17	97.50	-1.67
37	21	97.56	98.00	0.44	100.00	100.00	0.00
38	20	99.39	98.56	-0.83	98.84	99.84	1.00
39	25	97.00	97.11	0.11	91.61	95.95	4.34
40	26	98.72	98.11	-0.61	99.61	100.00	0.39
41	20	97.00	99.22	2.22	99.00	99.89	9.89
	M=27.05	M=95.00	M=95.05	M=0.09	M=96.63	M=97.55	M=1.34

Table 4

The Effect of Relaxation Training on the Percentage of Time Relaxed (30 Minute Period)

Area	Group	N	Mean Difference (% Time)	S.E. Difference Between Means	t	Significance Level
Forearm	Experimental	21	10.80	3.99	2.68	$95^{t}39$ 2.02
	Control	20	0.09			$99^{t}39$ 2.71
Forehead	Experimental	21	1.64	1.03	0.29 N.S.	
	Control	20	1.34			

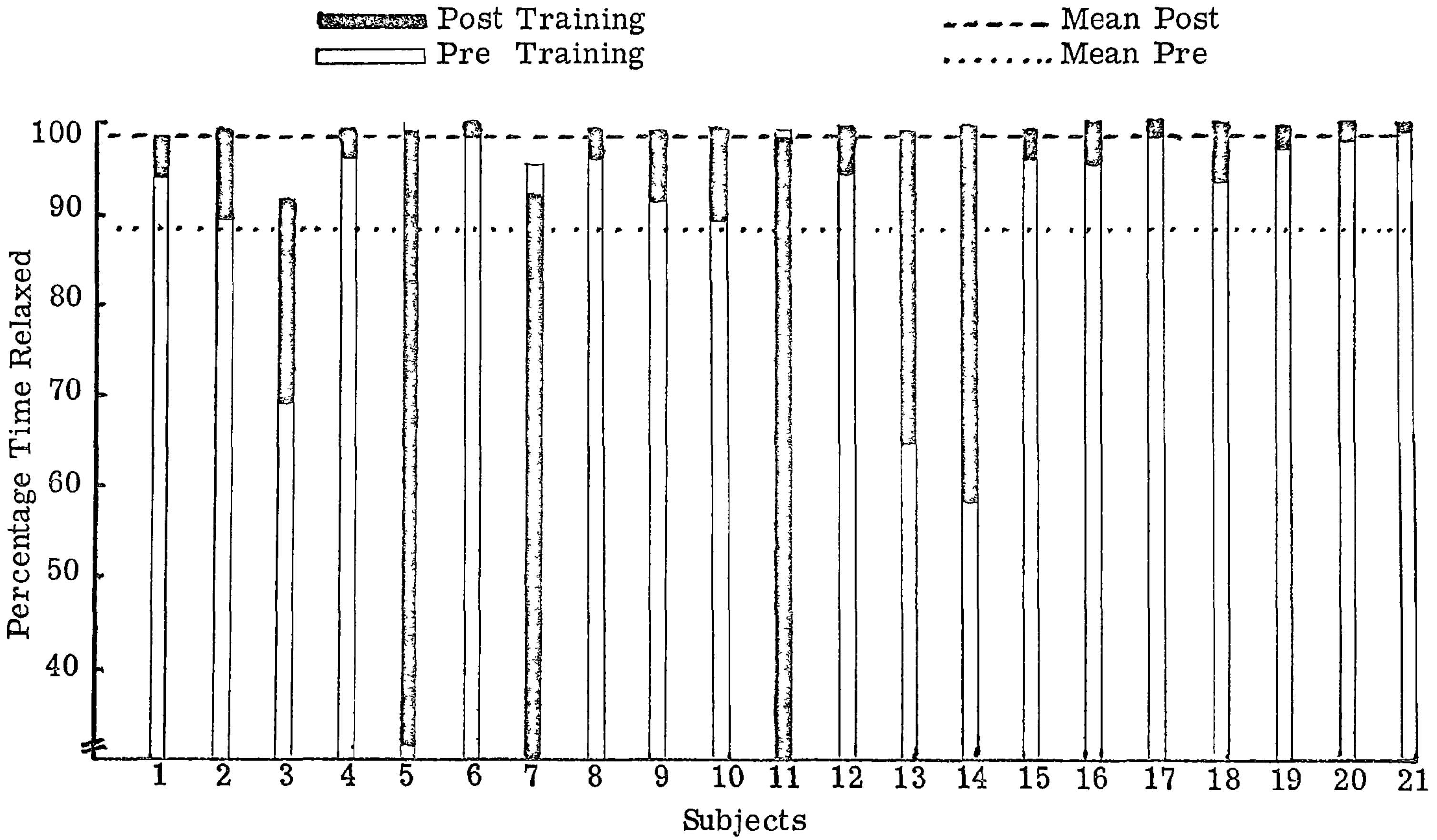

FIGURE 2: Changes in Percentages of Time Relaxed Between Pre and Post Measures for Experimental Group (Forearm) (N=21).

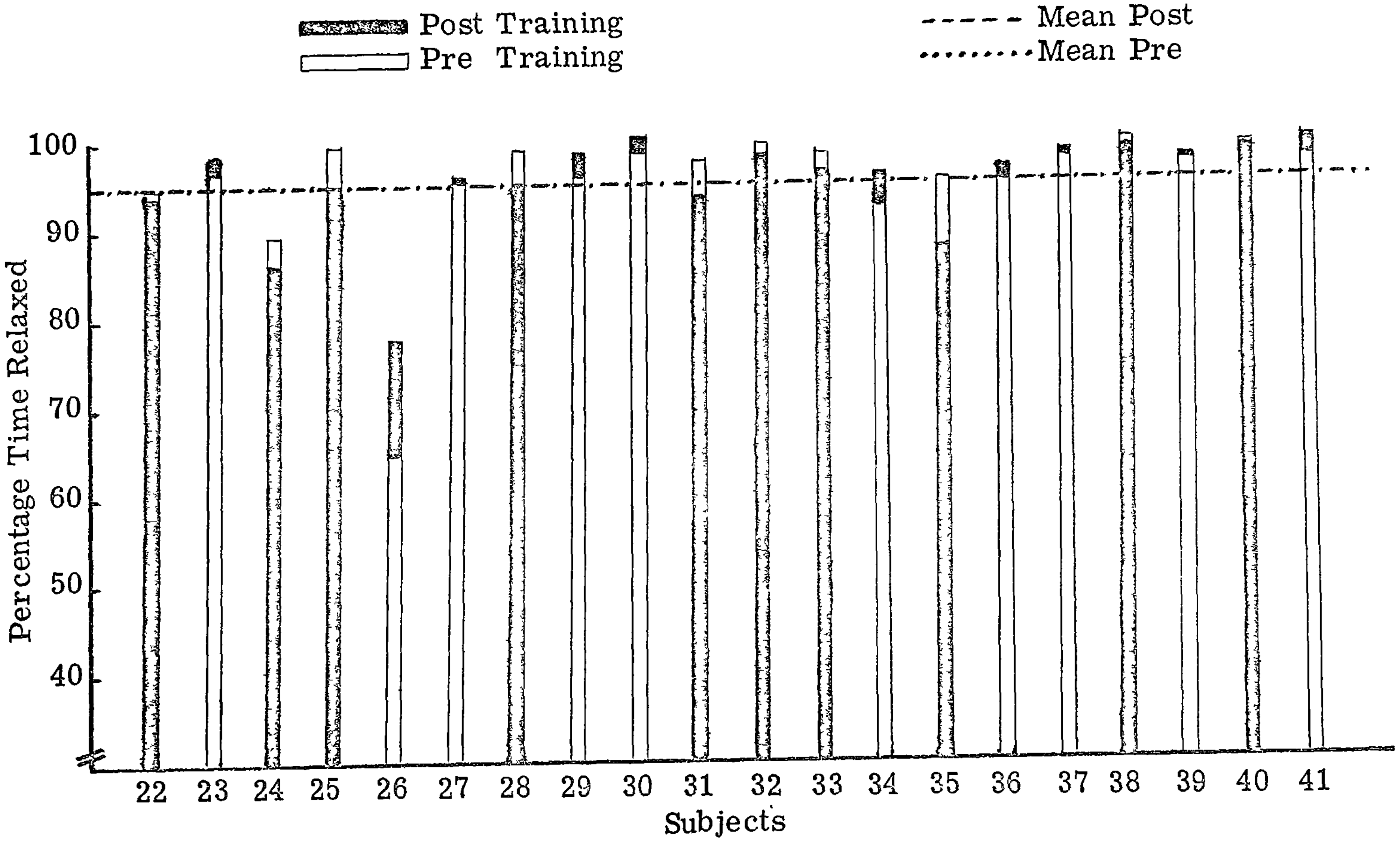

FIGURE 3: Changes in Percentage of Time Relaxed Between Pre and Post Measures for Control Group (Forearm) (N=20).

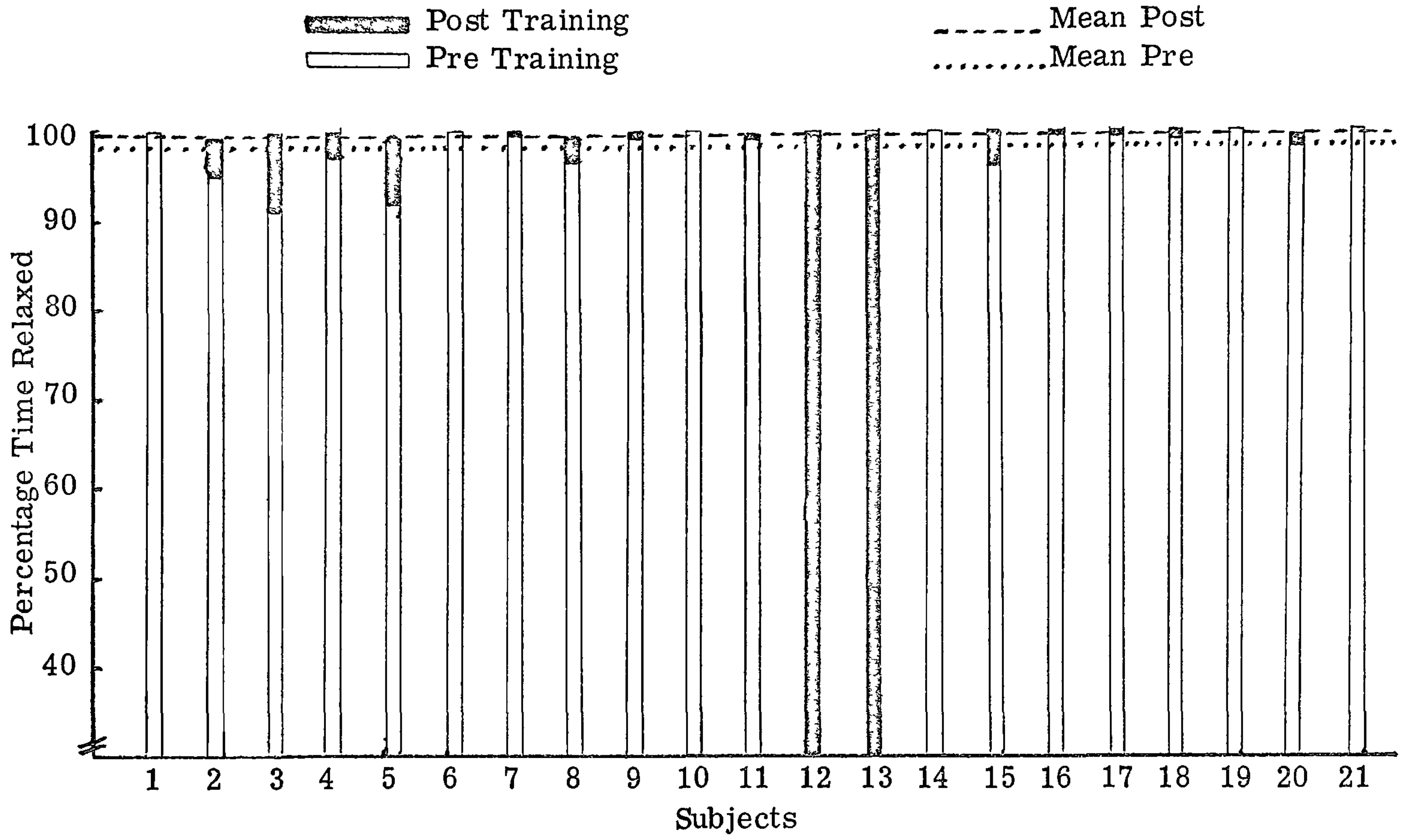

FIGURE 4: Changes in Percentages of Time Relaxed Between Pre and Post Measures for Experimental Group (Forehead) (N=21).

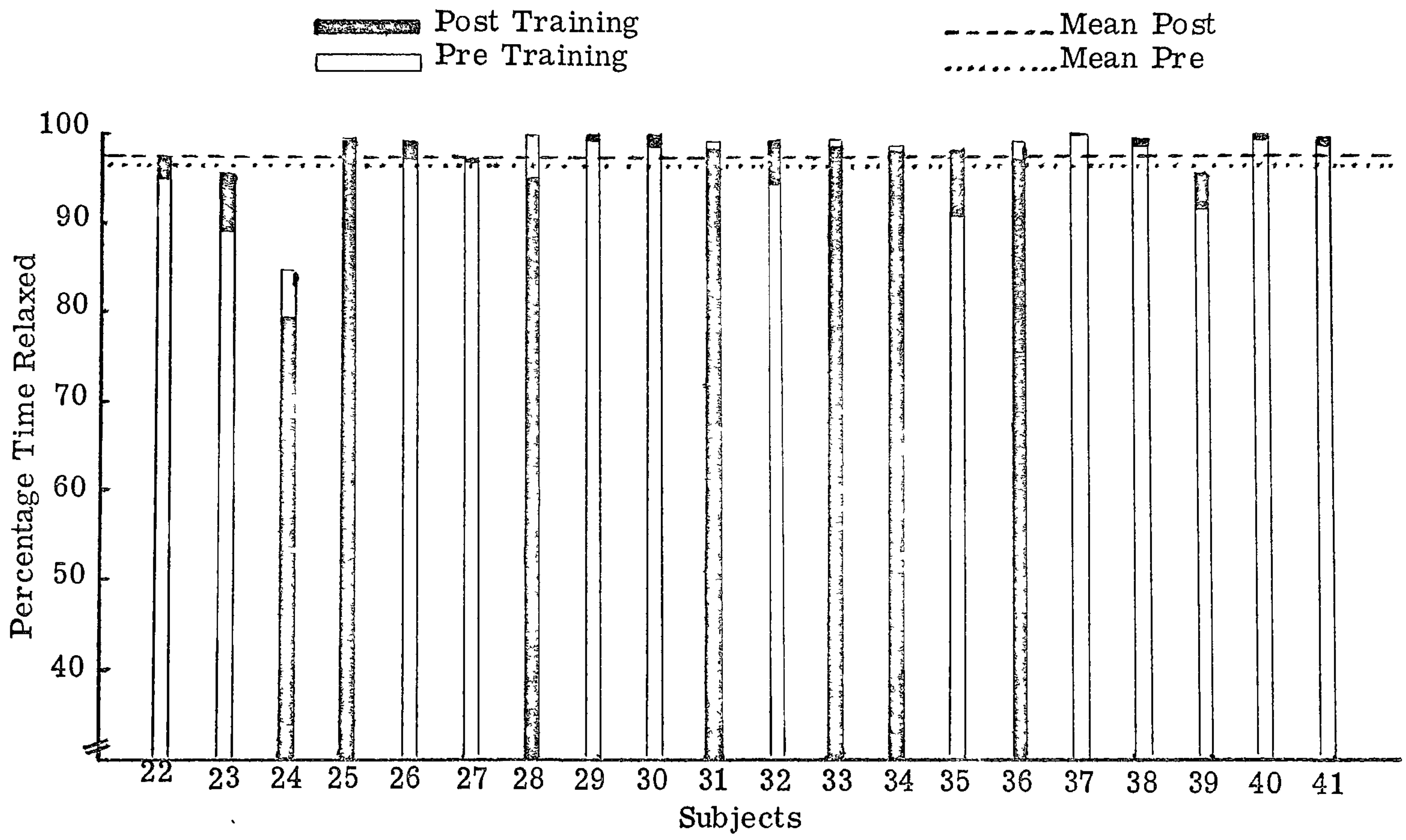

FIGURE 5: Changes in Percentages of Time Relaxed Between Pre and Post Measures for Control Group (Forehead) (N=20).

The observations from this data can be summarized as follows:

1. Table 4 (page 34) shows that the relaxation training produced a significant difference in the percentage time relaxed (forearm) of the experimental group at the 0.02 level of confidence. It is noteworthy that 0.02 or 0.05 level of significance was attained.

2. Table 4 (page 34) also suggested that the percentage of time the forehead muscles were relaxed increased more in the experimental group (M 1.64) than in the control group (M 1.34) but the difference was not found to be statistically significant.

3. Tables 2 and 3 (pp. 32-33) show that the mean improvement for the experimental group (forearm) was 10.80% while for the control group the improvement was 0.09%. Only two experimental subjects deteriorated slightly while ten of the control subjects relaxed less time in the post-training test. One control subject (number 26) showed a big improvement in the post-test and, even then, her time relaxed was low relative to the other subjects. This might be related to the fact that her mother died just before the pre-training test.

4. Tables 2 and 3 (pp. 32-33) also show, that all the experimental group who had low pre-training recordings showed an improvement by the time of the post-training test. Subject 5 improved 67.78% (and stopped taking tranquilizers half way through the training period), subject 3 improved 22.83% (and also stopped taking tranquilizers), and subject 13 (who reported being "very nervous" at the outset) improved 34.45%.

The information reported here from Tables 2 and 3 is clearly seen graphically in Figures 2-5 (pp. 35-38). The biggest post-training increase is seen in Figure 2 which represents the forearm recordings of the experimental group. Figure 3 shows no visible difference for a similar representation of the control group. Figures 4 and 5 show that there were small increases in the forehead averages and that the increase was common for both experimental and control groups.

Table 5 and Figure 6 (pp. 41-42) demonstrate that the experimental group showed an improvement difference throughout, and that the biggest mean difference (16.87%) (significant at 0.01) was in the first quarter of the recording period. The mean difference during the second quarter (15.52%) was significant at 0.02 while the mean difference (3.87%) in the third quarter was not statistically significant. The fourth quarter (mean difference 8.35%) was significant at 0.10.

The figures show that the biggest increase in relaxation time occurs in the first 7.5 minutes of testing. The difference became less followed by a declining in the next 15 minutes, and then rose toward that recorded during the initial 7.5 minutes (Figure 6, page 42).

Table 5

The Effect of Relaxation Training on the Percentage of Time Relaxed in each of Four 7.5 Minute Periods (Forearm only)

Time	Group	N	Mean Difference (% Time)	S.E. Difference Between Means	t	Significance level
1st Quarter	Experimental	21	17.50	5.49	3.07*	$.99{}^{t}39=2.71$
	Control	20	0.63			
2nd Quarter	Experimental	21	14.19	5.80	2.68*	$.98{}^{t}39=2.42$
	Control	20	-1.33			
3rd Quarter	Experimental	21	5.80	3.85	1.005 N.S.	$.95{}^{t}39=2.02$
	Control	20	1.93			
4th Quarter	Experimental	21	8.28	4.42	1.89*	$.90{}^{t}39=1.68$
	Control	20	-0.07			

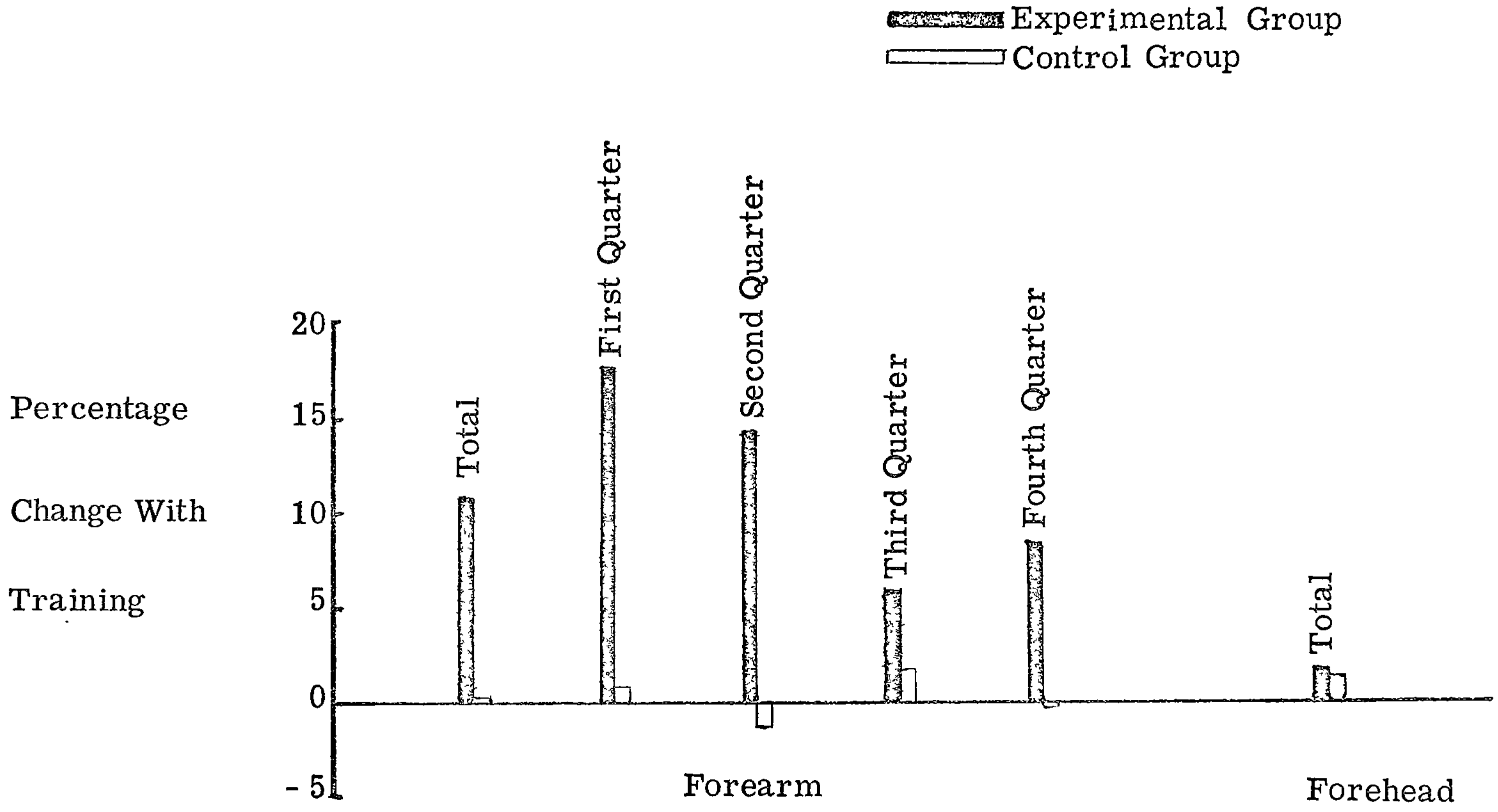

FIGURE 6: Percentage Changes of Experimental and Control Groups After the Training Period. Total Changes, and in 7.5 Minute Sections for the Forearm.

Subjective Observations

Before the initial electromyograph recording each subject was asked if she felt "nervous" in any way. Most felt normal (as defined in this paper) and the exceptions are noted below. (Experimental 1-21, Control 22-41).

- Subjects 3 and 5 were taking tranquilizer pills prescribed by their doctors.
- Subject 6 felt very "relaxed" as she had just finished some degree examinations.
- Subject 10 was taking pills for high blood pressure.
- Subject 13 said she was "very nervous".
- Subject 16 had recently taken a course of pre-natal relaxation training and was seven months pregnant.
- Subject 22 had taken a three hour written examination that morning and her father had had a serious operation in the afternoon.
- Subject 25 had practised Jacobson type relaxation for 25 years because she felt it necessary for her.
- Subject 26 was "upset" because of the recent death of her mother.

It is this investigator's opinion that any group of people may be expected to have a number of anomalous members.

After the final electromyograph recording each experimental subject (N = 21) was asked to complete a subjective questionaire (Appendix C, page 58). As a result of training in relaxation:

- Three subjects who had suffered from insomnia reported improvement (Numbers 2,10,13).
- Three subjects said their nervous headache condition had improved while another said there was no change (Numbers 3,5,13).
- Two subjects were sensitive to loud noises but the training made no difference (Numbers 13,16).
- One subject's menstrual pain did not improve (Number 5).
- One subject's excessive nail biting did not improve (Number 15).
- Three subjects (Numbers 3,5,6) still smoked excessively but one subject (Number 5) said she smoked fewer cigarettes.
- One subject had fewer involuntary muscle twitches (Number 16).
- One subject reported less urinary bladder tension (Number 16).
- Two subjects (Numbers 16,10) said they did less internal talking/singing and two subjects (Numbers 3,4) reported no change in this condition.
- One subject was still unable to concentrate (Number 16).
- Three subjects (Numbers 3,6,19) had become less worrisome but one subject (Number 16) still worried.
- One subject was less of a hypochondriac (Number 3).
- Five subjects said the training had given them a general feeling of "well being" (Numbers 3,4,5, 11,19).
- Two subjects found it beneficial to differentially relax and particularly at meetings (Numbers 2,15).

It is worth noting that various degrees of improvement were subjectively reported in insomnia, nervous headache, involuntary muscle twitches, urinary bladder tension, internal talking/singing, hypochondria, feeling of well-being, and differential relaxation. The training apparently did not help those suffering adversely:- sensitivity to loud noises, menstrual pain, nail biting, excessive smoking and inability to concentrate.

Chapter V

SUMMARY, DISCUSSION, CONCLUSIONS, AND SUGGESTIONS FOR IMPROVEMENT AND FURTHER STUDY

Summary

The purpose of this investigation was to determine whether or not Jacobson type relaxation training had a significant effect on neuromuscular activity in normal people. In particular, it was the intention to discover whether or not the training would make any significant difference in the forearm or forehead muscle tonus of female elementary school teachers. The degree of effect might then give some basis for deciding if relaxation training should be included in adult or general education programmes. 21 subjects were subjected to a programme of relaxation training and compared with a control group for differences in forearm and forehead electromyographs.

After the training period a significant difference in the percentage time relaxed (forearm) of the experimental group at the 0.02 level of confidence was recorded. The percentage of time the forehead muscles were relaxed increased more in the experimental group than in the control group but the difference was not statistically significant.

Discussion

During the training period there was no special emphasis placed on any particular muscle group, but the forearm was dealt with before the forehead and consequently received more attention in terms of practice time. This could possibly account for the better results with the forearm group, though it is worthy of note that there was no similarity between the patterns of tension displayed in the forehead and forearm of individuals.

The Jacobson training programme emphasized the reduction of tension through its presence being recognised by the subjects. Therefore it may be acceptable to believe that neuromuscular control through training caused the decrease in neuromuscular electrical activity.

It is perhaps appropriate to compare this experimental situation with Selye terminology (34). Noxious stimuli may have caused alarm reactions in some of the subjects with which they had learned to live ("stages of resistance"). But apparently none of the subjects had reached the stage of exhaustion, as evidenced by their general good health. Selye's use of the word "deviation" (page 7) has been referred to previously as "recreation" (page 5), but the form of relaxation training used in this experiment is another "deviation". As such a deviation, neuromuscular relaxation training may have helped to relieve the teachers' stressed condition.

It is very doubtful whether these results warrant the inclusion of relaxation training in school physical education programmes, but they do indicate that further study of the question may be beneficial.

Conclusions

1. Relaxation training is effective for the extensor digitorum muscle as proved by electromyographic techniques.
2. The length of the training period was adequate for experimental purposes using the forearm (extensor digitorum) as a site.
3. A testing period of 30 minutes is satisfactory but one of 20 minutes would be sufficient.

Suggestions for Improvement and Further Study

Observations:

1. The frontalis is not a good site for experiments of this nature.
2. The extensor digitorum muscle provides a good site for experimentation.
3. Jacobson hopes to have his own electromyographic equipment, specifically designed for measuring the electrical activity in relaxed muscles, on the commercial market within the next year (private communication). This could lead to increased precision.

Recommendations:

1. That many objective specific studies are done to test the subjective claims for relaxation training with normal subjects.
2. That studies of this nature are done with normal school children of varying ages.
3. When recommendations 1 and 2 have been carried out it will be possible to advise whether or not to include the teaching of neuromuscular relaxation in adult or general education programmes.

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APPENDICES

Appendix A

INITIAL CIRCULAR - EXPERIMENTAL

UNIVERSITY OF OTTAWA
SCHOOL OF PHYSICAL EDUCATION AND RECREATION

As an addition to the accepted objectives of physical education programmes, the profession is becoming increasingly interested in the subject of relaxation. Relaxation to the physiologist means reducing central nervous system activity sufficiently to result in the generalized cessation of muscular activity. When successfully accomplished, it is reported that there is a 35-40% reduction in neuromuscular activity as measured by electromyography. This apparently leads to dimunition of postural stiffness, restless motion and other nervous habits and the relaxed person sleeps better, works more efficiently with less worry and strain, feels less tired and irritable, experiences tension headaches or backaches less frequently, and improves his digestion.

In May and June of this year I am conducting an experiment to measure the effectiveness of relaxation teaching methods. At the outset, the subject will sit in a chair and be asked to relax for 30 minutes. During this time, surface electrodes will be connected to the subject's forearm and forehead (the subject feels nothing) and a recording of the muscle activity will be made.

Following this, there will be twelve 45-minute practice sessions on relaxation spaced over a period of six weeks. These will take place in Hull Elementary School at 3.30 p.m. on Mondays and Thursdays beginning on May 1, 1969.

After the training period, the subject will then pay another visit to Ottawa University for a recording session of 30 minutes on the electromyograph. The times for the University visits will be arranged to suit the convenience of the subjects and transport will be provided if required.

Your help would be invaluable in the successful completion of this investigation. Please indicate if you are willing to participate by completing and returning the attached form.

John J. Jackson,

(Research Assistant,
Department of
Kinanthropology).

FROM: Name ____________
Address ____________
Phones: School ____________
Home ____________

TO: John J. Jackson,
Research Assistant,
School of Physical Education
and Recreation,
University of Ottawa,
Ottawa 2, Ontario.

I am willing to be a subject in your experiment outlined above.

Signed: ____________

INITIAL CIRCULAR - CONTROL

UNIVERSITY OF OTTAWA
SCHOOL OF PHYSICAL EDUCATION AND RECREATION

As an addition to the accepted objectives of physical education programmes, the profession is becoming increasingly interested in the subject of relaxation. Relaxation to the physiologist means reducing central nervous system activity sufficiently to result in the generalized cessation of muscular activity. When successfully accomplished, it is reported that there is a 35-40% reduction in neuromuscular activity as measured by electromyography. This apparently leads to dimunition of postural stiffness, restless motion and other nervous habits and the relaxed person sleeps better, works more efficiently with less worry and strain, feels less tired and irritable, experiences tension headaches or backaches less frequently, and improves his digestion.

In May and June of this year I am conducting an experiment to measure the effectiveness of relaxation teaching methods. At the outset, the subject will sit in a chair and be asked to relax for 30 minutes. During this time, surface electrodes will be connected to the subject's forearm and forehead (the subject feels nothing) and a recording of the muscle activity will be made.

Following this, there will be twelve 45-minute practice sessions on relaxation spaced over a period of six weeks. These will take place in Hull Elementary School at 3.30 p.m. on Mondays and Thursdays beginning on May 1, 1969.

After the training period, the subject will then pay another visit to Ottawa University for a recording session of 30 minutes on the electromyograph. The times for the University visits will be arranged to suit the convenience of the subjects and transport will be provided if required.

Will you agree to be a "control subject" in this experiment? This would entail two visits to the University for half hour recording sessions - once just before May 1 1969 and again just after June 9, 1969.

Your cooperation would be a valuable contribution to the experiment.

If you are willing to assist, please indicate on the form provided below.

John J. Jackson,
(Research Assistant,
Department of
Kinanthropology).

FROM: Name: ____________
Address: ____________
Phones: School: ____________
Home: ____________

TO: John J. Jackson,
Research Assistant,
School of Physical Education
and Recreation,
University of Ottawa,
Ottawa 2, Ontario.

I am willing to be a subject in your experiment outlined above.

Signed: ____________

Appendix B

EMG APPOINTMENTS

UNIVERSITY OF OTTAWA
SCHOOL OF PHYSICAL EDUCATION AND RECREATION

April , 1969.

Dear

Your EMG appointment is on ________, 1969, at ________ a.m./p.m. Please report to the Department of Biology (30 Somerset St. E., Room B32), five (5) minutes before the above time.

Yours sincerely,

John J. Jackson,
(Research Assistant -
Department of
Kinanthropology)

JJJ/ld

Appendix C

SUBJECTIVE QUESTIONS

(Completed by the experimental group after
the training period)

If, prior to relaxation training, you suffered adversely any condition listed, please answer "yes/no" in the answer column.

Has your condition improved as a result of relaxation training?

1. Insomnia ____________________
2. Nervous Headache ____________________
3. Sensitivity to loud noises ____________________
4. Menstrual pain ____________________
5. Nail biting ____________________
6. Excessive smoking ____________________
7. Involuntary muscle twitches ____________________
8. Urinary bladder tension ____________________
9. Internal talking/singing ____________________
10. Inability to concentrate ____________________
11. Worrisome ____________________
12. Hypochondriacal ____________________
13. General feeling of "well-being" ____________________
14. Others ____________________

Appendix D

LETTER OF THANKS TO SUBJECTS

UNIVERSITY OF OTTAWA
SCHOOL OF PHYSICAL EDUCATION AND RECREATION

June 14, 1969.

Dear

I am very grateful to you for giving your time to help with my relaxation experiment.

It is co-operation such as this which may lead to the results of research having a practical application in schools.

Thank you very much.

Yours sincerely,

John J. Jackson,
(Research Assistant,
Department of
Kinanthropology).

Appendix E

TEACHING NOTES FOR THE JACOBSON APPROACH TO ACHIEVING NEUROMUSCULAR RELAXATION

Lesson 1 (Arm)

Minutes

1-10 Lie quietly - eyes closed. (Arms on mat several inches from body).

10-15 a) Bend back right hand at wrist in order to feel the signal of tension along the upper surface of the right arm. (Hand Flexors)

"This is *you doing*"
Individually show the difference between STRAIN (passive) and TENSION (active).

"Let go".

Repeat (a) Slowly
Repeat (a) Quickly

N.B. Ability to know tension is present.

15- b) Clench right fist - note tension on surface of lower forearm.

Repeat whole (a) procedure.

c) Bend right arm at the elbow joint - note tension in biceps.

Repeat (a) procedure.

-30 d) Extend right arm - pressing on the floor so that the entire arm is rigid and hold for 30 seconds - gradually relax.

30-45 Repeat (a) to (c) for the left arm.

N.B. Once a part has been covered in a practice session always include relaxing this part when another is being specially considered.

Lesson 2 (Legs)

Minutes

1-10 Lie Quietly - eyes closed - Remember to relax arm.

10- a) Bend right foot towards face - note sensation of tension in front of the leg below the knee.

Let go.

Repeat (a) slowly then quickly.

b) Bend right foot away from face - note tension in calf.

Repeat (a) procedure.

c) Extend right leg - note tension in front of thigh.

Repeat (a) procedures.

d) Bend leg - note tension in rear of thigh.

Repeat (a) procedure.

-25 e) Make right leg rigid and hold for 30 seconds - gradually relax.

25-40 Repeat (a) to (e) for left leg.

40-45 Lie quietly - eyes closed.

N.B. Know when tension is present.

Lesson 3 (Trunk/Neck)

Minutes

1-10 Lie quietly - eyes closed.
Remember to relax arms and legs.

10- a) Pull in abdominal wall and note tensions- let go.
Slowly.
Quickly.

b) Arch back - let go.
Slowly.
Quickly.

c) Breathe a little more deeply - note tensions all over chest and diaphragm regions - present only upon inspiration and when the breath is held. Absent during expiration (when not forced) and during the pause which preceeds the resumption of the breathing cycle.

d) Incline head to left
right
forward
backward
Slowly
and
Quickly

-40 e) Extend arms forward and inward - note tension in front of chest adjacent to arm.

Move shoulders backwards (downwards, towards spine - sensation between shoulder blades.

Slowly then quickly.

40-45 Lie quietly - eyes closed.

Lesson 4 (Forehead)

Minutes

1-10 Lie quietly - eyes closed.

10-20 Revision - arms, legs, abdomen, back, breathing, neck, trunk.

20-35 Wrinkle forehead/eyebrows - note tension.
Build up slowly and let go slowly - several times.

35-45 Lie quietly - eyes closed.

Lesson 5 (Eyelids)

Minutes

1-10 Lie quietly - eyes closed.

10-20 Revision.

20-35 a) Close eyelids tightly - build up and let go slowly several times.

b) As above - left eyelid.

c) As above - right eyelid.

35-45 Close eyes lightly and lie quietly.

Lesson 6 (Eyes)

Minutes

1-10 Lie quietly - eyes closed.

10-20 Revision.

20-35 Eyes closed:
look right
look left
look up and down
look forward

Let go and do not look in any direction.

Eyes open: Index fingers 3 feet apart - look from one finger to the other. Repeat with fingers 2 feet apart. Note tensions.

One finger above another - look up and down.

Look at one finger - note steady tension, when looking at a fixed object.

Lesson 7 (Visual Imagery)

Minutes

1-10 Lie quietly - eyes closed.

10-20 Revision.

20-35 Imagine a sky rocket shooting up - tension as for eyes up.

Imagine a friend - tension as for looking at friend.

With the above and the following practices you should notice that when eyes are relaxed no imagining occurs.

Imagine seeing fingers 3 feet apart.

Imagine seeing fingers 2 feet apart.

Imagine seeing a car pass.

Imagine seeing a bus pass.

Imagine seeing a ball rolling.

Imagine seeing a sailing boat in the distance.

Imagine seeing a tall tree.

Lesson 8 (Cheeks/Jaws)

Minutes

1-10 Lie quietly - eyes closed.

10-25 Revision.

25-35 Close jaws tightly - build up and let go slowly.
Open jaws widely - build up and let go slowly.
Show teeth as in forced smiling - build up and let go.

35-45 Close eyes - lie quietly.

Lesson 9 (Lips)

Minutes

1-10 Lie quietly - eyes closed.

10-30 Revision.

30-35 Round lips - say "Oh" - build up and let go slowly (noting tension).
Pout lips or whistle - build up and let go slowly.

35-45 Lie quietly - eyes closed.

Lesson 10 (Tongue)

Minutes

1-10 Lie quietly - eyes closed.

10-30 Revision.

30-35 Retract tongue - build up tension and let go slowly.

Press tongue on top of mouth - build up tension and let go slowly.

Push tongue against bottom front teeth - build up tension and let go slowly.

35-45 Lie quietly - eyes closed.

Lesson 11 (Speech)

Minutes

1-10 Lie quietly - eyes closed.

10-30 Revision.

30-35 Count loudly to 10 - note tensions in tongue, lips, jaw, throat, diaphragm, chest.

Count half as loudly - same tensions but not so obvious.

Count quietly decreasing tension.

Relax speech apparatus completely - should not long speak to self.

35-45 Lie quietly - eyes closed.

Lesson 12 (Imagined Speech)

Minutes

1-10 Lie quietly - eyes closed.

10-30 Revision.

30-35 Imagine asking a waiter to bring dinner and telling your students off.

Note tension in tongue, lips, throat, etc. as in speech. Do you notice eye tension as well?

Repeat above.

35-45 Lie quietly - eyes closed.

N.B. Totally relaxed - especially speech and eyes.

APPENDIX F

Table 6

Percentage Time Relaxed (Forearm)
(Statistical working details)

Experimental				Control			
To find $SS_e = \sum_{1}^{21} (d-M_e \text{diff})^2$				To find $SS_c = \sum_{1}^{20} (d-M_c \text{diff})^2$			
Subject	d	$d-M_e$ (d-10.8)	$(d-M_e)^2$	Subject	d	$d-M_c$ (d-0.09)	$(d-M_c)^2$
1	5.66	-5.14	26.42	22	-0.34	-0.43	0.19
2	9.95	-0.85	0.72	23	1.84	1.73	2.99
3	22.83	12.03	144.72	24	-3.56	-3.65	13.32
4	2.56	-8.24	67.90	25	-4.43	-4.34	19.62
5	67.78	56.98	3,246.72	26	13.67	13.58	184.42
6	1.33	-9.47	89.68	27	0.61	0.52	0.27
7	-4.56	-15.36	235.93	28	-2.83	-2.92	8.53
8	2.83	-7.97	60.68	29	2.55	2.46	6.05
9	7.77	-3.03	9.18	30	1.94	1.85	3.42
10	10.53	-0.27	0.07	31	-4.06	-4.15	17.22
11	-0.78	-11.58	134.09	32	-1.22	-1.31	1.71
12	5.32	-5.48	30.03	33	-1.67	-1.76	3.10
13	34.45	23.70	561.69	34	3.89	3.80	14.44
14	41.81	31.01	961.62	35	-7.28	-7.37	54.31
15	3.22	-7.58	57.46	36	1.33	1.24	1.54
16	3.22	-7.58	57.46	37	0.44	0.33	0.11
17	1.50	-9.30	86.49	38	-0.83	-0.92	0.85
18	6.33	-4.47	19.98	39	0.11	0.02	0.00
19	2.65	-8.15	66.42	40	-0.61	-0.70	0.49
20	1.83	-8.97	80.46	41	2.22	2.13	4.53
21	0.56	-10.24	104.85				
SS_e = 6,042.57				SS_c = 337.11			

$$\text{SE diff between two means} = \sqrt{\frac{SS_e + SS_c}{N_1 + N_2 - 2}\left(\frac{1}{N_1} + \frac{1}{N_2}\right)}$$

$$= \sqrt{\frac{SS_e + SS_c}{21+20-2}\left(\frac{1}{21} + \frac{1}{20}\right)}$$

$$= \sqrt{\frac{6{,}379.68 \times 0.0976}{39}}$$

$$t = \frac{D}{\text{SE diff}} = \frac{M_e - M_c}{\sqrt{15.9655}} = \frac{10.8-0.09}{3.9956} = \frac{10.71}{3.9956} = \underline{2.68}$$

$df=39$

$.95^{t}39 = 2.02$

$.99^{t}39 = 2.71$

Table 7

Percentage Time Relaxed (Forehead)
(Statistical Working details)

Experimental				Control			
To find $SS_e = \sum_{1}^{21} (d-M_e \text{ diff})^2$				To find $SS_c = \sum_{1}^{20} (d-M_c \text{ diff})^2$			
Subject	d	$d-M_e$ $(d-1.64)$	$(d-M_e)^2$	Subject	d	$d-M_c$ $(d-1.34)$	$(d-M_c)^2$
1	0.00	-1.64	2.69	22	2.61	1.27	1.61
2	4.39	2.75	7.56	23	6.78	5.44	29.59
3	8.72	7.08	50.13	24	-5.17	-6.51	42.38
4	2.54	0.90	0.81	25	-0.05	-1.39	1.93
5	7.97	6.33	40.07	26	1.67	0.33	0.11
6	0.00	-1.64	2.69	27	0.11	-1.23	1.51
7	-0.17	-1.81	3.28	28	-4.78	-6.12	37.45
8	2.77	1.13	1.28	29	0.67	-0.67	0.45
9	0.61	-1.03	1.06	30	0.05	-1.29	1.66
10	0.00	-1.64	2.69	31	-1.00	-2.34	5.48
11	0.82	-0.82	0.67	32	5.39	4.05	16.40
12	-0.02	-1.66	2.76	33	-0.89	-2.23	4.97
13	-0.11	-1.75	3.06	34	-0.71	-2.05	4.20
14	0.00	-1.64	2.69	35	8.22	6.88	47.33
15	3.56	1.92	3.69	36	-1.67	-3.01	9.06
16	0.33	-1.31	1.72	37	0.00	-1.34	1.80
17	0.50	-1.14	1.30	38	1.00	-0.34	0.12
18	1.00	-0.64	0.41	39	4.34	3.00	9.00
19	0.00	-1.64	2.69	40	0.39	-0.95	0.90
20	1.45	-0.19	0.04	41	9.89	8.55	73.10
21	0.00	-1.64	2.69				
$SS_e = \underline{133.98}$				$SS_c = \underline{289.05}$			

$$\text{SE diff between two means} = \sqrt{\frac{SS_e + SS_c}{N_1 + N_2 - 2}\left(\frac{1}{N_1} + \frac{1}{N_2}\right)}$$

$$= \sqrt{\frac{SS_e + SS_c}{21+20-2}\left(\frac{1}{21} + \frac{1}{20}\right)}$$

$$= \sqrt{\frac{423.03 \times 0.0976}{39}}$$

$$t = \frac{D}{\text{SE diff}} = \frac{M_e - M_c}{\sqrt{1.0586}} = \frac{1.64-1.34}{\sqrt{1.0586}} = \frac{0.3}{1.0288} = \underline{0.29}$$

$\text{df} = 39$

$.95{}^{t}39 = 2.02$

$.99{}^{t}39 = 2.71$

APPENDIX G

Table 8

QUARTER ANALYSIS

(Statistical Working details)

First Quarter of Time (Forearm)

Experimental					
No	Pre	Post	Diff	$d-M_e$	$(d-M_e)^2$
1	76.67	100.00	23.33	5.83	34.00
2	92.67	100.00	7.33	-10.17	103.43
3	79.56	97.33	19.57	2.07	4.29
4	93.56	98.89	5.33	-12.17	148.11
5	37.33	100.00	62.67	45.17	2040.33
6	94.67	100.00	5.33	-12.17	148.11
7	97.11	96.00	-1.11	-18.61	346.33
8	92.00	99.56	7.56	-9.94	98.80
9	84.89	99.56	14.67	-2.83	8.01
10	78.00	100.00	22.00	4.50	20.25
11	99.33	98.00	-1.33	-18.83	354.57
12	85.78	99.78	14.00	-3.50	12.25
13	10.22	97.78	87.56	70.06	4908.40
14	43.78	100.00	56.22	38.72	1499.24
15	95.56	99.11	3.55	-13.95	194.60
16	88.89	100.00	11.11	-6.39	40.83
17	96.89	100.00	3.11	-14.39	207.07
18	79.88	100.00	20.12	2.62	6.86
19	97.33	99.56	1.23	-16.27	264.71
20	97.11	100.00	2.89	-14.61	213.45
21	97.78	100.00	2.22	15.28	233.48
	M_e = 1750			SS_e = 10887.13	

Table 8

QUARTER ANALYSIS

(Statistical Working details)

First Quarter of Time (Forearm)

Control

No	Pre	Post	Diff	$d-M_c$	$(d-M_c)^2$
22	97.56	86.89	-10.67	-11.30	127.69
23	97.33	85.78	-1.55	-2.18	4.75
24	84.89	88.67	3.78	3.15	9.92
25	98.89	82.89	-16.00	-16.33	276.56
26	60.22	52.44	-7.78	-8.41	70.72
27	96.44	94.00	-2.44	-3.07	9.42
28	96.44	96.67	0.23	-0.40	0.16
29	87.33	96.89	9.56	8.93	79.75
30	96.22	100.00	3.78	3.15	9.92
31	96.67	95.78	-0.89	-1.52	2.31
32	98.67	95.56	-3.11	-3.74	13.99
33	95.44	93.11	-2.33	-2.96	8.76
34	75.78	92.22	16.44	15.81	249.96
35	91.78	95.56	3.78	3.15	9.92
36	86.89	98.22	11.33	10.70	114.49
37	82.89	95.11	12.22	11.59	134.33
38	98.44	97.11	-1.33	-1.96	3.84
39	96.89	94.22	-2.67	-3.30	10.89
40	98.00	96.44	-2.56	-3.19	10.18
41	94.67	96.56	2.89	2.26	5.11

$M_c = 0.63$

$SS_c = 1152.67$

$$\text{SE diff between means} = \sqrt{\frac{SS_e + SS_c}{N_1 + N_2 - 2}\left(\frac{1}{N_1} + \frac{1}{N_2}\right)}$$

$$= \sqrt{\frac{SS_e + SS_c}{21 + 20 - 2}\left(\frac{1}{21} + \frac{1}{20}\right)}$$

$$= \sqrt{\frac{12,039.80 \times 0.0976}{39}}$$

$$t = \frac{D}{\text{SE diff}} \quad = \frac{M_e - M_c}{\text{SE diff}} \quad = \frac{16.87}{\sqrt{30.13}} \quad = \frac{16.87}{5.49} \quad = \underline{3.07}$$

df = 39

$.95\,t_{39} = 2.02$

$.99\,t_{39} = 2.71$

<u>Therefore the treatment is significant at 0.01</u>

Table 9

QUARTER ANALYSIS

(Statistical Working details)

Second Quarter of Time (Forearm)

Experimental

No	Pre	Post	Diff	$d-M_e$	$(d-M_e)^2$
1	100.00	99.33	-0.67	-14.86	220.80
2	84.00	98.67	14.67	0.48	0.23
3	54.44	98.89	44.45	30.26	915.80
4	99.66	99.78	0.12	-14.07	198.00
5	21.11	100.00	78.89	64.70	4186.00
6	100.00	100.00	00.00	-14.19	201.50
7	91.11	72.00	-19.11	-33.30	1109.00
8	97.56	98.22	0.66	-13.53	183.50
9	83.56	100.00	16.44	2.25	5.06
10	85.78	100.00	14.22	0.03	0.00
11	100.00	98.44	-1.56	-15.75	242.30
12	96.89	100.00	0.11	-14.08	198.30
13	51.33	100.00	48.67	34.48	1190.00
14	26.89	100.00	73.11	58.92	3470.00
15	92.44	93.33	6.89	-7.30	53.29
16	99.78	100.00	0.22	-13.97	195.20
17	100.00	100.00	0.00	-14.19	201.50
18	96.22	100.00	3.78	-10.41	108.37
19	75.31	100.00	24.69	10.50	110.25
20	95.56	100.00	2.44	-11.75	138.00
21	100.00	100.00	0.00	-14.19	201.50
	M_e = 14.19			SS_e = 13128.60	

Table 9

QUARTER ANALYSIS

(Statistical Working details)

Second Quarter of Time (Forearm)

Control					
No	Pre	Post	Diff	$d\text{-}M_c$	$(d\text{-}M_c)^2$
22	98.00	99.33	1.33	2.66	7.08
23	98.00	98.44	0.44	1.77	3.13
24	96.44	80.89	-15.55	-14.22	20.22
25	100.00	99.11	-0.89	0.44	0.19
26	80.44	84.44	4.00	5.33	28.41
27	94.67	92.67	-2.00	-0.67	0.49
28	100.00	96.67	-3.33	-2.00	4.00
29	98.22	96.89	-1.33	0.00	0.00
30	96.67	100.00	3.33	4.66	21.72
31	97.56	97.11	-0.55	0.78	0.61
32	99.56	99.33	-0.23	1.10	1.21
33	98.00	98.89	0.89	2.22	4.93
34	98.89	95.44	-3.56	-2.23	4.97
35	97.00	92.00	-5.00	-3.67	13.47
36	97.33	96.22	-1.11	0.22	0.05
37	99.78	99.33	-0.45	0.88	0.77
38	99.56	99.33	-0.23	1.10	1.21
39	100.00	97.33	-2.67	-1.34	1.80
40	97.78	96.89	-0.89	0.44	0.19
41	98.89	100.00	1.11	2.44	5.95
	$M_c = -1.33$			$SS_c = 302.38$	

$$\text{SE diff between means} = \sqrt{\frac{SS_e + SS_c}{N_1 + N_2 - 2}\left(\frac{1}{N_1} + \frac{1}{N_2}\right)}$$

$$= \sqrt{\frac{SS_e + SS_c}{21+20-2}\left(\frac{1}{21} + \frac{1}{20}\right)}$$

$$= \sqrt{\frac{13,430.98 \times 0.0976}{39}}$$

$$t = \frac{D}{\text{SE diff}} = \frac{M_e - M_c}{\text{SE diff}} = \frac{15.52}{33.61} = \frac{15.52}{5.80} = 2.68$$

$df = 39$

$.95^{t}39 = 2.02$

$.99^{t}39 = 2.71$

<u>Therefore the treatment is significant at 0.05</u>

<u>And not significant at 0.01</u>

Table 10

QUARTER ANALYSIS

(Statistical Working details)

Third Quarter of Time (Forearm)

Experimental

No	Pre	Post	Diff	d-M_e	$(d-M_e)^2$
1	100.00	100.00	0.00	-5.80	33.64
2	87.56	100.00	12.44	6.64	44.09
3	82.22	100.00	17.88	11.98	143.52
4	97.56	100.00	2.44	-3.36	11.29
5	37.33	100.00	62.67	56.87	3237.61
6	100.00	100.00	00.00	-5.80	33.64
7	99.11	100.00	0.89	-4.11	16.89
8	96.67	99.33	2.66	-2.14	4.58
9	99.11	100.00	0.89	-4.11	16.89
10	96.00	100.00	4.00	-1.80	3.24
11	99.33	99.56	0.23	-5.57	31.03
12	97.78	100.00	2.22	-3.58	12.82
13	98.67	100.00	1.33	-4.47	19.98
14	90.00	100.00	10.00	4.20	17.64
15	99.78	100.00	0.22	-5.58	31.14
16	99.78	100.00	0.22	-5.58	31.14
17	98.00	100.00	2.00	-3.80	14.44
18	99.56	100.00	0.44	5.36	28.73
19	98.67	100.00	1.33	-4.47	19.98
20	100.00	100.00	0.00	-5.80	33.64
21	100.00	100.00	0.00	-5.80	33.64

M_e = 5.80

SS_e = 3819.57

Table 10

QUARTER ANALYSIS

(Statistical Working details)

Third Quarter of Time (Forearm)

Control					
No	Pre	Post	Diff	$(d-M_c)$	$(d-M_c)^2$
22	93.56	94.44	0.88	-1.05	1.10
23	96.89	100.00	3.11	1.18	1.39
24	93.78	86.67	-7.11	-9.04	81.72
25	100.00	100.00	0.00	-1.93	3.73
26	47.78	92.00	44.22	42.29	1789.29
27	94.67	98.89	4.22	2.29	5.24
28	99.11	94.22	-4.89	-6.82	46.51
29	98.22	100.00	1.78	-0.15	0.02
30	99.33	100.00	0.67	-1.26	1.59
31	98.44	90.44	-8.00	-9.93	98.61
32	98.67	99.56	0.89	-1.04	1.08
33	100.00	96.44	-0.56	-2.49	6.20
34	94.22	96.22	2.00	0.07	0.01
35	93.56	91.56	-2.00	-3.93	15.45
36	96.44	93.78	-2.66	-4.59	21.07
37	100.00	100.00	0.00	-1.93	3.73
38	99.56	97.78	-1.78	-3.71	13.76
39	98.00	99.89	1.89	-0.04	0.00
40	99.11	99.11	0.00	-1.93	3.73
41	94.00	100.00	6.00	4.07	16.57

$M_c = 1.93$ $SS_c = 2110.82$

$$\text{SE diff between means} = \sqrt{\frac{SS_e + SS_c}{N_1 + N_2 - 2}\left(\frac{1}{N_1} + \frac{1}{N_2}\right)}$$

$$= \sqrt{\frac{SS_c + SS_c}{21+20\ -2}\left(\frac{1}{21} + \frac{1}{20}\right)}$$

$$= \sqrt{\frac{5{,}930.39 \times 0.0976}{39}}$$

$$t = \frac{D}{\text{SE diff}} = \frac{M_e - M_c}{\text{SE diff}} = \frac{3.87}{\sqrt{14.84}} = \frac{3.87}{3.85} = \underline{1.005\ \text{N.S.}}$$

$df = 39$

$.95^{t}39 = 2.02$

$.99^{t}39 = 2.71$

Table 11

QUARTER ANALYSIS

(Statistical Working details)

Fourth Quarter of Time (Forearm)

Experimental

No	Pre	Post	Diff	$d-M_e$	$(d-M_e)^2$
1	100.00	100.00	0.00	-8.28	68.56
2	91.78	100.00	8.22	-0.06	0.00
3	60.22	100.00	39.78	31.50	992.25
4	98.67	100.00	1.33	-6.95	48.30
5	23.56	100.00	76.44	68.16	4651.24
6	100.00	100.00	0.00	-8.28	68.56
7	97.78	100.00	2.22	-6.06	37.72
8	97.56	100.00	2.44	-5.84	34.11
9	97.78	100.00	2.22	-6.06	37.72
10	97.56	100.00	2.44	-5.84	34.11
11	100.00	98.89	-1.11	-9.39	88.17
12	96.00	99.56	3.56	-4.72	22.28
13	98.67	100.00	1.33	-6.75	48.30
14	69.78	100.00	30.22	21.94	481.36
15	97.33	99.56	2.23	-6.05	36.60
16	99.33	100.00	0.67	-7.61	57.91
17	100.00	100.00	0.00	-8.28	68.56
18	99.11	100.00	0.89	-7.31	53.44
19	98.22	100.00	0.78	-7.50	56.25
20	99.89	100.00	0.11	-8.17	66.75
21	100.00	100.00	0.00	-9.28	68.56

$M_e = 8.28$

$SS_e = 7020.75$

Table 11

QUARTER ANALYSIS

(Statistical Working details)

Fourth Quarter of Time (Forearm)

Control

No	Pre	Post	Diff	$(d-M_c)$	$(d-M_c)^2$
22	89.56	97.78	8.22	8.29	68.72
23	94.67	100.00	5.33	5.40	29.16
24	84.67	87.56	2.89	2.96	8.76
25	99.33	100.00	0.67	0.74	0.55
26	68.44	82.67	14.23	14.30	204.49
27	95.78	98.44	2.66	2.73	7.45
28	100.00	92.67	-7.33	-7.26	52.71
29	99.78	100.00	0.22	0.29	0.84
30	100.00	100.00	0.00	0.07	0.01
31	97.56	90.67	-6.89	-6.82	46.51
32	100.00	98.22	-1.78	-1.71	2.92
33	99.34	97.78	-1.56	-1.49	2.22
34	99.33	100.00	0.67	0.74	0.55
35	98.00	80.44	-18.44	-18.37	338.56
36	99.11	97.11	-2.00	-1.93	3.73
37	99.56	100.00	0.44	0.51	0.26
38	100.00	100.00	0.00	0.07	0.01
39	97.78	98.00	0.22	0.29	0.84
40	100.00	100.00	0.00	0.07	0.01
41	98.89	100.00	1.11	1.18	1.39

$M_c = -0.07$

$SS_c = 769.69$

SE diff between means $= \sqrt{\frac{SS_e + SS_c}{N_1 + N_2 - 2} \left(\frac{1}{N_1} + \frac{1}{N_2}\right)}$

$$= \sqrt{\frac{SS_e + SS_c}{21 + 20 - 2} \left(\frac{1}{21} + \frac{1}{20}\right)}$$

$$= \sqrt{\frac{7790.44 \times 0.0976}{39}}$$

$$t = \frac{D}{SE\ diff} = \frac{M_e - M_c}{SE\ diff} = \frac{8.35}{\sqrt{19.5}} = \frac{8.35}{4.42} = \underline{1.89}$$

df = 39

$.95\,t_{39} = 2.02$

$.99\,t_{39} = 2.71$

$.90\,t_{39} = 1.68$

<u>Therefore the treatment is significant at 0.10</u>

<u>And not significant at 0.01 or 0.05</u>

APPENDIX H

PILOT PROJECT CALCULATIONS

Forearm Tension

$M = -47.92$

$M_1 - M_2 = -47.92$ (Diff of means = mean of diff)

St. Dev$^{\underline{n}.}$ of Diff (S_{Diff}) $= \sqrt{\frac{\sum x^2}{N}} = \sqrt{\frac{39,872.04}{3}}$

$$= \sqrt{13,290.68} = 115.29$$

St Error of Diff (SD) $= \frac{S_{Diff}}{\sqrt{N - 1}} = \frac{115.29}{\sqrt{2}} = 81.53$

$$t = \frac{D}{SD} = \frac{-47.92}{81.53} = \underline{-0.59}$$

Forehead Tension

$M = -52.08$

$M_1 - M_2 = -52.08$

$$S_{Diff} = \sqrt{\frac{\sum x^2}{N}} = \sqrt{\frac{2741.11}{3}} = \sqrt{913.7033} = 30.23$$

$$SD = \frac{S}{\sqrt{N - 1}} \quad \frac{30.23}{\sqrt{2}} = 21.38$$

$$t = \frac{D}{SD} = \frac{52.08}{21.38} = \underline{-2.43}$$

Percentage Time Relaxed (Forearm)

$$M = 0.50$$

$$M_1 - M_2 = 0.50$$

$$S_{Diff} = \sqrt{\frac{\sum x^2}{N}} = \sqrt{\frac{.13}{3}} = 0.21$$

$$SD = \frac{S}{\sqrt{N-1}} = \frac{0.21}{\sqrt{2}} = 0.15$$

$$t = \frac{D}{SD} = \frac{0.50}{0.15} = \underline{3.33}$$

Percentage Time Relaxed (Forehead)

$$M = 0.22$$

$$M_1 - M_2 = 0.22$$

$$S_{Diff} = \sqrt{\frac{\sum x^2}{N}} = \sqrt{\frac{0.23}{3}} = \sqrt{.0766} = 0.28$$

$$SD = \frac{S}{\sqrt{N-1}} = \frac{0.28}{\sqrt{2}} = .20$$

$$t = \frac{D}{SD} = \frac{0.22}{0.20} = \underline{1.1}$$

Appendix I

FINAL LETTER TO ALL SUBJECTS

Department of Kinanthropology,
School of Physical Education,
University of Ottawa.

July , 1969.

Dear

Relaxation Experiment - June 1969

The results of the experiment proved statistically that relaxation training was effective on the forearm muscle group. The post-training recordings on the forehead generally showed less tension, but this was not a statistically significant change.

The above is all that can be said objectively, but many subjects reported subjective benefits. These facts, plus previously reported subjective findings, may make some subjects think relaxation training would be worthwhile over a longer period. Whatever you decide, I do thank you again for your considerable help with the experiment.

Yours sincerely,

John J. Jackson
(Research Assistant)