THE EFFECTS OF CAFFEINE ON REFLEX RESPONSE TIME OF THE KNEE JERK

By

JAY REGAN STEPP

Bachelor of Science in Secondary Education

Oklahoma State University

Stillwater, Oklahoma

1984

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
July, 1989

THE EFFECTS OF CAFFEINE ON REFLEX

RESPONSE TIME OF THE KNEE JERK

Thesis Approved:

Ben Jacobson
Thesis Advisor

Betty M. Edgley

Milton D. Rhoades

Norman N. Durham
Dean of the Graduate College

ACKNOWLEDGMENTS

I wish to express my sincere appreciation to the Oklahoma State University, Health, Physical Education, and Leisure Science faculty for their expert participation in the preparation of my education. A special thanks is given to Dr. Steven Edwards for his participation in the statistical analysis of this thesis. To Dr. Betty Edgley and Dr. Milton Rhoads, I thank you for serving on my graduate committee.

To the students who participated in this study, I thank you. This would not have been possible without your cooperation. I would like to thank my sister Kerri for the endless hours she spent in helping me type and prepare this thesis. I would also like to say thank you to my boss, Jeff Brynsaas, for keeping my work hours flexible, therefore allowing me to complete this project.

My most deepest gratitude is extended to Dr. Bert Jacobson for serving as the head of my graduate committee. His knowledge and dedication to the health profession has been an inspiration to me. Over the past two years, his unwavering patience and moral support has given me the courage to continue.

Finally, to my parents Larry and Elizabeth Stepp, I say thank you. Your support and confidence in me, has helped me to realize the potential that I possess. It is to you that I dedicate my thesis.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

History of Caffeine

The use of caffeine is widespread throughout the American society today. Adults, teenagers, and children ingest caffeine in a multitude of products. Its widespread use has invoked some controversy as to its potential health hazard since caffeine, in large doses, is considered a very potent drug.

Caffeine's most common sources are the coffee bean, the tea leaf, the kola nut, and the cocoa bean. Hence, caffeine is consumed through soft drink, chocolate, candies, baked goods, frozen dairy products, gelatines, puddings, common medications, and, of course, coffee. The average American now drinks thirty-two gallons of soft drink annually-compared with twenty-eight gallons of coffee (15). The Food and Drug Administration (FDA), lists more than one-thousand over-the-counter drugs that have caffeine as an ingredient (Table I).

The International Coffee Organization estimated that in 1974, 2.25 cups of coffee were consumed by persons ten years

TABLE I

CAFFEINE CONTENT OF DRINKS AND NON-PRESCRIPTION DRUGS

Caffeine Content of Soft Drinks

Brand	Mg. Caffeine (12 oz.)
Sugar Free Mr. Pibb	58.8
Mountain Dew	54.0
Mellow Yello	52.8
TAB	46.8
Coca-Cola	45.6
Diet Coke	44.4
Shasta Cola	44.4
Shasta Cherry Cola	44.4
Shasta Diet Cola	40.8
Mr. Pibb	40.8
Dr. Pepper	39.6
Sugar Free Dr. Pepper	39.6
Big Red	38.4
Sugar Free Big Red	38.4
Pepsi-Cola	38.4
Diet Pepsi	36.0
RC Cola	36.0
Diet Rite	36.0

Source: Institute of Food Technologists (IFT), April, 1983, based on data from National Soft Drink Association, Washington, D.C.

Caffeine Content of Drugs (Non-Prescription)	Mg. Caffeine
Weight-Control Aids (capsule/tablet)	
Codexin	200
Dexatrim	200
Dietac	200
Prolamine	140
Alertness Tablets	
Nodoz	100
Vivarin	200
Caffedrine	200

TABLE I (Continued)

Analgesic/Pain Relief	
Anacin	32
Excedrin	65
Midol	32.4
Vanquish	33

Source: FDA's National Center for Drugs and Biologics.

Item	Mg. Caffeine	
	Average	Range
Coffee (5 oz. cup)	115	60-180
Brewed, drip method	80	40-170
Instant	65	30-120
Cocoa Beverage		
Chocolate milk beverage (8 oz.)	4	2-20
Milk Chocolate (1 oz.)	5	2-7
Dark Chocolate (1 oz.)	6	1-15
Baker's Chocolate (1 oz.)	20	5-35

Source: FDA, Food Additive Chemistry Branch, based on evaluations of existing literature on caffeine levels.

of age and older in the U.S. Since coffee accounts for about 90 percent of caffeine available for consumption in the U.S., total caffeine consumption from all sources is approximately 10 percent more, thus the estimate is an average intake of 230 mg. per day, per adult (assuming 85 to 120 mg. per cup of coffee).

The Generally Recognized As Safe (GRAS) Survey Committee data give reasonable estimates of the individual intakes from all sources, ranging up to about 800 mg. per day at 99 percentile. This figure approximates 10 or 12 milligrams per kilogram (mg./kg.), of bodyweight (bwt). Some individuals who are also users of over-the-counter drugs, which contain 30 to 200 mg. of caffeine per tablet, receive substantially more on some days (25).

Presently, research suggests that eight of every ten adults drink an average of three cups of coffee per day (15). Likewise, it is probable that a child drinking one soft drink would experience the same effect from caffeine as an adult drinking two to three cups of coffee. This is due to the ratio of caffeine intake to body weight.

Properties of the Drug

Caffeine is a xanthine derivative and is structurally identified as 1, 3, 7-trimethylxanthine (Figure 1). Other xanthine derivatives include theophylline (1, 3-dimethylaxanthine) and theobromine (3, 7-dimethylaxanthine) which are found in tea and cocoa respectively (1). The

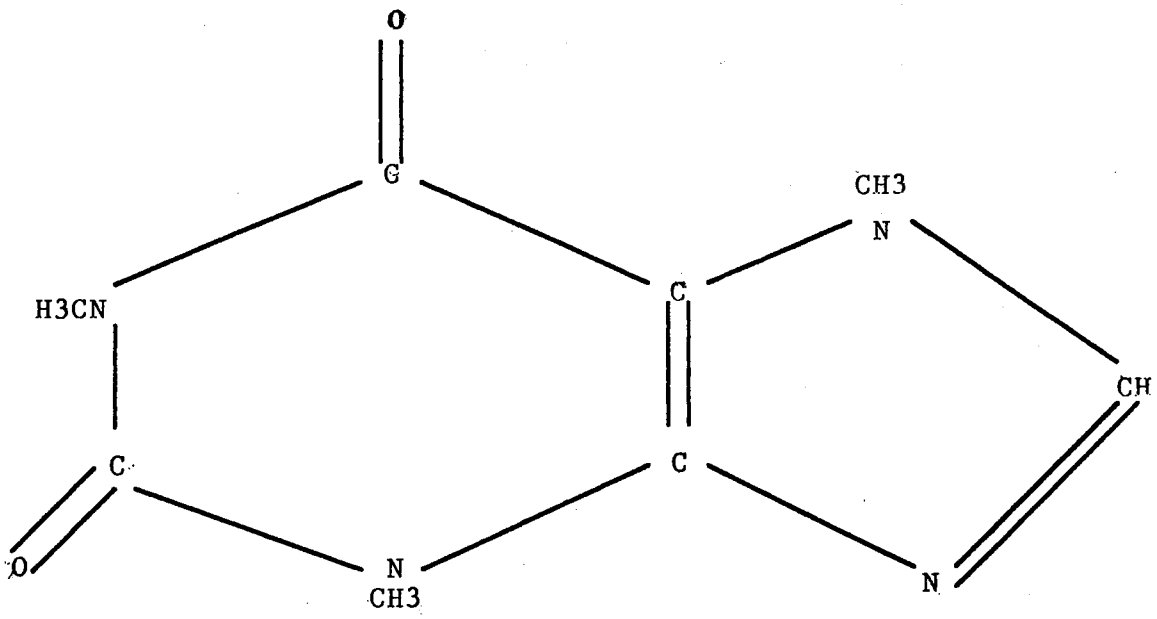

Figure 1. Chemical Structure of Caffeine

stimulating effects of coffee, tea, and cocoa is due to the methyl derivatives of xanthine, (2, 6-dihydroxidepurine) (2).

Caffeine empties rapidly from the stomach and is absorbed from the gastrointestinal tract (3). The drug readily passes the blood brain barrier (4, 5) and directly acts on the vagal, medullary, and vasomotor centers (6). Peak blood concentration occurs approximately 45-60 minutes after ingestion (7). Caffeine is readily absorbed from the stomach into the blood. Caffeine serves to stimulate the central nervous system, cardiac muscles, kidneys, and certain glands (7). Additional reported physiological responses may include effects on the adenosine receptors (9) by inhibition of enzyme activity (8). Research indicates caffeine also concentrates in muscle tissue and: (a) accentuates either the release (10) or uptake (11) of calcium by the muscle sarcoplasmic reticulum, (b) alternates the permeability of the sarcolemma (12), or (c) enhances the transmissions at the myoneural junction (13).

Effects of Caffeine

Caffeine is a stimulant of the central nervous system (CNS), and is absorbed by all organs and tissues in proportion to the water content of the tissue (3). Half-life of caffeine has been reported to extend from two hours (14) to ten hours (7) and may be affected by hormone interaction. For example, oral contraceptives taken in conjunction with caffeine increases the half-life threefold (15). Lethal

doses of caffeine have been reported to be 6000 mg. to 10,000 mg. or 6 grams (g.) to 10 g.

Although distribution of ingested caffeine is dependent on the water content of the tissue and the response proportional to the concentration, the habitual user of caffeine may alter the response because of his/her tolerance level (16). Also, heredity may play a role in that some subjects are more or less sensitive to caffeine (16). Even small amounts of caffeine may alter blood pressure, heart rate, respiration, and metabolic rate (17). Other side effects that may occur after the ingestion of caffeine include, loss of hand steadiness, trembling, tremors, and chronic muscle tension (18). Caffeine has also been under heavy investigation as being a cause for peptic ulcers, certain breast disorders, and pancreatic cancers (19). Recent caffeine research suggests possible associations with coronary disease, arrthymias (20), myocardial infarctions (21), and elevated levels of cholesterol (1). As normally ingested from food sources, caffeine produces a variety of biological effects (Table II).

The possible relationship between caffeine and pathogenesis of peptic ulcers has long been debated. Stimulation of gastric secretion by caffeine has been shown with several experimental animals and with human subjects in single dose experiments (20). A variety of field studies, however, have failed to establish a clear-cut cause and

TABLE II

BIOLOGICAL EFFECTS OF CAFFEINE

1.	Diuretic
2.	Cardiac Muscle Stimulant
3.	Central Nervous System Stimulant
4.	Smooth Muscle Relaxant
5.	Stimulates Gastric Acid Secretion
6.	Elevates Plasma, Free Fatty Acids, and Glucose
7.	Probably not mutagenic for men
8.	Increases urinary output
9.	Increase blood pressure
10.	Increases metabolic rate
11.	Decreases heart rate

effect relationship between caffeine ingestion and induction or exacerbation of peptic ulcers.

Protracted abuse of coffee drinking appears responsible for arrythmia in a small percent of the population. Coffee and tea drinking have long been suspected, along with other risk factors, as a cause of myocardial infarction and other cardiovascular diseases. Definitive evidence to support this suspected relationship is lacking (26).

Perhaps the most alarming news regarding caffeine is its association with birth defects. Caffeine enters the bloodstream and easily crosses the placental barrier to reach the fetus (1). To date, no empirical conclusions have been drawn; however, laboratory rats have been found to breed deformed and premature offspring after being fed large amounts of caffeine. Consequently, the FDA has urged expectant mothers to beware of caffeinated drinks and avoid medications that contain caffeine.

It has been suggested that caffeine may enhance physical performance and working capacity and, as such, may be considered as an ergogenic aid. Caffeine is presently being examined as a drug that may potentiate fat mobilization which could produce extended duration in long-term physical events. In addition, caffeine and alcohol interaction has been investigated with regard to the effects on movement, task performance and choice reaction time.

Waldeck (1973) noted that caffeine is a central nervous system stimulant. It increases excitability, possibly by

reducing neuron threshold. This results in an easier recruitment of motor units, spreading the tension requirement over a larger muscle mass, thus reducing both the perception of exertion and altering the pattern of substrate utilization in the working fibers (23).

Purpose of the Study

It is the purpose of this investigation to explore and examine the effects of two selected doses of caffeine on reflex response time of the knee jerk in subjects exhibiting similar consumption levels of caffeine.

Hypotheses

The following hypotheses were examined in this investigation:

HO1: There will be no difference between pre- and post-tests on reflex response time of the knee jerk after consumption of 0 mg./kg. bwt. caffeine.

HO2: There will be no difference between pre- and post-tests on reflex response time of the knee jerk after consumption of 3 mg./kg. bwt. caffeine.

HO3: There will be no difference between pre- and post-tests on reflex response time of the knee jerk after consumption of 6 mg./kg. bwt. caffeine.

HO4: There will be no difference between groups of 0 mg./kg. bwt. and 3 mg./kg. bwt. caffeine on reflex response time.

HO5: There will be no difference between the groups of 0 mg./kg. bwt. and 6 mg./kg. bwt. caffeine on reflex response time.

HO6: There will be no difference between the groups of 3 mg./kg. bwt. and 6 mg./kg. bwt caffeine on reflex response time.

Delimitations

1. There were 18 subjects used in the investigation.
2. Only subjects who exhibited similar consumption levels of caffeine were chosen.
3. All subjects were college students from Oklahoma State University, ranging in age from 18 to 25 years old.
4. There were only two doses of caffeine given, 3 mg./kg. bwt. and 6 mg./kg. bwt.

Limitation

1. The subjects' diets were not controlled for the ingestion of caffeine except for 24 hours prior to the experiment.

Assumptions

1. Subjects correctly followed all directions.
2. Subjects were all similar in the amount of consumption of caffeine.
3. Subjects consumed all caffeine mixed with decaffeinated coffee and water.

CHAPTER II

LITERATURE REVIEW

Introduction

Caffeine, in recent years, has been the current topic of study as an ergogenic aid. Most research in this area has been conducted to explore the effect caffeine has on endurance; however some research exists involving muscular strength, and movement and reaction time. Except for very few studies done by Russian investigators, relatively little data can be found on the effect caffeine has on reflex reaction time.

Effects on Movement and Reaction Time

Jacobson and Edgley (1987) tested thirty subjects to examine the effects of caffeine on simple reaction time and simple movement time. They discovered that caffeine significantly decreased movement and reaction time at a moderate dose (300 mg.). However there was no difference found in the control group (0 mg.), or the high dose group (600 mg.) (33).

Cheney (1934) examined the effects of caffeine and a caffeine beverage on reaction time in young adults. Subjects were split into two groups according to similarities in weight and subjects were given two stimulants (caffeine capsule and black coffee), and a placebo (starch capsule), on alternating days to study the effect on reaction time. It was noted that a dose of less than 3 mg./kg. bwt. produced no significant effect on reaction time. A dose of 3.0 to 4.0 mg./kg. bwt. caffeine produced variable effects, but a dose of 5.0 mg./kg. bwt. caffeine or greater always produced a decrease in reaction time over a three hour period. Over a twenty-four hour period, no significant effects in reaction time were discovered (34).

In a similar study, Cheney (1935), tested five women for the effect caffeine and a caffeine beverage on reaction time behavior. Each of the women were of the same age, height, weight, and had established equal normal reaction time readings. They were given caffeine doses of 3.3 to 3.6 mg./kg. of bwt. and the equivalent in a caffeine beverage. It was discovered that coffee was slightly more effective in reducing reaction time within the first thirty minutes. From thirty to sixty minutes, coffee became less effective and remained below caffeine for the duration of the experiment. Likewise, there were no significant effects from either dose at the twenty-four hour period (35).

Neurological Effects of Caffeine

The following studies concerning the neurological effects of caffeine all had to be translated from Russian to English. The English abstracts that did exist were very limited as to the specificity of the criteria.

Kliavina (1960) examined the effects of caffeine on conditioned reflex in 15-30 day old puppies. It was noted that, after securing conditioned reflexes with stable latent periods, 0.01 g., 0.015 g., and 0.03 g., caffeine did not produce any change in the conditioned reflex in 24-day old puppies. However, when a dose of 0.05 g. caffeine was given, the latency period was reduced 1-2 seconds (27).

Borisova (1959) found that caffeine given in small doses to dogs (0.03 g.) caused a reduction in previously elaborated food conditioned reflexes. He also noted the effect of caffeine was of an inhibitory character, irrespective of the size of the dose induced. One possible basis for this, is the diphasic action of caffeine (28).

Lovchikov (1975) further discovered that a dose of .01 g. caffeine decreased the magnitude of conditioned reflexes in dogs. However, a dose of caffeine from .05 g. to 1.0 g. caffeine increased the magnitude of reflexes to the maximum, but a dose from 0.1 g. to 0.5 g. caffeine diminished the magnitude from maximum to normal level. Furthermore, a dose of 0.5 g. or greater resulted in a decrease below the normal

level (29). This study would seem to suggest a dose response relationship to the effects of caffeine.

Arushanyan and Karpov (1975) conditioned 13 freely movable cats to jump over a barrier to an opposite chamber at the sound of a bell. It was discovered that there was a corresponding decrease in motor latency subsequent to caffeine dose injection (30).

Kostenko's (1968) study on rabbits was very similar to that of Lovchikov. He found that a dose of 0.06 g. to 3.0 g. caffeine detained the formation of conditioned reflexes. The same dosage also resulted in partial disinhibition on previously formed conditioned reflexes (31).

Effects on Humans

Using five subjects, Sunday (1982) introduced a study testing the influence of caffeine on the monosynaptic reflex threshold. Electro-stimulation of the H-reflex was performed following the administration of approximately 100 mg. to 150 mg. caffeine. The results indicated that caffeine lowered the stimulus threshold for the elicitation of the H-reflex. Sunday concluded that a lowering of the stimulus threshold is a marked potentiation of the H-reflex (32).

Summary

In the literature no study was found that addressed the effects of caffeine on reflex reaction time. The studies reviewed examined the effect caffeine has on conditioned

reflexes and reflex threshold magnitude. Jacobson and Edgley did show that 300 mg. caffeine had a significant effect on simple reaction time, but did not investigate caffeine's effects on reflex reaction time. Although Sunday researched involuntary reflexes, his study was focused on the magnitude of the response, not the reflex response time.

CHAPTER III

METHODS

Subjects

The study consisted of eighteen volunteer subjects, twelve females and six males, all of whom were students at Oklahoma State University, Stillwater, Oklahoma. The subjects had a mean age of 20.3 years old and a mean weight of 62.9 kg. All subjects were informed as to the nature of the experiment, including any risks and side effects involved. Each voluntarily signed an informed consent document as stipulated and approved by the Institutional Review Board at Oklahoma State University (Appendix A). The subjects were then screened, both orally and through a medical questionnaire (Appendix B), for pregnancy, high blood pressure, cardiac or vascular disorders, stomach or intestinal disorders, and current medication. If any of these symptoms were apparent prior to testing, the subjects were eliminated from the study. Each subject then completed a caffeine consumption questionnaire (Appendix B). Only those subjects who showed similar consumption levels of caffeine were chosen (Table III).

TABLE III

AVERAGE DAILY CAFFEINE CONSUMPTION PER GROUP

Group	Coffee	Soda	Total	Average Per Person
0 mg./kg. bwt.	115 mg.	292.5 mg.	407.5 mg.	67.9 mg.
3 mg./kg. bwt.	115 mg.	225.0 mg.	340.0 mg.	56.7 mg.
6 mg./kg. bwt.	115 mg.	360.0 mg.	475.0 mg.	79.2 mg.

Preliminary Procedure

Prior to testing the subjects were asked to fast a minimum of eight hours and refrain from using any form of caffeine for twenty-four hours.

Following the explanation of the experiment, the subjects' heart rate and blood pressure were taken and recorded. The subjects were then randomly assigned to one of three groups; (1) 0 mg./kg. bwt., (2) 3 mg./kg. bwt., (3) 6 mg./kg. bwt., and their weight recorded to determine the amount of caffeine, if any, that was to be ingested.

Equipment and Testing Procedure

The study used a double-blind, placebo controlled design. Prior to the ingestion of caffeine, each subject's monosynaptic reflex was recorded using a Lafayette Knee

Reflex Reaction Timer (model 63645). The timer was interfaced with a Decan Automatic Performance Analyzer (model 741) to measure the response time to the nearest .001 second. The subjects were then given one of the following doses of caffeine orally: 0 mg./kg. bwt., 3 mg./kg. bwt., and 6 mg./kg. bwt. Each dose of caffeine was mixed with 0.5 tsp. decaffeinated coffee and 150 ml. hot water. The placebo consisted of 0.5 tsp. baking soda and the same mixture of decaffeinated coffee and water. The decaffeinated coffee contained approximately 0.05 mg. of caffeine, this may have caused a slightly larger dose of caffeine to be ingested by the subjects. Immediately following the ingestion of caffeine, the time was recorded so re-testing could be done approximately one hour after ingestion. During the one hour waiting period, subjects were placed in a waiting room conducive to relaxation and asked to avoid any strenuous activities.

Testing was done in a quiet isolated room so as to avoid any outside interference. Subjects were seated comfortably and asked to relax and not to anticipate the stimulus. To ensure non-anticipation their vision was restricted by having them look straight ahead at a point on the wall. Additionally, the subject's leg was marked at mid-thigh and at the patellar ligament mid-way between the tibial tuberosity and the inferior patellar border. This was done to ensure the post-testing procedure would be identical to the pre-test. The equipment used to stimulate the patellar

ligament was a small hammer containing a micro-switch suspended by a steel rod. The stimulus was then dropped from a height of 20 degrees below the horizontal level (Figure 2). A total of six pre-and post-test times were recorded (Appendix C). These times were acquired by taking three of five scores from each pre-and post-test. The three scores that were most closely grouped in each test were recorded, the remaining scores were omitted. Time measurements were obtained from the moment of contact with the patellar ligament to the initial reflex response produced by the quadricep muscles.

Post-Procedure

Following the experiment the subject's heart rate and blood pressure were taken. Subjects were also asked to refrain from eating any spicy foods so as not to produce any gastrointestinal adverse effects. They were given the name and number of the principal investigator to contact should any adverse effects arise as a result of the ingestion of caffeine.

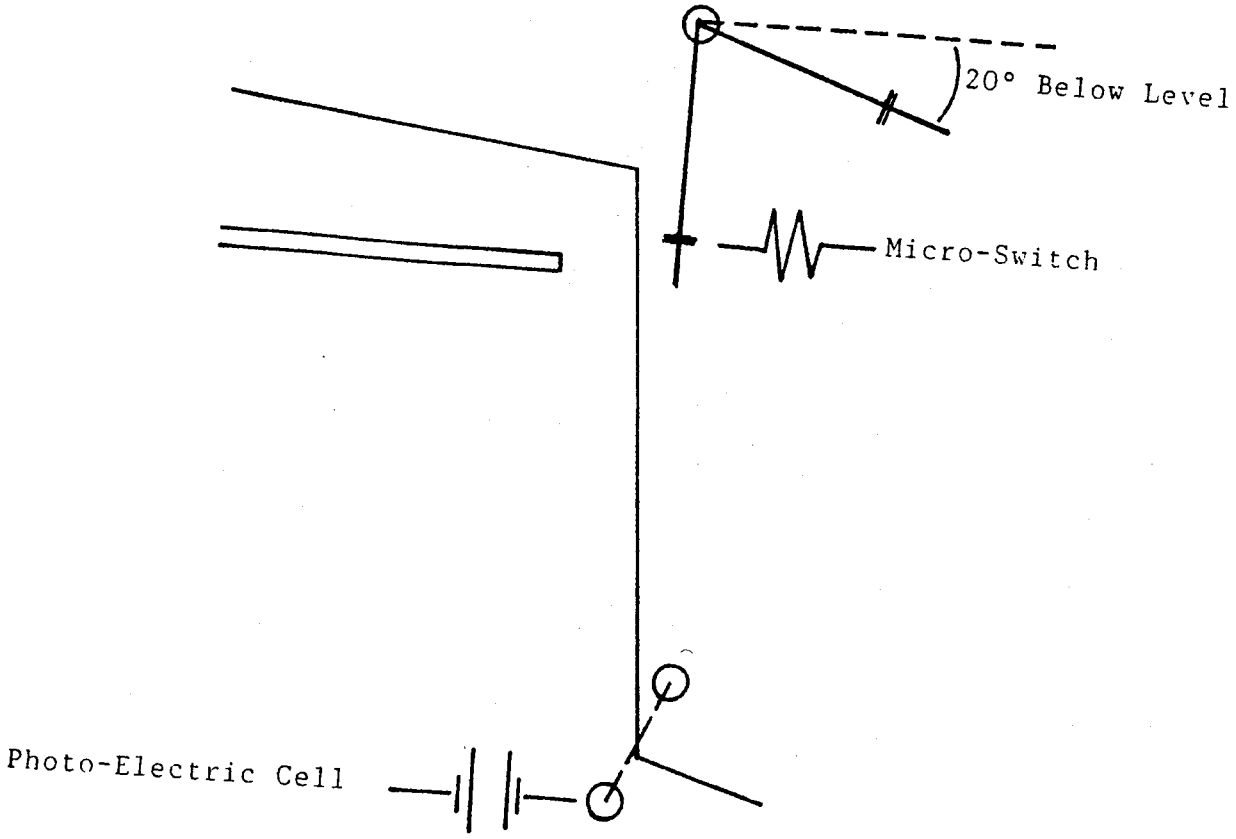

Figure 2. Diagram of Apparatus

CHAPTER IV

RESULTS AND DISCUSSION

Results

Six hypotheses were tested for significance at the .05 level in this investigation. Three hypotheses were examined to see if a difference occurred in the reflex response time between the pre- and post-tests of the knee jerk when 0 mg./kg. bwt., 3 mg./kg. bwt. and 6 mg./kg. bwt. caffeine was ingested. The other three hypotheses examined the differences between the groups when caffeine was ingested.

Hypothesis 1

The first hypothesis stated that there would be no significant difference between the pre-test and post-test of the knee jerk when 0 mg./kg. bwt. of caffeine is ingested.

Hypothesis 2

The second hypothesis stated that there would be no significant difference between the pre-test and post-test of the knee jerk when 3 mg./kg. bwt. of caffeine is ingested.

Hypothesis 3

The third hypothesis stated that there would be no significant difference between the pre-test and post-test of the knee jerk when 6 mg./kg. bwt. of caffeine is ingested.

Hypothesis 4

The fourth hypothesis stated that caffeine would have no significant difference between the groups of 0 mg./kg. bwt. and 6 mg./kg. bwt.

Hypothesis 5

The fifth hypothesis stated that caffeine would have no significant difference between the groups of 0 mg./kg. bwt. and 6 mg./kg. bwt.

Hypothesis 6

The sixth hypothesis stated that caffeine would have no significant difference between the groups of 3 mg./kg. bwt. and 6 mg./kg. bwt.

A repeated measures analysis of variance was used in analyzing the data. As indicated by Table IV a significant difference did occur between the groups. Using the Student-Newman-Kuels post hoc procedure (Table V), it was discovered that there was no significant difference between the pre- and post-test when 0 mg./kg. bwt. was ingested. Therefore, the first hypothesis was accepted.

TABLE IV

ANALYSIS OF VARIANCE OF MONOSYNAPTIC REFLEX REACTION

Pre-Test					
Source	Sum of Squares	D.F.	Mean of Squares	F Ratio	F Prob.
Between Groups	586.3086	2	293.1543	.8143	.4616
Within Groups	5400.2407	15	360.0160		
Total	5986.5494	17			

Post-Test					
Source	Sum of Squares	D.F.	Mean of Squares	F Ratio	F Prob.
Between Groups	3295.4568	2	1647.7284	4.0321	.0397
Within Groups	6129.7778	15	408.6519		
Total	9425.2346	17			

Difference					
Source	Sum of Squares	D.F.	Mean of Squares	F Ratio	F Prob.
Between Groups	1594.4815	2	847.2407	3.7339	.0483
Within Groups	3403.5741	15	226.9049		
Total	5098.0556	17			

TABLE V

MEAN TIMES ± STANDARD DEVIATION OF GROUPS

Group	Pre-Test Sd	Post-Test Sd	Change
1. 0 mg./kg. bwt.	111.4 ± 13.53	115.6 ± 16.30	4.17
2. 3 mg./kg. bwt.	125.3 ± 25.02	140.1 ± 21.31	14.78
3. 6 mg./kg. bwt.	119.2 ± 16.46	147.1 ± 22.50	27.89*

*Denotes statistically significant difference.

Table V also indicates that there was no significant difference between the pre- and post-test when 3 mg./kg. bwt. was ingested and 6 mg./kg. bwt. was ingested. Therefore the second and third hypotheses were accepted.

When analyzing the data between the groups, the post hoc procedure indicated there was no significant difference between the control group and the 3 mg./kg. bwt. group. As a result, the fourth hypothesis was accepted (Table V).

The fifth hypothesis was rejected when a significant difference was found between the control group and the 6 mg./kg. bwt. group (Table V).

Finally, Table V indicates that there was no significant difference found between the groups of 3 mg./kg. bwt. and 6 mg./kg. bwt.

Discussion of Results

The results of this investigation indicated a slight but insignificant reflex response time increase within the groups of 3 mg./kg. bwt. and the 6 mg./kg. bwt. groups. However, a significant increase in reflex response time was found between the groups of 0 mg./kg. bwt. and 6 mg./kg. bwt. The results also indicate that caffeine may have the following effects on the nervous system: (1) altering the conductivity of the neurons, (2) altering the contractibility of the muscle fibers so they do not directly follow the intrafusal fibers of the muscle spindle. Caffeine has been shown to alter certain neurotransmitters in both the CNS and the peripheral nervous system. Schlosberg (1981) raised the level of serotonin in the brain by administering acute doses of caffeine. By injecting caffeine, Berkowitz (1970), caused norepinephrine (NE) synthesis and turnover. This was believed to be caused by the blocking adenosine receptors, therefore inhibiting the NE neurons (Fenstrom and Fenstrom, 1984). Because of the immediate increase in dopamine formation after the ingestion of caffeine and subsequently the rapid decrease, Corrodi (1972) suggests that caffeine may decrease dopamine neuron activity.

Further studies show the inhibitory effects of caffeine on the calcium and calcium dependent neurotransmitters such as gamma-aminobutyric acid and acetylcholine, into the sarcoplasmic reticulum (Weber, 1968; Fabiato and Fabiato,

1975; Jhamandas, 1978; Kirk and Pucock, 1979; Scholfield, 1982) may play a major role in the control of spinal reflexes.

Bowman and Bowman (1964), along with McIntosh, Barbee, and Stainsby (1981) has suggested that caffeine may initiate contractures and increase the muscle tissue's contractile capacity. This may predispose the latency response to delay, particularly if the intrafusal fibers of the muscle spindle are not simultaneously stimulated to respond to an external phasic stretch.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS FOR FURTHER STUDY

Summary

Eighteen university students were tested for the effects caffeine has on the reflex reaction time. They were randomly assigned to three different groups consisting of 0 mg./kg. bwt., 3 mg./kg. bwt., and 6 mg./kg. bwt. Subjects were given three pre-tests to determine their reflex reaction time. After the pre-tests they were given a solution of either 0 mg./kg. bwt., 3 mg./kg. bwt., or 6 mg./kg. bwt. depending upon which group they were assigned. Following the ingestion, subjects were re-tested approximately sixty minutes later.

Conclusions

The investigation concerning the effects caffeine has on reflex response time may suggest the following conclusions. One conclusion drawn from the study would seem to suggest that with a larger sampling group caffeine may in fact significantly increase the reflex response time between the

pre- and post-tests of both the 3 mg./kg. bwt. and 6 mg./kg. bwt. groups. In relation to athletics, one may see the potential for an increase in injuries should an athlete's reflexes be slowed.

Recommendations for Further Study

To further study the effects caffeine has on reflex response time, the author suggests that an electrical stimulation be induced on the H-reflex, interfaced with a dose response relationship of caffeine. This type of study will hopefully help in determining where the increase in reflex response time actually occurs. The author also suggests a larger sampling group be incorporated into the study. Another possible topic for research could be found in comparing the reflex response times of men's to women's.

BIBLIOGRAPHY

1. Graham, D. M. (1978). "Caffeine--Its Identity, Dietary Sources, Intake, and Biological Effects." Nutrition Review, 36, 97-102.

2. Van Handle, P. (1983). "Caffeine." In M. H. Williams (Ed.), Ergogenic Aids in Sports. Human Kinetics Publishers, Champaign, IL.

3. Axelrod, and Reichenthal, J. (1953). "The Fate of Caffeine in Man and a Method for its Estimation in Biological Material." Journal of Pharmacology and Experimental Therapeutics, 107, 519-523.

4. Oldendorf, W. H. (1971). "Brain Uptake of Metabolites and Drugs Following Carotid Arterial Injections." Transactions of the American Neurological Association, 96, 46-50.

5. Van Handle, P. (1986). "Effects of Caffeine on Physical Performance." Journal of Physical Education and Recreation, Feb., 56-57.

6. Syed, I. B. (1976). "The Effects of Caffeine." Journal of the American Pharmaceutical Association, 16, 568-572.

7. Robertson, D., Wade, D., Workman, R., Woosley, R. L., and Oates, A. (1981). "Tolerance to the Humoral and Hemodynamic Effects of Caffeine in Man." Journal of Clinical Investigation, 67, 1111-1117.

8. Bevo, J. A., Roders, N. L., Crofford, O. B., Hardman, J. G., Sutherlance, E. W., and Newman, E. V. (1970). "Effects of Xanthine Derivatives on Lipolysis and on Adenosine 3'5'-Monophosphate Phosphodiesterase Activity." Molecular Pharmacology, 6, 597-603.

9. Fredholm, B. B. (1980). "Are Methylxanthine Effects Due to Antagonism of Endogenous Adenosine?" Trend in Pharmacological Research, 1, 129-132.

10. Fabiato, A., and Fabiato, B. (1975). "Dependence of the Contractile Activation of Skinned Cardiac Cells on the Sarcomere Length." Nature, (London), 256, 54-56.

11. Weber, A. (1968). The Mechanism of the Action of Caffeine on Carcoplasmic Reticulum." Journal of General Physiology, 68, 760-772.

12. Kavaler, F., Anderson, T. W., and Fisher, V. (1978). "Sarcolemmal Site of Caffeine's Inotropic Action on Ventricular Muscle of the Frog." Circulation Research, 42, 285-290.

13. Varagic, V. M., and Zugic, M. (1971). "Interactions of Xanthine Derivatives, Catecholamines, and Glucose-6-Phosphate on the Isolated Phrenic Nerve Diaphragm Preparation of the Rat." Pharmacology, 5, 275-286.

14. Burg, A. W. (1975). "Physiological Disposition of Caffeine." Drug Metabolism Review, 4, 199-228.

15. Kastrup, E. K. (1986). Facts and Comparisons: Drug Information. J. B. Lippincott Co., St. Louis, Missouri.

16. Goldstein, A., Warren, R., and Kaiser, S. (1965). "Psychotropic Effects of Caffeine in Man. I: Inter-Individual Differences in Sensitivity to Caffeine-Induced Wakefulness." Journal of Pharmacology and Experimental Therapeutics, 149, 156-159.

17. Lombardo, J. A. (1986). "Stimulants and Athletic Performance (Part 1 of 2): Amphetamines and Caffeine," Physician and Sports Medicine, 14, 128-140.

18. Stephenson, P. E. (1977). "Physiologic and Psychotropic Effects of Caffeine in Man." Journal of American Dietary Association, 71, 240-247.

19. Grady, D. (1986). "Don't Get Jittery Over Caffeine." Discover, 7, 73-79.

20. Prineas, R. J., Jacobs, D. R., Crews, R. S., and Blackburn, H. "Coffee, Tea, and VPB." Journal of Chronic Disease, 33, 73-76.

21. Jick, H., Mittinen, O. S., Neff, R. K., Shapiro, S., Heironen, O., and Sloan, D. (1973). "Coffee and Myocardial Infarction." New England Journal of Medicine, 289, 63-67.

22. Victor, B. S., Lubetsky, M., and Greden, J. F. (1981). "Somatic Manifestations of Caffeinism." Journal of Clinical Psychiatry, 42(5), 185-188.

23. Waldeck, . (1973). "Sensation by Caffeine by Central Catecholamine Receptors." Journal of Neural Transmission, 34, 61-72.

24. Ivy, J. L., Costill, D. L., Fink, W. J., and Lower, R. W. (1979). "Influence of Caffeine and Carbohydrate Feedings on Endurance Performance." Medicine and Science in Sports and Exercise, 11, 6-11.

25. "Committee on GRAS List Survey, Phase III: Estimating Distribution of Daily Intakes of Caffeine." National Academy of Sciences, Washington, D. C., (National Technical Information Services, U. S. Department of Commerce, Publication Pending).

26. "Select Committee on GRAS Substances: Tentative Evaluations of the Health Aspects of Caffeine as Food Ingredient (SCOGS-89)." Life Sciences Research Office, Federation of American Societies for Experimental Biology, Bethesda, Maryland, 1976.

27. Kliavana, M. P. (1960). "Effect of Caffeine and Bromide on the Process of Conditioned Reflex Generalization in Puppies." Pavlov Journal of Higher Nervous Activity, 10(2), 289-294.

28. Borisova, T. P. (1959). "The Direct and Conditional Reflex Effects of Small Doses of Caffeine on Higher Nervous Activity in Dogs." Pavlov Journal of Higher Nervous Activity, 9, 227-232.

29. Lovchikov, V. A. (1975). "The Relationship Between the Dose of Caffeine and the Magnitude of Conditioned Reflex Salivation in Dogs." Pavlov Journal of Higher Nervous Activity, 25(5), 949-952.

30. Arushanyan, E. B. et al. (1975). "The Effect of Phenamine and Caffeine on Caudate Inhibition of Conditioned Reflex." Pavlov Journal of Higher Nervous Activity, 25(4), 744-751.

31. Kostenko, N. D. (1968). "Influence of Caffeine on the Formation and Manifestation of Conditioned Reflexes to Time." Pavlov Journal of Higher Nervous Activity, 18(4), 621-627.

32. Sunday, T., Eke-Okoro. (1982). "The H-Reflex Studied in the Presence of Alcohol, Aspirin, Caffeine, Force, and Fatigue." Electromyography and Clinical Neurophysiology, 22(7), 579-589.

33. Jacobson, B., and Edgley, B. (1987). "The Effects of Caffeine on Movement and Reaction Time." Aviation, Space, and Environmental Medicine, 58, 1153-1156.

34. Cheney, R. (1934). "Comparative Effect of Caffeine Per Se and a Caffeine Beverage (Coffee) Upon the Reaction Time in Normal Young Adults." The Journal of Pharmacology and Experimental Therapeutics, 53(3), 304-313.

35. Cheney, R. (1935). "Reaction Time Behavior After Caffeine and Coffee Consumption." The Journal of Pharmacology and Experimental Therapeutics, 55 (2), 357-369.

APPENDIXES

APPENDIX A

INFORMED CONSENT DOCUMENT

Date _____

OKLAHOMA STATE UNIVERSITY
INFORMED CONSENT
EFFECTS OF CAFFEINE ON REFLEX REACTION TIME

I, _____, the undersigned, understand that I am participating in a research study designed to measure the effect of caffeine ingestion has on reflex reaction time. The study will involve the following procedure:

1. Testing the reflex of the knee five times on the Lafayette Knee Reflex Reaction Timer (Model 63054).

Prior to all evaluations each subject will be asked to consume a pre-mixed solution consisting of 150 ml. of water, 1 level teaspoon decaffeinated coffee and one of the following additions:

1. 3 mg. caffeine/kg. bwt.
2. 6 mg. caffeine/kg. bwt.
3. 1 tsp. baking soda (control)

The entire procedure should require no more than 1.5 hours and presents the possible benefits to me:

Learn the effects caffeine has on the reflex reaction time in humans. I also understand that this is on a voluntary basis and no penalties will be ensued should I decide not to participate or withdraw from the study. Furthermore, all records will be stored under lock and key, available only to the investigators. The ingestion of caffeine presents the following possible symptoms/reactions to me:

1. Temporary nervousness and anxiety.
2. Elevated heart rate and blood pressure.
3. Decreased hand stability.
4. Rapid heart beat.
5. Increased urinary output.

Special Note:

I realize, should any adverse effect arise, I will be transported immediately to the OSU Student Health Center. There will be no compensation for me.

Signed	Witness
Printed Name	Investigator

APPENDIX B

CAFFEINE CONSUMPTION QUESTIONNAIRE

CAFFEINE RESEARCH QUESTIONNAIRE

Caffeine Consumption History
Vital Statistics
Medical History

Name _____ Age_____ Sex_____ Wt._____ Ht._____

Pre Hr. _____ Pre BP _____
Post _____ Post _____

Caffeine Consumption History

Coffee: Cups/Day _____avg.

Soft Drinks (Coke, Dr. Pepper, Mt. Dew, Pepsi, etc.)
per day _____avg.

Tea/day _____. Glasses/day _____.

Other:
Explain_____
How does caffeine affect you? _____
_____

Have you ever experienced or know of:

Heart Trouble ____ Stomach Disorders ____
Intestinal Disorders ____ High Blood Pressure ____
High Heart Rate ____ Mental/Emotional Disorders____

Are you presently on medication? _____
If so, explain _____

Are you suffering from a hangover? _____
Do you think you are pregnant? _____
Are you currently taking oral contraceptives? _____
Are you suffering from lack of sleep? _____

Have you fasted for at least 8 hours? _____

Last meal was _____ hrs. ago.

Last caffeine was consumed _____ hrs. ago., in the form of
_____.

_____ Time of ingestion.

_____ Time of testing.

Group _____.

APPENDIX C

RAW DATA

SUBJECTS' PRELIMINARY DATA

Subject	Group	Age	Wt. Kg.	Sex
01	0	24	47.27	2
03	0	19	65.90	2
04	0	19	79.55	1
08	0	20	56.82	2
09	0	18	81.82	1
10	0	20	49.10	2
12	3	21	59.10	2
13	3	25	54.55	2
15	3	19	54.55	2
16	3	18	52.27	2
18	3	21	56.82	2
19	3	24	80.91	1
21	6	21	81.82	1
22	6	19	54.55	2
24	6	19	75.00	1
27	6	20	59.10	2
28	6	19	70.45	1
29	6	19	53.18	2

Group: 0 = Control; 3 = 3 mg./kg. bwt.; 6 = 6 mg./kg. bwt.
Sex: 1 = male; 2 = female.

PRE-TEST DATA

Subject	Pre-Test 1	Pre-Test 2	Pre-Test 3
01	114	117	118
03	093	097	097
04	119	124	138
08	114	119	124
09	092	093	096
10	111	128	121
12	110	110	113
13	098	102	107
15	154	165	169
16	101	103	111
18	128	160	160
19	121	122	122
21	140	145	149
22	109	113	131
24	127	132	134
27	103	119	128
28	098	103	105
29	095	105	109

POST-TEST DATA

Subject	Post-Test 1	Post-Test 2	Post-Test 3
01	109	112	114
03	097	098	098
04	137	138	143
08	137	138	143
09	095	100	101
10	111	121	125
12	154	158	168
13	116	122	127
15	146	162	182
16	096	110	122
18	134	137	170
19	134	141	143
21	154	155	156
22	145	176	185
24	161	182	186
27	116	125	142
28	122	136	131
29	121	123	129

VITA

Jay Regan Stepp

Candidate for the Degree of

Master of Science

Thesis: THE EFFECTS OF CAFFEINE ON REFLEX RESPONSE TIME OF THE KNEE JERK

Major Field: Health, Physical Education and Recreation

Biographical:

Personal Data: Born in Napa, California, July 26, 1961, son of Lawrence D. and Elizabeth A. Stepp.

Education: Graduated from Jenks High School, Jenks, Oklahoma, in May, 1979; received Associate Degree in Physical Education from Eastern Oklahoma State College, in December, 1981; received Bachelor of Science Degree in Health and Physical Education from Oklahoma State University in December, 1984; completed requirements for the Master of Science degree at Oklahoma State University in July, 1989.

Professional Experience: Substitute Teacher, Tulsa Public Schools, Tulsa, Oklahoma, January, 1985 to June, 1986.