THE EFFECTS OF EXERCISE AND TRIAZOLAM ON NEUROMUSCULAR TENSION AS MEASURED BY THE H/M RATIO

by

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DEDICATION

This is dedicated to my family and friends.

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CHAPTER 1

INTRODUCTION

One of the growing concerns in today's society is the adverse effects of stress. Stress consists of both cognitive and physiological components. A cognitive emotional aspect of stress is anxiety which can be examined through physiological measures such as heart rate, blood pressure, and muscle tension. Electromyography (EMG) is a common technique used in measuring muscle tension. This method records electrical activity of muscle action potentials (MAP's) which indicate potential muscle tension. MAP's are the ionically produced electrical activity involved in muscle contraction. The level of electrical activity in a muscle will approximate total body tension (deVries, Wiswell, Bulbulian, & Moritani, 1981). Another indication of muscle tension and a measure of spinal reflex activity is the Hoffman reflex (H-reflex), typically induced by artificial electrical stimulation of the tibial nerve in humans.

Some evidence points to exercise as an effective means of reducing muscle tension. deVries (1968), for example, found both acute and chronic exercise led to decreased electrical activity in resting muscle action potentials (MAP's) as measured by by the H-reflex (deVries, Wiswell, Bulbulian, & Moritani, 1981). To control for H-wave variations due to stimulus changes,

the H/M ratio was developed by dividing the maximum H-wave by the maximum M-wave (produced by direct stimulation of the alpha motoneuron) (Angel & Hofmann, 1963). While low and high intensity exercise showed decreases in the H/M ratio, high intensity exercise in particular appears more proficient in reducing muscle tension (Bulbulian & Darabos, 1986). These findings have led several researchers to conclude that reductions in H/M ratios were due to a "tranquilizer effect" (a decrease in neuromuscular tension) as a result of exercise (deVries et al., 1981; Bulbulian & Darabos, 1986).

Possible explanations of an exercise induced tranquilizer effect include: a) exercise induced heating of the hypothalamus and body to produce diminished muscle spindle activity coincident with synchronous cortical electrical events (Von Euler & Soderberg, 1956), b) varied, periodic, and continual alterations in proprioceptive stimuli during exercise which allow normal activity of the cortex (Haugen, Dixon, & Dickel, 1960), and c) endorphin release during exercise also believed to produce a "morphine-like" effect (Morgan, 1985).

The tranquilizer effect of pharmacological agents also shows reductions of the H-reflex (Brunia, 1973). Therefore, a comparison between drugs and exercise as muscle relaxants would seem appropriate. Comparing the effects of exercise and meprobamate, a muscle relaxant, deVries and Adams (1972) indicated that exercise more

effectively reduced muscular tension than meprobamate. Conclusions suggest that exercise at 100 BPM brought about greater reductions in muscle tension than higher intensity exercise (120 BPM) and meprobamate. However, noting that both the plasma concentrations and physiological effects of meprobamate peak within 2-3 hours after ingestion (Goodman & Gilman, 1975) post-tests occurring 30-90 minutes after drug administration did not allow sufficient time for meprobamate effects to take place. Therefore, interpretation of these data should be approached with caution.

A fast acting anti-anxiety benzodiazepine, triazolam, may overcome the problem of slow activation seen in meprobamate (Greenblatt, Divoll, Abernathy, & Shader, 1982). Triazolam, introduced in 1981, reaches peak blood concentrations at approximately 30 minutes post- ingestion (Pugsley & Cohon, 1982). Using triazolam should produce decreased neuromuscular tension concurrent with exercise induced relaxation since the peak exercise effects occur at 30 minutes. This information infers that triazolam could produce greater changes in muscle tension reduction than meprobamate.

Purpose of the Study

The purpose of this study was to examine the effects of exercise and triazolam on the neuromuscular tension and motoneuron excitability as measured by H/M ratios.

Hypotheses

The following hypotheses were tested:

1) Subjects using triazolam will show a greater reduction in H/M ratios than subjects using the placebo.

2) Subjects performing moderate to high intensity exercise will show a greater reduction in H/M ratios than subjects using triazolam or the placebo without exercising.

3) Subjects using both triazolam and exercise will show a greater reduction in H/M ratios than subjects using triazolam or exercise alone.

Delimitations

The following delimitations are given because they restrict the extent that the conclusions may be validly generalized:

1) Subjects were eight college male volunteers, aged 22-30 years.

2) Participation was limited to competitive or recreational runners able to complete 20 minutes of running on the treadmill at 75% of VO2max.

3) The H/M ratio measured motoneuron pool excitability during artificial electrical stimulation of the soleus muscle.

4) Triazolam was administered in .25 mg doses.

Limitations

The following limitations may have diminished the validity of this study:

1) Daily variations in emotional states of subjects may have influenced H/M ratios during testing.

2) The H/M ratios may include the measurement of both the triceps surae and peroneals.

3) The H/M ratio is a measurement of motoneuron pool excitability and infers changes in neuromuscular tension.

Definition of Terms

The following section will define several terms within this text to prevent ambiguous interpretation:

Muscle Action Potentials (MAP's): The exchange of counter-ions across the cellular membrane created by neural suprathreshold stimulation which ultimately produces muscle contraction.

Electromyography (EMG): The recording of electrical events between two surface electrodes resulting from muscle action potentials.

Hoffman Reflex (H-reflex): The reflex response which results from artificial electrical stimulation of a mixed nerve.

M-wave: A contraction in response to direct stimulation of motor fibers in skeletal muscle.

H/M Ratio: The ratio produced by dividing the maximum H-wave by the maximum M-wave measured.

Maximal Oxygen Consumption (V02max): The maximum rate of oxygen consumption by the body during work.

CHAPTER 2

LITERATURE REVIEW

A review of the literature regarding decreases in anxiety and neuromuscular tension facilitated by exercise will be presented in this chapter. Measurement techniques for muscle tension and decreased motoneuron excitability will be introduced in unison with literature which demonstrates this occurrence. Finally, the physiological rationale for muscle tension reduction and the tranquilizer effect of exercise will be discussed.

Use of the H/M Ratio as a Measure of Stress

The Hoffmann reflex (H-reflex) measures spinal reflexes which reflect muscle tension associated with stress (Angel & Hofmann,1963; deVries, 1981; Dishman, 1985). In a study by Magladery, Porter, Park, and Teasdall (1951) stimulation of afferent fibers of the tibial nerve produced muscle action potentials whose magnitude was believed to indicate central inhibition or excitation on reflexes. The reflex muscle action potentials produced from artificial electrical stimulation of mixed nerve fibers in the soleus muscle is known as the Hoffmann reflex or H-reflex. The H-reflex is the result of an action potential created by artificial electrical stimulation. This is achieved by an electrical impulse delivered to the tibial nerve at the popliteal fossa. The electrical shock given will elicit two MAP's which are recorded by an oscilloscope.

By studying the electric waves produced by these MAP's, motoneuron excitability may be determined (Angel & Hofmann, 1963). The first wave recorded is the M-wave which results from direct stimulation of the alpha motor fibers. After a slight delay the H-wave or H-reflex will appear. Formation of this complex occurs through electrical impulses traveling along the afferent nerve to the central nervous system (CNS) and back down the efferent pathway (alpha motor neuron) to the same muscle which stimulates contraction. The size of the second MAP (H-reflex) is an indication of motoneuron excitability and reflects the level of muscle tension in a subject. According to Crayton and King (1981) the H-reflex is high in individual variability. When using this measure as an indicator of motoneuron excitability caution must be taken to ensure factors other than neuromuscular tension do not contaminate the results. For example, Issacs and Szumski (1968) tested four variables and their influence on the H-reflex. Results indicated that a Jendrassik manuever (muscular contractions which enhance reflex excitability) and postural changes altered the H-reflex. Hugon (1973) also noted that proper body positioning and correct soleus electrode placement are essential for reliable recordings.

Angel and Hofmann (1963) developed a variation of the H-reflex believed to be more useful and accurate. They measured normal, rigid, and spastic subjects from which they concluded that: a) absolute values of the H-

wave were affected by skin thickness and electrode placement, and b) one stimulus intensity allowed large variations in the size of H- and M-waves. By measuring the maximal H-wave and M-wave and then dividing these values, the H/M ratio was derived. Since the maximum M-wave is acquired through direct stimulation it has a constant value due to 100% recruitment of the motor fibers. The H-wave, achieved only after passing through the CNS, is subject to various levels of excitation or inhibition. Therefore, any change in the H/M ratio indicates a change in motoneuron excitability or neuromuscular tension. Experimental reproductions of H/M ratios by changing stimulus intensity would mimic different electrical levels in muscle. By increasing the stimulus strength the H-wave will also be elevated. If the experimenter increases the stimulus to levels greater than the maximum H-wave it will begin to disappear simultaneously as the M-wave increases (Hugon, 1973; Magladery et al., 1951). When the M-wave is at maximum amplitude the H-wave is nonexistent suggesting a blocking effect of antidromic impulses in motoneurons (Magladery et al., 1951). Therefore, stimulus strength must be increased slowly or the H-reflex may be overlooked. Hugon (1973) suggested that the maximum M-wave first be dicovered, then a retracing back through lower voltages will bring back the H-wave. Once these procedures have been properly executed an accurate assessment of a

subjects neuromuscular tension may be interpreted.

Anxiety and Neuromuscular Tension Reduction

In a review article by Dishman (1985), both acute and chronic exercise are cited as decreasing levels of anxiety. Morgan (1985) suggested this effect may last from 2-5 hours. The National Institute of Mental Health also contends that: a) exercise is associated with cognitive stress reductions such as in anxiety, b) long term exercise decreases anxiety, and c) appropriate execise will result in decreased muscle tension.

Anxiety is often noted by subjective feelings of increased muscle tension (Bahrke, 1979). Therefore, studies which have tested both anxiety and muscle tension reduction were performed. Sime (1977) tested the effect of exercise, meditation, and a placebo treatment on reducing several stress-related physiological measures and state anxiety. Subjects were 48 students who reported state anxiety. Measures of state anxiety were made during pre- and post-treatment. Physiological measures were performed at the same time with an additional recording during the test. Students were randomly placed into groups which consisted of: a) exercise on a treadmill at a heart rate (HR) of 100-110 beats per minute (BPM), b) meditation for 15 minutes, and c) a control placebo pill. Results indicated state anxiety was lower (although not significantly) for exercise and meditation groups. Electromyography (EMG) data indicated that all treatment groups decreased muscle

tension.

The former results may have prompted a more substantial study by Bahrke and Morgan (1978). They compared three separate conditions to find their effects on muscle tension and state anxiety as defined by the State Trait Anxiety Inventory (STAI). Adult males (n=75) were placed into three experimental groups which received treatment during 20 minutes under each condition. These groups consisted of: 1) walking on a treadmill at 70% VO2max, 2) meditation, and 3) a distraction group which rested quietly. All groups possessed similar capabilities in reducing state anxiety according to the STAI scores. The anti-anxiety effect of distraction and exercise are initially equal, however, tension reduction following exercise has a much longer lasting effect.

Review articles and previously cited evidence agree that a reduction in state anxiety can effectively be brought about through the use of various types of exercise (Dishman, 1985; Morgan, 1985).

Exercise and the H/M Ratio

Recent studies utilizing the H/M ratio as an indicator of neuromuscular tension have met with generally successful results. A study by deVries, Wiswell, Bulbulian, and Moritani (1981) attempted to measure what they termed a "tranquilizer effect" of exercise since tranquilizers are known to reduce the H/M ratio. Subjects included two elderly subjects (ages 66

and 80) with chronic stress related conditions and eight young (20-34 years) adults. Subjects were tested on three different days before and after exercise and control conditions. Exercise consisted of 20 minutes of cycling on a bicycle ergometer at 40% of heart rate range (HRR). The control condition consisted of 20 minutes of sitting quietly. Motoneuron excitability decreased following exercise as shown by a mean reduction of 18.7% in the H/M ratio. Following the control trial an insignificant mean increase of 1.2% was shown. This significant decrease in the H/M ratio occurred in all subjects which supports a generalized neuromuscular relaxation or tranquilizer effect. Thus, it was concluded that low intensity exercise continued for at least 20 minutes produced a reduction in neuromuscular tension.

A similar study, recently completed, tested the H/M ratio following both low and high intensity exercise. Bulbulian and Darabos (1986) proposed that the previous evidence negating the importance of high intersity exercise was invalid. Pitts and McClure (1967), for example, prompted anxiety attacks in twenty neurotic patients by infusing dl-sodium lactate. They concluded these induced lactate levels would simulate those attained during strenuous exercise. However, deVries (1981) cited several inconsistencies with Pitts and McClure's assumptions in his review on the tranquilizer effect of exercise. deVries (1981) questioned whether:

a) endogenous lactate differs in composition from dl-sodium lactate, b) highly anxious individuals to possess a high resting level of lactate, and c) whether it is not consistent for patients with anxiety neurosis to have anxiety attacks due to high lactate levels. Bulbulian and Darabos (1986) investigated the relationship between high lactate levels and anxiety. Their subjects were five males and five females measured before and after each treatment by the H/M ratio. After a control period of sitting quietly, subjects ran on a treadmill for 20 minutes at 40% of VO2max and then 75% of VO2max. Results indicated H/M ratios decreased after both exercise trials. The low intensity exercise resulted in a mean decrease of 12.8% while the high intensity group showed a reduction of 21.5%. The control group exhibited an insignificant mean increase of 2.1%. The results of this study suggest that high intensity exercise more effectively reduced muscle tension than low intensity exercise.

Proposed Mechanisms for Exercise Induced Relaxation

Although the previously mentioned studies present evidence of decreased muscle tension, the physiological mechanisms of decreased muscle tension have not been addressed. This section, therefore, addresses possible physiological explanations for muscle relaxation.

Heat. Several studies cite the work of Von Euler and Soderburg (1956; 1957) as one possible explanation for

exercise tension reduction. In their animal studies they noted drowsiness and muscular relaxation resulting from an increase in hypothalamic and total body temperature. deVries (1968), utilizing this theory in his study postulated that exercise would increase body temperature, and as a result, decrease neuromuscular activity. Two processes for this reduction were proposed: a) decreased cortical activity should decrease alpha innervation of muscles, and b) gamma activity on intrafusal fiber should decrease muscle activity. An elevation of heat would be quite evident in high intensity exercise, but may not occur in low intensity exercise. However, a recent study by Bowles (1987) found that metabolically matched concentric and eccentric work produced unequal post- H/M ratio reductions. Matched work should produce similar temperature responses and therefore equal changes in motoneuron excitability. This new evidence suggests that body temperature may not be a primary causal mechanism for decreased motoneuron pool excitability. Further study is needed to clarify the relationship between elevation of body and hypothalamic temperature and decreased motoneuron excitability.

Central Influences. A theory by Haugen, Dixon, and Dickel (1960) may explain the tranquilizer effect of low intensity exercise. The theory states that random and variable proprioceptive stimuli would allow normal cortical activity, while consistent exposure to excessively strong stimuli may induce arousal. Low

intensity exercise, as suggested previously, also allows normal cortical activity, which in turn, may induce relaxation (deVries, 1981). However, it is the high intensity exercise which is particularly associated with the tranquilizer effect (Bulbulian & Darabos, 1986). These exercise effects may best be understood by focusing on central and peripheral factors. Extensive reviews by Bonnet, Requin and Semjen (1981) and McCrea (1986) confirm these possibilities which are too detailed to list completely in this review. However, both of these reviews refer to the importance of presynaptic inhibition or excitation upon motoneuron excitability. In group Ia alpha-motoneuron inhibition occurs when excitatory post-synaptic potentials (EPSP) are decreased via augmentation of presynaptic inhibition or elevated through a lowered level of tonic presynaptic inhibition (McCrea, 1986).

One theory which incorporates the influences of both Ia and Ib afferents upon motoneuron excitability is the "moto servo" theory (Houk, 1979). Ib afferents are influenced by muscle tension changes while Ia afferents are controlled through variations in muscle spindle length. The product of muscle tension and length is referred to as a measure of muscle "stiffness" which is controlled by Ia and Ib afferents. An explanation of these occurrences has been summarized by Bonnet et al. (1981). The changes in excitability along the reflex pathway include: a) stretch sensitivity of muscle

spindles governed by gamma motoneuron activity, b) spindle transmissions to alpha-motoneurons controlled by spinal interneuron inhibition, and c) alpha-motoneuron excitability which determines reflex response amplitude.

Endorphins. Another theory for exercise induced relaxation is the production of endorphin-related tranquilization during exercise. Endorphins reportedly reduce pain and lend a sense of euphoria through a morphine-like effect (Grossman & Sutton, 1985; Morgan, 1985). Many anecdotal accounts support these views without any valid human data. Work by Pert and Bowie (1979) involved five minutes of forced swimming in an ice bath by rats. Results indicated an increase in opiate receptor occupancy, an indication of increased release of endorphins. Support for this theory was noted when the opiate antagonist naloxone was introduced to animal and human subjects. Christie and Chesher (1982) found that mice engaging in a regular swimming program seemed to show physical addiction to exercise. This assumption was formulated following the administration of naloxone. A development of symptoms similar to withdrawl from drug addiction occured among the mice. Similar findings occurred when rats and human subjects were tested for pain duration.

Shyu, Andersson, and Thoren (1982) reported that pain or squeak threshold was elevated in rats following exercise. Rats were exercised for seven kilometers/night for three to four weeks. During the first hour of

running the squeak threshold was elevated and remained so til the following morning. The elevation in threshold was reflected by the amount of running. The squeak threshold was decreased following six hours of inactivity or naloxone treatment . These findings suggest that exercise may induce an analgesic effect via central endorphin mechanisms.

Haier, Quaid, and Mills (1981) tied a 3 lb. weight to each subjects finger until pain was reported. Subjects then ran one mile. Following exercise, subjects given 10 mg of nalaxone reported pain more rapidly than subjects receiving placebo. Endorphin release possibly blocked by the drug, thereby attenuated the opiate effect. However, no conclusive evidence confirms that opiate receptor occupancy is attributed to exercise induced tranquilization. Clearly more data is needed for proper interpretation of endorphin related decreases in motoneuron pool excitability.

Monoamine Theory. Other neurotransmitters such as norepinepherine (NE) and serotonin (5-HT) have been altered in animal brains following exercise. Barchus and Freedman (1962) attained significant alterations in brain levels of NE and 5-HT following an acute bout of swimming. Brown and Van Huss (1973) and Brown, Payne, Kim, Moore, Krebs, and Martin (1979) found increased levels of NE and 5-HT in rat brains following interval training as compared to sedentary controls. It is

interesting to note that benzodiazepine tranquilizers are believed to exert there relaxant effects through alterations in 5-HT transmission; however, evidence supporting these claims is inconclusive (Nutt & Cowen, 1987).

Tranquilizers and Exercise

The previous work of deVries (1981) mentioned the tranquilizer effect of exercise and Morgan (1985) has referred to the morphine-like properties of endorphins. Tranquilizers are known to reduce CNS excitability as measured by the H-reflex (Brunia, 1973; Gassel, 1973)). In 1972, deVries and Adams compared a tranquilizing drug (meprobamate) and certain forms of exercise. Five conditons were used: 1)400 mg of meprobamate, 2) placebo; 400 mg of lactose prepared in identical capsule form , 3) 15 minutes of walking at a heart rate of 100 BPM, 4) 15 minutes of walking at a heart rate of 120 BPM, and 5) control; where the subject sat and read for an equivalent amount of time. Pre-trial tests were completed during disturbed or undistured conditions. Disturbed conditions involved completing problems using arithmetic, while undisturbed trials lacked this stressor. Post-tests occurred 30, 60, and 90 minutes following the pre-test. Results indicated that exercise was more effective in reducing muscular tension than meprobamate. Exercise at a heart rate of 100 BPM showed reductions of 20%, 23%, and 20% during the three post-trials, while meprobamate and placebo showed no

significant difference from controls. Exercise at a heart rate of 120 BPM showed less effectiveness. It was concluded that single doses of specific low intensity exercise may reduce muscle tension more effectively than meprobamate. However, methodological errors cloud proper interpretation of these data.

Triazolam

Triazolam is a hypnotic drug with a short mean plasma half-life of 2.3 hours which ranges from 1.7-3.0 hours (Physicians Desk Reference, 1985). Peak blood concentrations of triazolam tablets diluted in water to concentrations of .0083% occur at approximately .5 hours (Pugsley & Cohon, 1982). Triazolam is rapidly and efficiently absorbed by humans with a short elimination half-life (2.3-4.5 hrs.) which shows no significant accumulations when administered once daily for one week (Pugsley & Cohon, 1982). At 8.25 hours after intake performance of psychomotor and cognitive skills returned to baseline levels while at 10 hours a facilitation of these skills occurred (Roth, Roehrs, & Zorick, 1983). The action of benzodiazepines appears to be located almost solely in the CNS. Therefore, the drug binds specifically to receptors found only in the brain. At these receptor sites a relaxation effect is promoted by enhancement of the neurotransmitter gamma-aminobutyric acid (GABA). Common side effects include: a) drowsiness, b) dizziness, and c) lightheadedness; however, these

effects are subject to individual variation (Physicians Desk Reference, 1985). Previous data indicate that triazolam effects are rapid, as is the elimination of this substance.

Summary

Several studies were reviewed which demonstrated reductions in tension following exercise. The H/M ratio appears to be an accurate measure for detecting changes in neuromuscular tension. Studies using this method report a decrease in motoneuron excitability following exercise, referred to as a tranquilizer effect. Proposed mechanisms for this effect were presented. These included a drug-like condition attributed to endorphin release which produces relaxation, central influences, and elevated body temperature and monoamines. However, when exercise is compared to a tranquilizer, the data seem inconsistent with current findings and predicted drug induced effects. Therefore, further investigation is needed to determine if exercise and drugs have differences in their effects on muscle tension reduction.

CHAPTER 3

METHODS

This chapter presents the experimental methods for selecting subjects, metabolic and neuromuscular measurement, drug preparation and administration, and research design and statistical analysis.

Subjects

Eight college males, aged 22-30 years and possessing a fitness level which allowed them to engage in 20 minutes of treadmill running at 75% of V02max, were volunteers. A questionnaire was administered to eliminate those potential subjects with contraindications for heart disease and drug interactions. Subjects filled out an informed consent document explaining the rights, benefits, and dangers relating to the experimental procedures and provisions for maintaining the privacy of each subject. The document was also verbally reviewed. Continuation of the experiment occurred only after the subject read, understood, and signed the consent form.

Testing Schedule

Subjects reported after fasting for 10-12 hours to the exercise physiology laboratory on 5 different occasions separated by a minimum of 2 days. The first visit a consisted of general orientation and a conference regarding informed consent. A graded maximal oxygen consumption test was also administered to determine running speed for future trials.

The four subsequent visits consisted of each of the following conditons. Each session began with the measurement of baseline H/M ratios followed by one of four randomly assigned trials as follows:

Trial 1- Exercise at 75% VO2max with post testing under placebo conditions

Trial 2- Exercise at 75% VO2max with post testing under drug conditions

Trial 3- Triazolam administration followed by post testing

Trial 4- Placebo administraion followed by post testing

Exercise bouts consisted of 20 min. of running at 75% VO2max intensity on a treadmill as determined by each subject's VO2max test.

Triazolam and placebo administrations were performed double-blind immediately following exercise and non-exercise trials.

Following the control or exercise periods the H/M ratio was measured at 30 minutes. The literature indicates mean peak blood concentrations of triazolam are attained at one half hour post ingestion (Pugsley & Cohon, 1982); exercise effects also appearing approximately 30 minutes after exercise (deVries & Adams, 1972).

Measurement of the H/M Ratio

Neuromuscular excitation was estimated using the H/M

ratio (Angel & Hofmann, 1963) and modified by Hugon (1973). Tests consisted of electrical stimulation of the tibial nerve at the popliteal fossa using an indifferent lead and stimulating electrode. The indifferent lead was an electrocardiogram (ECG) plate electrode located 15 centimeters above the popliteal fold on the posterior thigh. The stimulating electrode, was a 1.5 cm disc electrode in the popliteal fossa. Prior to securing the stimulating electrode a probe electrode was used to find the location that produced the maximum H-wave response at a specific stimulus intensity. Single square wave impulses of 0.5 msec duration were applied using an electric stimulator (Grass S 44) via a stimulation isolation unit (Grass SIU5). A 20-30 second interval separated each trial. Stimulation voltage was selected by choosing a threshold value which produced an M-wave. This voltage was increased in 5 volt increments until a plateau M value was reached. Peak M-wave values were accepted when three consecutive stimuli produced no further increases in M-wave amplitude. The H-wave was initially identified during determination of the M-wave amplitude and then more precisely evaluated by retracing its normal 10-15 stimulus volt range with stimulation increments of 1.0 volt. Oscilloscope sensitivity was increased when appropriate to improve resolution in the peak H-wave recording. The re-examination of the H-wave at 1.0 volt increments provided assurance that the maximum H-wave amplitude was not missed between wider 5.0

volt increases used during initial H-wave location and maximal M-wave measurement. Further care was taken to ensure accurate H-wave determination by recording two readings at each 1.0 volt increment. The stimulus voltage which produced the largest mean H-wave was then used to record eight additional peak H-wave recordings. After completion of this procedure the high and low scores were eliminated and an overall mean peak value was calculated (Bowles, 1987).

An electromyograph (EMG), using two 1.5 cm disc electrodes in a bipolar arrangement, recorded the H- and M-waves. The active electrode was placed on the midline of the leg over the soleus while the reference electrode was placed proximal to the medial malleolus. The ground electrode was placed proximal to the lateral malleolus. The skin beneath the electrode sites was abraded using sandpaper to ensure interelectrode resistance no higher than 5000 ohms. Before measurement of MAP's, subjects were moved inside a copper plated cage to screen out 60 cycle interference. In addition to this procedure, calibration of the recording equipment via a standardized calibration signal took place prior to each testing period. Muscle action potentials were then amplified through a Coulbourn Instruments Hi Gain Bioamplifier/Coupler with a gain of 100 displayed and stored on a storage oscilloscope (Tektronix (T912)) from which the M- and H-wave amplitudes were measured.

For exercise and control trials the indifferent lead and stimulating electrodes were removed. To ensure accurate reproductions of pre-trial data, electrode locations were marked for replacement during post-trial measurements.

Maximal Oxygen Uptake

Subjects ran on a Quinton treadmill to attain maximum oxygen uptake (VO2max). Tests consisted of three two-minute stages at 0% grade using three ascending speeds ranging from five to nine mph depending upon each subject's normal training pace. These stages provided three VO2 values which were plotted and a regression equation was derived to determine running speed at 75% VO2max. Following these three stages, continuous collection of VO2max data began. A speed from the former trials which simulated normal training pace was held constant while a 2.5% elevation of grade occurred each minute until VO2max was reached. Expired air was analyzed every thirty seconds of each stage for oxygen and carbon dioxide content by a Beckman OM-11 and LB-2 analyzer, respectively. The expired air volumes were recorded simultaneously by an Alpha Technologies Ventilation Meter.

Research Design and Statistical Procedures

Data analysis consisted of evaluating differences among groups both before and after treatments. The order of administration of treatments to subjects was counterbalanced to control for carryover effects.

Table 1

Latin Square Design for Subjects and Treatments

	Periods			
	1	2	3	4
Subjects	Treatments			
BS	3	4	2	1
CH	4	1	3	2
BL	2	3	1	4
JN	1	2	4	3
FJ	2	4	1	3
GM	4	3	2	1
JK	3	1	4	2
DB	1	2	3	4

Randomized block design with one-way treatment structure was used to test for intergroup differences on pre-treatment and post-treatment results. The .05 level of significance was used for decision making.

CHAPTER 4

RESULTS

This chapter presents the results and data analysis and is divided into six main sections: a) physical characteristics of subjects, b) H- and M-wave responses, c) raw data on H/M ratios, d) oxygen consumption during exercise, e) group comparisons of pre- and post- tests, and f) changes in H/M ratios from pre- to post-tests.

Physical Characteristics of Subjects

The physical characteristics of the subjects are summarized in Table 2. Mean age, weight, and height of subjects was 25.1 years, 180.0 cm, and 69.6 kg, respectively. The mean VO2 max was 71.3 $ml*kg^{-1}*min^{-1}$.

Table 2

Physical Characteristics of Subjects

Subject	Age	Height (cm)	Weight (kg)	VO2max ($ml*kg^{-1}*min^{-1}$)
BS	25	180.3	71.8	68.8
CH	25	175.3	66.4	58.0
BL	22	185.4	70.5	80.0
JN	30	182.9	72.3	74.6
FJ	24	170.2	63.7	74.6
GM	28	182.9	73.2	70.7
JN	22	180.3	63.6	80.6
DB	25	182.9	75.0	63.2
Mean	25.1	180.0	69.6	71.3
SD±	2.7	5.0	4.4	7.9

Typical H- and M-wave Responses

The typical stimulus-response pattern which is created by the recorded H- and M-waves is shown in Figure 1. The H-wave appears at a lower range of stimulus voltages, quickly peaks and then disappears as the M-wave begins to increase in magnitude. The H-wave varied between and within subjects as a significant difference across all treatments was noted ($p > 0.001$). The M-wave will normally plateau and remain stable upon reaching its maximal value following the occlusion of H-wave readings. This stability allows the M-wave to serve as a control measure. The data show no significant differences in M-wave changes across all trials ($p > 0.4268$). From the maximal H- and M-waves the H/M ratio is derived by dividing the maximal H-wave recorded by the maximum M-wave recorded.

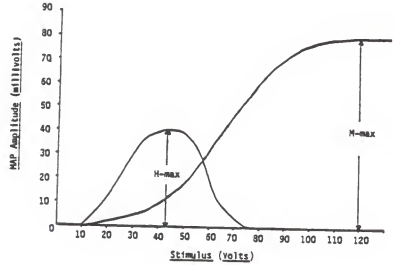

Figure 1: Plots of typical H- and M-waves. Stimulus is shown in volts and H- and M-wave amplitude is shown as millivolts.

Raw Data

The data for H- and M-waves are given for each subject in Tables D-1, D-2, D-3 and D-4 (see Appendix D). Trials are divided into: a) pre- /post-treatments, b) exercise/non-exercise, and c)drug/placebo trials. H/M ratios and the changes following treatment are also given for pre- and post-measurements.

Oxygen Consumption During Exercise

The oxygen consumption for exercise trials is presented in Tables E-1 and E-2 (see Appendix E). Oxygen consumption was measured during minutes 8-9, 9-10, 18-19, and 19-20 of each 20-minute exercise bout. Mean oxygen consumption was computed at the end of each two minute period. Mean oxygen consumption values for condition T (triazolam) and P (placebo), their combined average (grand mean), and the percent of VO2max the combined average represents is given in Table E-3 (see Appendix E). The mean oxygen consumption was 76.2 $ml*kg^{-1}*min^{-1}$ with a range of 70.3 to 81.0 $ml*kg^{-1}*min^{-1}$.

H/M Ratio Changes in Response to Exercise

The following sections will present the results of pre-and post-treatment analysis followed by the results of each treatment condition.

Table 3

A Comparison of Pre- and Post- H/M Ratio Means and Mean Changes (MC)

Time	NEX T	EX T	NEX P	EX P
Pre-	63.2±28.4	59.1±22.3	67.2±31.0	61.6±27.6
Post-	69.2±28.4	*54.2±26.2	71.9±29.3	*55.7±26.4
MC	6.0	-4.9	4.7	-5.9

* indicates significant differences between post-means

Pre-Treatment H/M Ratios

Pre-treatment ratios were recorded in millivolts before each treatment (see Appendix D). Mean values ranged from 59.1±22.3% to 67.2±31.0% for the four experimental conditions. Mean values for drug trials were 63.2±22.4% for non-exercise (NEX T) and 59.1±22.3% for exercise (EX T). Means for non-exercise (NEX P) placebo trials were 67.2±31.0% and 61.6±27.6% for exercise (EX P) under placebo conditions. An analysis of variance one-way randomized block design was used to determine group differences. Statistical analysis revealed a significant difference between subjects ($p < 0.0001$), but no differences between groups as shown by Table 4. These finding indicate there were no significant intergroup differences in H/M ratios prior to the treatments.

Table 4

Analysis of Variance for the Pre-test H/M Ratio

Dependent Variable: Pre-Ratio

Source	df	Sum of Squares	Mean Square	F value	p>F
Model	16	1.75	0.11	7.87	0.0001
Error	15	0.21	0.01		
Total	31	1.97		Root MSE	0.1181

Source	df	Type IV SS	F value	p > F
Subject	7	1.66	16.93	0.0001
Period	3	0.01	0.15	0.9278
Exercise	1	0.03	2.07	0.1709
Drug	1	0.01	0.76	0.3973
Exercise*Drug	1	0.00	0.02	0.8999

Post-Treatment H/M Ratios

The post-treatment H/M ratios were analyzed following treatments using an analysis of variance one-way randomized block design. Mean values for the non-exercise conditions were 69.2±28.4% and 71.9±29.3 for drug and placebo, respectively. Exercise conditions showed mean values of 54.2±26.2 for placebo trials and 55.7±26.4 for drug trials. Analysis of variance on post-test scores yielded a significant overall inter-group difference (0.0008). Table 5 provides a summary of this test. Both exercise groups were significantly different from the non-exercise groups and that the drug and placebo conditions showed no differences.

Table 5

Analysis of Variance for Post-Treatment H/M Ratios

Dependent Variable: Post-Ratio

Source	df	Sum of Squares	Mean Square	F value	p > F
Model	16	2.23	0.14	12.41	0.0001
Error	15	0.16	0.01		
Total	31	2.39		Root MSE	0.1059

Source	df	Type I SS	F value	p > F
Subject	7	1.87	23.83	0.0001
Period	3	0.03	0.77	0.5301
Exercise	1	0.19	17.41	0.0008
Drug	1	0.00	0.01	0.9213
Exercise*Drug	1	0.00	0.05	0.8314

Mean Changes (MC)

Consistent with previous studies, the exercise and non-drug condition showed a reduction, in this case an H/M ratio reduction of 5.9%. This was the largest mean reduction in H/M ratio and the only trial in which all subjects showed a consistent reduction in H/M ratio. The change in H/M ratio when exercise and drug were combined showed a 4.9% mean reduction with all but five of eight subjects showing a reduced H/M ratio.

In the non-exercise drug condition the H/M ratios changed from 63.2 to 69.2% with six subjects showing increased H/M ratios. Under placebo conditions the common non-exercising pattern appeared with a mean

increase of 4.7% in H/M ratio. Six subjects displayed an increase in H/M ratio.

Summary of Results

Results indicated the following:

1) No differences existed between groups prior to the first treatment condition.

2) Post-treatment conditions revealed a significant difference ($p < 0.0008$) between exercise and non-exercise conditions.

3) Exercise groups were significantly different from non-exercise groups while no drug effect existed among treatments.

4) Mean changes from pre- to post-trials disclosed reductions in H/M ratios during exercise and elevations during non-exercise treatments.

CHAPTER 5

SUMMARY, DISCUSSION, AND CONCLUSIONS

This chapter consists of a summary, discussion and interpretation of results, conclusions, and recommendations for future research.

Summary

Studies comparing reductions of neuromuscular tension through exercise or drugs show limited and inconclusive results. The purpose of this study was to examine the potential tranquilizer effect of exercise and triazolam on motoneuron excitability and associated neuromuscular tension as measured by the H/M ratio.

Eight male subjects were randomly assigned to one of four separate treatments. Trials consisted of drug and placebo conditions with or without 20 minutes of treadmill running at 75% of VO2max. Using a repeated measures ANOVA pre- and post- treatment H/M ratios were evaluated to determine treatment effects. Post hoc intergroup comparisons revealed an exercise effect among both exercise groups while no drug effect emerged across all groups.

The hypotheses projected reductions in H/M ratios following drug administration, exercise, and an enhanced tranquilizer effect following the combined trial of drug and exercise.

Post hoc results only partially supported the hypotheses indicating that differences in mean post- H/M

ratios occurred with exercise. Exercise trials under drug conditions showed post-mean treatment differences; however, the hypothesis of enhanced reduction through a drug and exercise combination did not appear. Non-exercising drug and placebo conditions showed no post-treatment differences.

Discussion of Exercise Results

This study indicated that exercise at 76.2% of VO2max would promote neuromuscular tension reduction and decreased motoneuron pool excitability as measured by the H/M ratio. Exercise post-trial means differenced from non-exercise post-trial means. Several studies have reported similar reductions through a variety of exercise modes and intensities (deVries, 1968; deVries et al., 1981; deVries & Adams, 1972; Bulbulian & Darabos, 1986; Bowles, 1987). In one of the first studies of execise effects on muscle relaxation, deVries (1968) found that bench stepping decreased activity in the biceps by 58% as recorded by EMG. deVries et al. (1981) tested the effects of cycling exercise on the centrally occurring reflexes influenced by muscle tension. Once again, a reduction of 18.7% in muscle tension was found leading deVries to conclude that exercise acted as a "tranquilizer effect" and decreased motoneuron excitability. However, only one study, deVries and Adams (1972) has directly tested tranquilizers against exercise for decreased neuromuscular activity. Peak drug and exercise effects were not matched which clouded results.

An exercise effect of reduced MAP's again occurred. Post-treatment comparisons of H/M ratios occurred at a time which allows physiological effects of drugs and exercise to be assessed. The present study indicated that exercise conditions brought about the greatest reduction in motoneuron excitability and neuromuscular tension as measured by post- H/M ratios. When comparisons are made using mean changes (MC), the exercise placebo condition was the only trial which produced a drop in post-treatment H/M ratios for all subjects. These results are in agreement with studies mentioned in the previous section. The results of the present study simulates the finding of Bulbulian and Darabos (1986). However, a difference between the percent reduction exists as Bulbulian and Darabos (1986) report a 21.5% reduction in spinal motoneuron activation while only a 5.9% decrease is shown in the present study. One possible explanation for this discrepancy in magnitude may be the unusually high ratios produced in the current study's subject pool due to differences in methodology. Two subjects were consistently within a range of 80% to 100% or above. The highest ratio attained by Bulbulian and Darabos (1986) was 49.7% which was exceeded by all trial means in the present study. As noted earlier, individuals which initially have lower ratios may have a greater predisposition for attaining decreased excitability. This predisposition is evident

when JK is compared to subject DB. Within this trial (EX P) subject JK's pre- treatment ratio is 104.5%. Post-exercise results show a dramatic reduction to 85.9%. However, DB pre- tested at 28.6% and after exercise dropped to 19.0%. Further research establishing predictive equations for predispositions within subjects towards lower H/M ratios needs exploration.

Results indicate a 4.9% reduction in H/M ratio during the drug condition. The post- H/M ratios for subjects under this condition ranged from 8.6% to 93.6%. The 10.4% reduction is the largest change of any trial in this experiment. The subject which attained this value may be predisposed to relaxation as mentioned earlier. Five of eight subjects have decreased values in this drug trial. Increases again seem minute with values of +0.8% to 2.7%. When EX T is compared to NEX T there seems to be a general trend towards H/M ratio reduction as opposed to increase, respectively, indicating an ability of exercise to "mask" drug effects. For example, subject FJ had a post- H/M of 111.6% and MC of 16.8 in NEX T, but during EX T post- values were 93.6% and MC equal to 2.5%. The values, while still positive, appeared to be moderately subdued. ANOVA results indicate that this relationship proved to be insignificant. However, the data show that three possible effects may have occurred including: a) small elevations in the H/M ratio resulting from drug administration are reversed by exercise, b) larger increases in the H/M ratio are attenuated through

exercise, and c) decreases in the H/M ratio brought about by the drug are augmented via exercise.

Subjective comments and attenuated drug reactions seem to support the theory that exercise may reverse drug effects. One subject following the EX T trial commented that he "definitely did not receive the drug." Another subject who lost motor functions in the NEX T trial made no comments following the EX T trial and had no noticeable impairments in coordination. One possible explanation for this occurence may be the ability of the body to override drug effects through either decending or spinal inhibitory mechanisms as a result of exercise. An alternative explanation may be an enhanced drug clearance from the plasma following exercise. Discussion of theories related to exercise reduction of motoneuron excitability will follow.

Several hypotheses have been offered to explain exercise induced reductions in motoneuron excitability and neuromuscular tension. One theory cited for these reductions is offered by Von Euler and Soderburg (1956; 1957). Their work notes muscular relaxation in cats following an increase in hypothalamic and total body temperature. deVries (1968) reasoned that exercise would elevate body temperature and thereby reduce neuromuscular activity. This may be a mechanism for the present study, however recent evidence by Bowles (1987) which matched metabolic work in level and down-hill treadmill running

found mean differences of 15.7% in post- H/M ratios. Equal metabolic work should match temperatures, therefore heat mechanisms may have limited effects on decreasing neuromuscular activity.

Another possible explanation of the tranquilizing effect of exercise may be due to random, intermittent proprioceptive stimuli which allows normal cortical activity (Haugen et al., 1960). Treadmill running would appear to provide a source of incoming stimuli which may be conducive to sound cortical activity.

Finally, endogenous opoid peptides may be responsible for reductions in motoneuron pool excitability and neuromuscular activity. Pert and Bowie (1979) found increased opiate receptor occupancy in rats after swimming. This may be interpreted as increased endorphin release which is believed to promote feelings of euphoria (Morgan, 1985). The psychological state noted during the release of endorphins may be linked to decreased spinal excitation via descending inhibitory responses or motoneuron pool inhibition. Further research is needed before this hypothesis can be established as a causal mechanism.

Discussion of Non-Exercise Results

The non-exercise trials failed to elicit a difference in post-treatment H/M ratios. Post- H/M ratios in both drug and placebo conditions were elevated when compared to post-exercise ratios.

When using mean change (MC) comparisons the NEX T trial unexpectedly showed a 6.0% mean increase in the post- H/M ratio. Six subjects showed an increased post-trial response. The two remaining subjects showing post-treatment drops also recorded the lowest pre-test values indicating a possible predisposition for tension reduction. However, the magnitude of these drops were very small at -3.8% and -3.4%. Another important observation within these data which should be discussed are the H/M ratios which exceed 100%. These elevated values have been shown in a previous study and an explanation has subsequently been offered (Bowles, 1987). Bipolar placement of recording electrodes allowing a field of pickup including the triceps surae and peroneals combines both muscles MAP's. A condition seemingly elevating H-wave responses in excess of M-wave values reflecting 100% recruitment of the triceps surae muscle. This conditon seems to be present in a small percentage of subjects.

The drug effects on H/M ratios would appear to be opposite of predicted results since the tranquilizer triazolam would be expected to show a decreased H/M response. Analysis of variance revealed no drug effect during post-treatment comparisons which is surprising since triazolam, is a known muscle relaxant (Kroboth & Juhl, 1983; Roth et al., 1983). These results are also in contrast to a previous study in which a similar tranquilizer, diazepam, was linked to a decreased H-

reflex response (Brunia, 1973). However, it has been shown that small doses of a similar benzodiazepine (diazepam) have actually improved psychomotor skills (Mattila, 1984). This may be interpreted as disinhibition of inhibitory drug mechanisms that centrally influence the motoneuron pool. The precise mechanisms by which triazolam promotes relaxation effects is still unclear, however the actions of benzodiazipines appear to cause inhibitory activities upon the central nervous system (CNS) via the neurotransmitter gamma-aminobutyric acid (GABA) (Kroboth & Juhl, 1983). Exercise reductions imitate this process through unknown disinhibitory mechanisms. With inhibition removed, the motoneurons become less resistant to excitatory responses and spinal excitation.

Results indicate that an increase from 67.2 to 71.9% occurred in the H/M ratio during non-exercise placebo trials. Two subjects showed a decrease, one of which appears to be somewhat substantial at -8.7% The other value is once again minimal at -2.9%. Only individual variation can be offered as an explanation for the large drop of the one subject. The mean increase observed in the present study during non-activity supports several previously reported EMG and H/M ratio data (deVries, 1968; Ebert, 1986; deVries et al., 1981; Bulbulian & Darabos, 1986; Bowles, 1987). deVries (1968) found a 23.7% increase in control EMG data which appeared after

one hour of inactivity. deVries et al. (1981) found subjects had an increase of 1.2% in post- H/M ratios following 20 minutes of sitting while Bulbulian and Darabos (1986) found increases of 2.11%. A recent study by Bowles (1987) with closely related methodology found an increase of 12.6%. Evidence of neuromuscular excitability increases lasting up to one hour during control conditions support the probability that spatial differences have no appreciable effect upon the results. The elevated control trials by Bowles lend additional support to this assumption. Analysis of variance in the present study also appears to support this hypothesis as placebo differences were found to be insignificant. The absence of proprioceptive stimuli, anticipation of future post- testing, lack of distraction, and cortical influences could have contributed to elevated motoneuron pool excitability (Haugen et al., 1960; Bahrke & Morgan,1978).

Conclusions

Within the limits of this study, it is concluded that exercise is more effective in reducing motoneuron excitability and neuromuscular tension than triazolam ingestion. Also, triazolam ingestion does not affect motor neuron excitability when taken in conjunction with exercise.

Recommendations for Future Research

The following related research is recommended:

1. Further evaluation of the H/M ratio to determine validity of this measure.

2. Replication of the present study with other drugs and/or dosages. Ideally, the drug dosage should be large enough to produce inhibitory rather than excitatory responses.

3. Determine if subjects with lower initial pre-test H/M scores have a predisposition for tension reduction.

4. The replication of the present study with a more stringent control period.

5. A biochemical analysis of exercise effects at the cellular level which identifies possible neurotransmitter mechanisms, such as serotonin, involved in reduction of motoneuron excitability and neuromuscular tension.

6. A comparison of exercise and drug effects between trained and untrained subjects.

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Appendix A

EXERCISE AND TRIAZOLAM QUESTIONAIRRE

Please read the following questions silently to yourself making no verbal or written responses. If you answer "yes" to any question without specifying which one, please inform the experimenter that you would rather not participate in this study. No questions will be asked.

1. Are you currently taking any prescribed diuretics (a drug which decreases water retension), parabrom, or ammonium chloride?

2. Within the past 12 hours prior to testing have you consumed any coffee, tea, hot chocolate or cola which contains caffeine?

3. Have you ever had an allergic reaction to tranquilizers?

4. Do you have any history of heart disease?

5. Do you have any history of high blood pressure (above 140/90)?

6. Do you smoke?

7. Are you diabetic?

8. Does your family have a history of heart disease prior to the age of 50?

9. Do you have an elevated total cholesterol/ HDL ratio (above 5)?

10. Have you consumed any alcohol or ethanol within the past 12 hours (prior to testing)?

11. Are you currently taking cimetidine?

12. Have you eaten within the past 12 hours (prior to testing)?

13. Are you epileptic?

14. Are you currently taking any psychotropic, anticonvulsant, anti-histaminic or any other CNS depressant medications?

15. Are you currently taking any prescribed, non-prescibed or illegal drugs?

Appendix B

INFORMED CONSENT

I _____ voluntarily consent to participate in this study which compares a tranquilizing drug (triazolam) and exercise effects on muscle tension reduction. Muscle tension will be measured using a surface electrode which will elicit a noticable but not painful shock to the back of the knee to initiate a muscle contraction. The electrical activity of this muscle twitch will be recorded before and 30 minutes after the drug administration or exercise trials. Exercise trials will be 20 minutes in duration at submaximal effort. Ingestion of placebo or tranquilizer solutions will occur after each exercise trial. Drug trials will consist of ingestion placebo or tranquilizers solutions, followed by no exercise and muscle tension testing 30 minutes later.

During the first of 5 visits, a maximal oxygen uptake test will be given to determine future exercise loads. The test wil start slow and progressively become more difficult until maximum effort and resulting fatigue causes termination of the test. This will typically take 10-15 minutes and can cause discomforts such as fatigue, breathlessness, and muscle soreness. Risks include personal injury during treadmill running, cardiac abnormalities or arrest. These risks are decreased by readily available emergency numbers and phones, CPR certification of the tester, and screening of participants before testing via questionairre.

The drug received is triazolam which is a fast acting tranquilizer. A .25mg dose will be in a solution which is ingested after the randomly selected trial. Since the possibility of drowsiness, dizziness, or lightheadedness may occur, the experimenter will deliver each subject home safely. Subjects are encouraged to stay home under supervision of another adult for the remainder of the day. No subject will be allowed out of the lab alone following any trial. About 10 of 1000 patients using triazolam have noted discomforts of headache, nervousness, ataxia, or stomach upset. With chronic use of up to 42 days less than 1% have experienced euphoria, tachycardia, tiredness, confusion, cramps, depression and visual disturbances. Less than .5% have had constipation, taste changes, diarrhea, dry mouth, dermatitis, sleep disturbances, paresthesia, tinnitus, dysesthesia, weakness, and congestion. Risks include allergic reactions to triazolam, addictive effects when coupled with other CNS depressing drugs, anterograde amnesia with theraputic doses (which are much stronger than subjects will receive), and hepatic failure occurred in one subject using diuretic drugs. Screening of the subject's drugs intake before the experiment through the questionairre should eliminate these risks. If any adverse effects from the drug should occur, emergency personnel will be contacted.

I, the undersigned, understand the procedures which have been explained and my questions have been answered. I also understand the following:

1. The risks and discomforts involved with this experiment.

2. The benefits of this experiment to me are knowledge of my own personal fitness level and learning if exercise can effectively replace drugs to relieve neuromuscular tension.

3. I understand that in the event of injury during this experiment, no financial compensation will be available since state regulations prohibit Kansas State University from carrying insurance for such situations.

4. If I have any questions regarding this experiment, I am free to contact the project director, Brent Stauth or Dr. Ronald Bulbulian(532-6765).

5. I am free to withdraw my participation from this experiment at any time without prejudice towards me.

6. All results will be confidential by encoding data sheets and storing the code in a seperate location from the experimental data. It will be available to me upon request.

Signature_____ Date_____

Appendix C

GUIDELINES FOR SUBJECTS RECEIVING TRIAZOLAM

Subjects must follow the proceeding guidelines and be aware of the precautions listed below to ensure personal safety.

1. After being delivered home following testing you must stay home under adult supervision for at least eight hours. After this time period normal physical and mental functions should return. A call to your home will be made to ensure this.

2. Triazolam has been shown to cause drowsiness and dizziness. Therefore, activities requiring balance and perception such as driving, operation of machinery, or excessive walking must be avoided for the entire eight hour period. It is suggested that you sleep, watch TV, or read while sitting at home.

3. No other drugs can be combined with triazolam. The physician supervising this experiment has noted that the dosage used would appear extremely safe. However, detrimental side effects including one death has occurred when another drug was taken in addition to triazolam. Stomach discomforts and headache may accompany the use of triazolam. Do not take any medication (i.e. aspirin, alka seltzer) to relieve these discomforts. They will dissipate with time. If any complications arise contact Brent Stauth at 532-6765 (office) or 776-2420 (home) or the Lafene Student Health Center Emergency Service at 532-6544.

Appendix D

Raw Data

Table D-1

H- and M-wave Amplitudes and H/M Ratios for Non-Exercise Triazolam Conditions (NEX T).

Subject	H	M	H/M	H	M	H/M	%C
		Pre-NEX T			Post-NEX T		
BS	3.5	8.6	40.7	3.3	8.4	39.3	-3.4
CH	5.2	8.0	65.0	6.0	8.2	73.2	12.6
BL	4.0	7.6	52.6	3.8	7.1	53.5	1.7
JN	6.4	8.9	71.9	7.5	8.4	89.3	24.2
FJ	7.3	7.7	94.8	7.7	6.9	111.6	17.7
GM	7.0	9.6	72.9	7.6	10.1	75.2	3.2
JK	7.1	8.7	81.6	7.8	9.0	86.7	6.3
DB	2.5	9.6	26.0	2.4	9.6	25.0	-3.8
Mean	5.4	8.6	63.2	5.3	8.5	69.2	7.3
SD±	1.9	0.8	22.4	2.2	1.1	28.4	10.1

* recordings are in millivolts

Table D-2

H- and M-wave Amplitude and H/M Ratios for Exercise Triazolam Conditions (EX T).

Subject	H	M	H/M	H	M	H/M	%C
		Pre-EX T			Post-EX T		
BS	5.4	9.2	58.7	4.5	8.0	56.3	-4.3
CH	4.1	7.4	55.4	3.5	7.4	47.3	-14.6
BL	3.3	7.2	45.8	2.5	6.1	41.0	-10.5
JN	5.6	8.3	67.5	4.2	8.6	48.8	-27.7
FJ	7.2	7.9	91.1	7.3	7.8	93.6	2.7
GM	4.4	8.3	53.0	4.7	8.8	53.4	0.8
JK	7.1	8.6	82.6	7.5	8.9	84.3	2.1
DB	1.6	8.4	19.0	0.7	8.1	8.6	-54.7
Mean	4.8	8.2	59.1	4.4	8.0	54.2	-13.3
SD±	1.9	0.6	22.3	2.3	0.9	26.2	19.7

* recordings are in millivolts

Table D-3

H- and M-wave Amplitudes and H/M Ratios for

Non-Exercise Placebo Conditions (NEX P).

Subjects	H	M	H/M	H	M	H/M	%C
		Pre-NEX P			Post-NEX P		%C
BS	4.3	9.0	47.8	5.3	9.0	58.9	23.2
CH	6.4	8.8	72.7	6.0	8.6	69.8	-4.0
BL	3.0	6.5	46.2	3.7	5.9	62.7	35.7
JN	4.6	8.0	57.5	4.1	8.4	48.8	-15.1
FJ	8.4	7.2	116.7	8.6	7.3	117.8	0.9
GM	4.2	8.1	51.9	6.1	8.9	68.5	32.0
JK	9.6	8.6	111.6	10.0	8.8	113.6	1.8
DB	2.9	8.8	33.0	3.3	9.4	35.1	6.4
Mean	5.4	8.1	67.2	5.9	8.3	71.9	10.1
SD±	2.5	0.9	31.0	2.4	1.1	29.3	18.2

* recordings are in millivolts

Table D-4

H- and M-wave Amplitudes and H/M Ratios for

Exercise Placebo Conditons (EX P).

Subjects	H	M	H/M	H	M	H/M	%C
		Pre-EX P			Post-EX P		%C
BS	3.3	9.0	36.7	2.6	10.0	26.0	-29.2
CH	3.8	7.9	48.1	3.6	8.5	42.4	-11.9
BL	3.6	8.8	40.9	3.0	9.6	31.3	-23.5
JN	5.4	8.4	64.3	5.0	8.5	58.8	-8.6
FJ	8.0	8.8	90.9	8.3	9.3	89.2	-1.9
GM	8.1	10.3	78.6	7.5	10.0	75.0	-4.6
JK	9.2	8.8	104.5	7.9	9.2	85.9	-17.8
DB	2.4	8.4	28.6	1.6	8.4	19.0	-33.6
Mean	5.5	8.8	61.6	4.9	8.8	55.7	-16.4
SD±	2.6	0.7	27.6	2.6	1.2	26.4	11.6

*recordings are in millivolts

Appendix E

Oxygen Consumption During Exercise

Table E-1

Oxygen Consumption During Exercise Triazolam Trials (EX T)

	Exercise T Oxygen Consumption ($ml*kg^{-1}*min^{-1}$)					
Ss	8-9min	9-10min	Mean	18-19min	19-20min	Mean
BS	54.2	55.2	54.7	57.7	56.0	56.8
CH	45.2	47.0	46.1	48.8	48.2	48.5
BL	61.1	60.9	61.0	64.1	66.3	65.2
JN	57.8	55.8	56.8	64.6	62.4	63.5
FJ	55.8	54.2	55.0	55.2	55.2	55.2
GM	53.9	54.0	54.0	53.7	54.3	54.0
JK	62.8	63.4	63.1	59.1	60.3	59.7
DB	43.8	44.1	44.0	44.9	44.0	44.5
Mean	54.3	54.3	54.3	56.0	55.8	55.9
SD±	6.8	6.4	6.6	6.9	7.3	7.1

Table E-2

Oxygen Consumption During Exercise Placebo Trials (EX P)

Exercise P Oxygen Consumption ($ml*kg^{-1}*min^{-1}$)						
Ss	8-9min	9-10min	Mean	18-19min	19-20min	Mean
BS	48.8	54.7	51.7	52.3	53.6	52.9
CH	39.1	40.6	39.9	42.6	39.9	41.4
BL	61.2	60.5	60.9	65.8	64.9	65.3
JN	58.2	61.2	59.7	61.8	61.3	61.6
FJ	53.9	53.1	53.5	56.5	57.4	57.0
GM	52.2	54.7	53.4	55.4	54.6	55.0
JK	57.6	57.6	57.6	59.5	59.4	59.5
DB	43.8	43.3	43.5	46.7	44.6	45.6
Mean	51.9	53.2	52.5	55.1	54.5	54.8
SD±	7.6	7.5	7.5	7.7	8.4	8.0

Table E-3

Mean Oxygen Consumption for Trial T and Trial P, Grand Mean,and Exercise Intensity Across All Trials

Subject	Mean VO2 ($ml*kg^{-1}*min^{-1}$) EX T	EX P	Mean	Percent of V02max
BS	55.8	52.3	54.1	78.6
CH	40.7	47.3	44.0	75.8
BL	63.1	63.1	63.1	78.9
JN	60.1	60.6	60.4	81.0
FJ	55.1	55.2	55.2	73.9
GM	54.0	54.2	54.1	76.5
JK	61.4	58.5	60.0	74.4
DB	44.2	44.6	44.4	70.3
Mean	54.3	54.5	54.4	76.2
SD$\pm$	8.0	6.4	7.1	3.4

THE EFFECTS OF EXERCISE AND TRIAZOLAM ON THE REDUCTION OF NEUROMUSCULAR TENSION AS MEASURED BY THE H/M RATIO

by

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B. S., Fort Hays State University, 1984

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Abstract

Previous work comparing the role of tranquilizers and exercise on the reduction of muscle tension has shown limited and inconclusive results (deVries & Adams, 1972). The purpose of this study was to examine the effects of exercise and triazolam on neuromuscular tension reduction as measured by the H/M ratio. Eight male subjects participated in four separate trials: a) placebo administration, b) drug administration, c) exercise followed by placebo administration, and d) exercise followed by drug administration. Exercise performed was 20 minutes of treadmill running at 75%VO2max. Pre- and post-trial muscle tension was assessed by artificially stimulating the tibial nerve producing variable H/M ratios. Analysis of data using a repeated measures ANOVA with a Latin Square treatment design on both pre- and post-test scores found a significant exercise effect ($p < 0.0008$). Post hoc intergroup comparisons using Fisher's least significant test supported exercise effects by finding both exercise group means significantly lower in H/M ratios when compared to non-exercised group means. Failure to support expected drug effects and enhanced exercise effects using drugs and exercise in combination appeared when no significant differences in H/M ratios followed across all triazolam trials. Future research should include replication of this study using other drugs and/or dosages, comparisons

of exercise and drug effects on H/M ratios in trained and untrained subjects, and the identification of neurotransmitters involved with reductions of neruomuscular tension.