THE EFFECTS OF CAFFEINE ON HAND STEADINESS, TRACING ABILITY, KINESTHETIC SENSE AND MANUAL DEXTERITY IN REGULAR CAFFEINE CONSUMERS

By

STACY RENEE' THURMAN II

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Oklahoma State University

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INTRODUCTION

History of Caffeine

Caffeine derived from natural sources has been consumed and enjoyed by people throughout the world for centuries and is currently the most widespread and indiscriminately used drug available to consumers of all ages (1). This fact creates the need for more research regarding the health risks and deleterious effects encountered by regular consumers of caffeine. The general public usually acknowledges the xanthine derivative as an ingredient in coffee, tea, and soft drinks (Table I). A 12 ounce can of many carbonated beverages contains about 30-50 milligrams caffeine, 5 ounces instant coffee contains approximately 60 mg., the same size serving of brewed coffee contains about 110 mg., and 5 ounces of brewed tea contains about 30 mg. of a similar xanthine (1). Coffee accounts for over 80% of caffeine intake in adults (2). The public may be unaware, however, of other products containing xanthines such as; chocolate, gelatins, puddings, frozen dairy products and the largest being medication. According to the FDA, about 1000 prescription drug products and about 2000 over the counter non-prescription (OTC) drug products contain caffeine (3).

Typical prescription drugs range between 30-100 mg. caffeine per tablet or capsule. Caffeine levels in OTC drugs also vary widely (typically from 15-200 mg. per tablet or capsule) and not only depend on the type of product but also the brand involved.

Since the products containing caffeine are so diverse, most adults are not aware that their average daily consumption may be as high as 250 mg., which is considered to be a large dose (1). The Market Research Corporation of America (MRCA) Survey data revealed the mean daily caffeine intake from all sources for adults to be 2.6 milligrams per kilogram of body weight (mg./kg. bwt.). For example, for a 150 pound person this would be approximately 177 mg. (or about two cups of coffee). Doses of 50-200 mg. of caffeine result in increased alertness, decreased drowsiness, and lessened fatigue. However, doses in the range of 200-500 mg. may produce headache, tremors, nervousness, and irritability. MRCA Survey data have calculated the mean estimated intake in the 10th percentile of adult consumers to be 7.0 mg./kg. body weight (4). According to another source, the daily consumption of caffeine in the U.S. is estimated to be 206 mg. (5). Heavy consumption of caffeine is known to cause symptoms collectively know as caffeineism. Yet, these symptoms are indistinguishable from a classic description of anxiety attack (6). Specifically, the patient may exhibit symptoms of nervousness, irritability, tremulousness, muscle twitching, insomnia, sensory

disturbances, rapid breathing, palpations, flushing, arrhythmias, and gastrointestinal disturbances (7).

A need exists for research regarding the effects of caffeine on hand steadiness, tracing ability, kinesthetic sense and manual dexterity in those individuals who are regular caffeine consumers. Many occupations today demand precision and the performance of simple yet delicate motor skills. If caffeine should affect these motor skills in heavy consumers, employees as well as employers have the right to know this information.

TABLE I

CAFFEINE CONTENT IN BEVERAGES, DRUGS,

& MISCELLANEOUS PRODUCTS

CAFFEINE CONTENT OF SOFT DRINKS (MG. CAFFEINE IN 12 OZ.)

---

	*Source			
BRAND	1	2	3	4
Sugar Free Mr. Pibb	58.8	58.0		
Mountain Dew	54.0	54.0	54.7	49.0
Mellow Yellow	52.8	52.0		
Tab	46.8	46.0	49.4	45.0
Coca-Cola (old and new)	45.6	46.0	64.7	42.0
Diet Coke	44.4	46.0		
Shasta Cola	44.0	44.0		
Shasta Cherry Cola	44.4	44.0		
Shasta Diet Cola	40.8	44.0		
Mr. Pibb	40.8	40.8		57.0
Dr Pepper	39.6	40.8	60.9	61.0
Sugar Free Dr. Pepper	39.6	40.8	54.2	
Big Red	38.4	30.8		
Sugar Free Big Red	38.4			
Pepsi	38.4	38.4	43.1	35.0
Diet Pepsi	36.0	36.0		34.0
RC Cola	36.0	36.0	33.7	36.0
Diet Rite	36.0		31.7	
Diet RC			33.0	

*Source

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

2. Soft Drink Companies

3. Bunker, L. and McWilliams, M. (1979). "Caffeine Content of Common Beverages." Journal of The American Dietetic Association, 74: 28-32.

4. Soft Drink Companies and the Journal of the American Dietetic Association.

CAFFEINE CONTENT IN COFFEE (MG. IN 5 OZ.)

---

	*Source		
	1	2	3
Brewed, drip method	60-180	150	40-170
Brewed, percolator	40-170	110	
Instant	30-120	66	30-120
Decaffeinated, brewed	2-5	4.5	
Decaffeinated, instant	1-5	2	

*Source

1. FDA, Food Additive Chemistry Evaluation Branch.
2. Journal of the American Dietetic Association.
3. FDA, Food Additive Chemistry Branch, based on evaluations of existing literature on caffeine levels.

CAFFEINE CONTENT IN TEA (MG. IN 5 OZ)

---

	*Source	
	1	2
Brewed	20-90	45
Iced (12 oz.)	67-76	
Instant	25-50	45

*Source

1. FDA, Food Additive Chemistry Evaluation Branch.
2. Journal of the American Dietetic Association.

TABLE I (Continued)

CAFFEINE CONTENT IN NON-PRESCRIPTION DRUGS

	*Source
Weight-control Aids (capsule/tablet)	Mg. caffeine
Codexin	200
Dexatrim	200
Dietac	200
Prolamine	140

*Source

1. FDA's National Center for Drugs and Biologics.

	*Source
Pain Relievers (capsule/tablet)	Mg. caffeine
Anacin	32.0
Excedrin	65.0
Midol	32.4
Vanquish	33.0
Dristan	16.2
Duradyne	15.0
Cold & Allergy Remedies (capsule/tablet)	Mg. caffeine
Coryban-D capsules	30
Triaminicin	30
Diuretics	Mg. caffeine
Aqua-Ban	100
Aqua-Ban Plus	200

*Source

1. Physician's Desk Reference and Pharmaceutical Companies

TABLE I (Continued)

CAFFEINE IN NON-PRESCRIPTION DRUGS

	*Source
Alertness Tablets (tablet/capsule)	Mg. caffeine
Nodoz	100
Vivarin	200
Caffedrine	200

*Source

1. FDA's National Center for Drugs and Biologics.

CAFFEINE CONTENT IN MISCELLANEOUS PRODUCTS

	*Source
	Mg. caffeine
Cocoa (5 oz.)	2-20
Chocolate Milk (8 oz.)	2-7
Milk Chocolate (1 oz.)	1-15
Semi-sweet Chocolate (1 oz.)	5-35
Chocolate flavored syrup (1 oz.)	4

*Source

1. FDA, Food Additive Chemistry Evaluation Branch.

Properties of Caffeine

To understand the effects of caffeine on hand steadiness, tracing ability, kinesthetic sense, and manual dexterity one must possess general knowledge of the chemical makeup of the drug and it's effects on various organ systems in the body. Caffeine is a methylxanthine whose chemical structure facilitates its use and dispersion within the central nervous system (CNS) of the body. Caffeine is defined structurally as a 1, 3, 7-trimethyl xanthine (Figure I). The drug forms readily stable combinations with sodium benzoate and sodium salicylate, which are used in oral and intramuscular medicinal applications, and is decomposed by hot alkalies and reacts with chlorine (8). Pure caffeine is odorless, has a distinctly bitter taste and is stable at temperature, pH, and salt concentrations normally encountered in food processing (1).

The majority of neuropharmalogical information on caffeine is limited to effects related to formation and release of neurotransmitters (9), specifically the catecholamines in the autonomic nervous system. Caffeine is moderately soluble in water, yet it is hydrophobic enough to easily pass through biological membranes. It passes through biological membranes mostly by passive diffusion (1).

Caffeine is absorbed rapidly from the gastrointestinal tract and reaches peak plasma levels in approximately one hour after oral ingestion (7). It quickly passes through the blood brain barrier to act directly on medullary, vagal,

and vasomotor centers (10). It can move then into various tissues in proportion to their water content; tissue response is proportional to caffeine content (11). Caffeine acts as a stimulant to the CNS, a diuretic on the kidneys, a stimulant to cardiac muscles, and a relaxant to smooth muscle (7).

The average half life of caffeine is 3.5 hours (15% metabolism rate) and may be affected by hormone interaction. Women utilizing oral contraceptive steroids have a decreased capacity to eliminate caffeine from the body (12). Syed (13) states that oral contraceptives taken in conjunction with caffeine increases the half life of caffeine threefold.

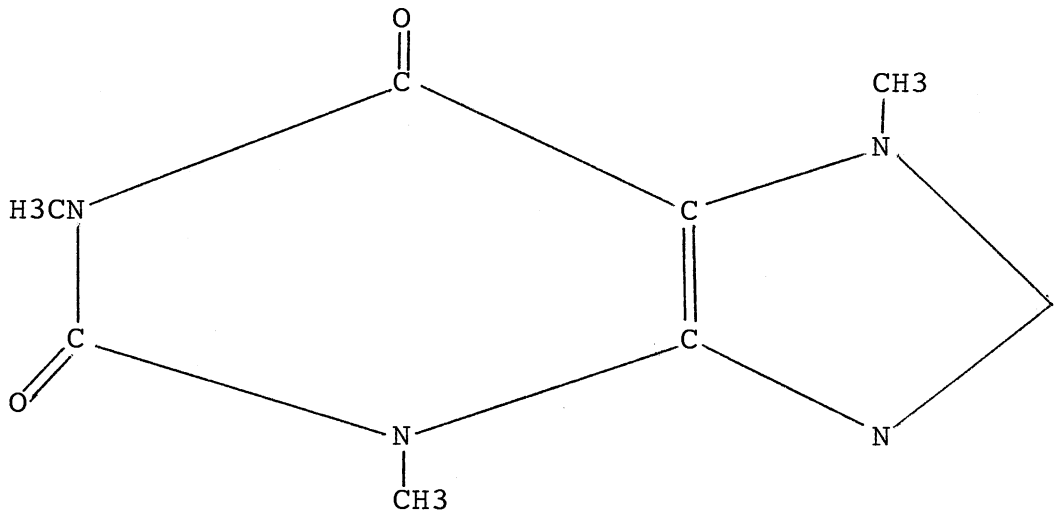

Figure 1. Chemical Structure of Caffeine

Effects of Caffeine

Some studies indicate that prolonged habitual use of caffeine may produce hazardous medical and physical complications. In women, caffeine has been implicated in the development of benign fibrocystic disease of the breast (14). Caffeine dramatically increases the vasoactive constrictive properties that alter uterine and placental blood flow patterns. High caffeine intake (600 mg. per day) is associated in a greater incidence of fetal loss (15). Nursing mothers inadvertently may cause biological trauma to their offspring through their ability to pass caffeine on via their milk (16). The FDA has advised pregnant women to eliminate completely or limit their intake of products containing caffeine (17).

Prineas and associates (18) demonstrated a link between premature ventricular contractions (PVC) and heavy coffee or tea consumption in 7252 men. The association remained significant after adjustment for age, known coronary risk factors, simultaneous food consumption, duration of sleep and alcohol consumption. Their results suggested that the consumption level of tea and coffee required to induce or increase the prevalence of PVC's is high (greater than 9 cups of coffee per day).

Very low concentrations (ie. within the range of caffeine levels commonly found in human plasma) can block the physiological effects of the purine nucleoside adenosine (19). Caffeine may produce it's effects by acting as an

antagonist of the influences of endogenous adenosine upon neural, cardiovascular, respiratory, renal, and other physiological processes (21). Adenosine's actions are mediated through stereospecific "receptors" on the extracellular surfaces of cell membranes. Caffeine competes with adenosine and certain pharmacological active adenosine derivatives for occupancy of these receptor sites; (20) adenosine and caffeine have certain structural similarities. Endogenous adenosine exerts a tonic sedative effect on the brain so it's blockade produces, as a net result, caffeine's familiar apparent stimulatory effect (22).

Boulenger (23) found that when rats were given daily caffeine in their food for several weeks they undergo a compensatory increase in the number of adenosine receptors in their brains. It is possible that some of the symptoms of caffeine withdrawal (such as headache and fatigue) may reflect an enhanced sensitivity to endogenous adenosine. Caffeine is used as an ingredient in several headache remedies, wherein it's beneficial effect may result from it's capacity to constrict cerebral arteries; (24) adenosine is a potent dilator of the cerebral vasculature (25).

Fisher et al. (26) concluded that habitual caffeine users appeared to be desensitized or to have developed a tolerance to caffeine that was evident at both rest and exercise. Prior to participation in Fisher's study all subjects were screened for habitual caffeine intake by recording daily caffeine intake over a consecutive five day

period. Furthermore, four days (or more) of withdrawal from caffeine resensitizes an individual to caffeine's physiological effect.

Some researchers have suggested that caffeine impairs hand steadiness and causes tremors (7,37,38,39). However, Goldstein, Kaizer, and Warren (46) found no impairment of coordination as a result of 150 mg. and 300 mg. of caffeine. No available investigations have explored the dose response curve as it applies to hand steadiness or manual dexterity.

Purpose of the Study

The intent of this investigation was to examine the effects of two levels of caffeine (2.5 mg./kg. bwt. and 5.0 mg./kg. bwt.) and a placebo of lactose powder on hand steadiness, tracing ability, kinesthetic sense, and manual dexterity on regular caffeine consumers.

Delimitations

1. There will be eight subjects used in this study.
2. All subjects were above the national average (206 mg.) in the amount of caffeine consumed per day.
3. All subjects were apparently healthy females, ages 20 to 26, from a rural midwestern college town.
4. There were two levels of caffeine administered, 2.5 mg./kg. bwt. and 5.0 mg./kg. bwt.

5. The subjects who participated in this investigation were not randomly selected.

Limitations

1. Good health was determined by medical questionnaire and blood pressure only.
2. There may have been individual sensitivity to caffeine.

Assumptions

1. Subjects correctly followed all instructions.
2. Subjects consumed the caffeine capsule.
3. Subjects were honest in their estimates of caffeine ingestion prior to the study.
4. Subjects fasted from caffeine 24 hours prior to each testing session and from food five hours prior to each testing session.

Hypotheses

The following hypotheses will be examined in this investigation:

HO1: There will be no difference between pre- and post-test scores on hand steadiness after consumption of 0 mg/kg bwt. caffeine in regular caffeine consumers.

HO2: There will be no difference between pre- and post-test scores on hand steadiness after consumption of 2.5 mg/kg bwt. in regular caffeine consumers.

HO3: There will be no difference between pre- and post-test scores on hand steadiness after consumption of 5.0 mg/kg bwt. in regular caffeine consumers.

HO4: There will be no difference between pre- and post-test scores on tracing after consumption of 0 mg/kg bwt. caffeine in regular caffeine consumers.

HO5: There will be no difference between pre- and post-test scores on tracing after consumption of 2.5 mg/kg bwt. caffeine in regular caffeine consumers.

HO6: There will be no difference between pre- and post-test scores on tracing after consumption of 5.0 mg/kg bwt caffeine in regular caffeine consumers.

HO7: There will be no difference between pre- and post-test scores on kinesthetic sense after consumption of 0 mg/kg bwt. caffeine in regular caffeine consumers.

HO8: There will be no difference between pre- and post-test scores on kinesthetic sense after consumption of 2.5 mg/kg bwt. caffeine in regular caffeine consumers.

HO9: There will be no difference between pre- and post-test scores on kinesthetic sense after consumption of 5.0 mg/kg bwt. caffeine in regular caffeine consumers.

HO10: There will be no difference between pre- and post-test scores on fingertip dexterity after consumption of 0 mg/kg bwt. caffeine in regular caffeine consumers.

HO11: There will be no difference between pre- and post-test scores on fingertip dexterity after consumption of 2.5 mg/kg bwt. caffeine in regular caffeine consumers.

HO12: There will be no difference between pre- and post-test scores on fingertip dexterity after consumption of 5.0 mg/kg bwt. caffeine in regular caffeine consumers.

HO13: There will be no difference between perceived ingestion of 0 mg/kg bwt., 2.5 mg/kg bwt., and 5.0 mg/kg bwt. caffeine in regular caffeine consumers.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

Recently, much attention has been directed toward caffeine and its properties as a possible ergogenic aid (27). Ergogenic aids are any substance or method that tend to increase the performance capacity of athletes. While the physiological and biochemical effects of caffeine have been reasonably well defined, the actual ergogenic effects are less clear. This is due mainly to the fact that many studies of caffeine and performance have had poor methodological controls (10). Current research has resulted in equivocal conclusions.

The speculative physical effect of caffeine has prompted the International Olympic Committee and the National Collegiate Athletic Association of the U.S. to adopt bans on the use of caffeine to aid sport performance. Doses equivalent to 500-600 mg. caffeine or five to six cups of coffee within a one to two hour period currently are prohibited (27).

Biological Effects of Caffeine

Caffeine acts on almost every organ system in the body. Caffeine, the most potent methylxanthine, is a powerful CNS stimulant. It has prominent actions on the circulatory system. After therapeutic doses of caffeine peripheral vascular resistance declines. Vasodilation, coupled with cardiac output, results in increased blood flow. However, in man the increase in peripheral blood flow is short-lived. In contrast to caffeine's dilating effect on systemic blood vessels, it causes a marked increase in cerebrovascular resistance. Caffeine relaxes various smooth muscles other than those of blood vessels. Most importantly, caffeine acts to relax the smooth muscles of the bronchi, especially if the bronchi have been constricted by histamine or clinically in asthma. Caffeine augments the release of secretory products of a number of endocrine and exocrine tissues. Moderate oral doses of caffeine causes secretion of both stomach acid and pepsin. Caffeine also can increase the concentration of circulating catecholamines and can augment dopamine beta-hydroxylase and renin activity in the plasma in man.

Three separate studies (28,29,30) found that caffeine did prolong endurance exercise bouts of one hour or more in competitive cyclists. The substrates that are used for fuel for endurance activities are mainly free fatty acids and muscle glycogen. The longer the muscle glycogen is spared, the greater the delay in the onset of exhaustion (29).

Since caffeine ingestion increases plasma levels of free fatty acids, these substances are used as fuel and the muscle glycogen stores are not depleted as rapidly. Caffeine did not significantly improve performance during maximal short-term (anaerobic) exercise bouts (10).

Robertson, Frolich, and Carr (31) and Colton, Gosswlin, and Smith (32) have demonstrated that habitual caffeine users developed a tolerance to caffeine with respect to its effects on resting blood pressure and heart rate. Habitual caffeine users also have demonstrated tolerances to caffeine's effects on plasma and urinary catecholamines, (33) parotid gland secretion, (34) and it's sleep disturbing properties (35).

Cornish and Christman (36) reported that 48 hours were needed to clear 66% of a 100 mg. caffeine dose. Axelrod and Reichenthal (11) stated that there was no day-to-day accumulation of the drug after a 500 mg. dose.

Golstein et al. (35) was the first to document that heavy users became less jittery and nervous and had fewer headaches with high doses of caffeine. In the abstainers, caffeine produced jitteriness, nervousness, and gastrointestinal distress.

Effects of Caffeine on Hand Steadiness and Manual Dexterity

The relationship between hand steadiness and the consumption of caffeine has intrigued researchers for a number of years. However, the results of such studies have had different outcomes. Caffeine, a phosphodiesterase inhibitor, has been shown to decrease tension and the degree of fusion of incomplete tetanic contractions of the cat and guinea pig soleus muscle (48,49). Bowmann and Nott have suggested further that such phosphodiesterase inhibitors, like beta-adrenoreceptor agonists, might enhance tremor in man. Some researchers have suggested that caffeine impairs hand steadiness and causes tremors (7,37,38,39). A psychologist, Hollingsworth, carefully devised nine double-blind tests which he carried out meticulously over a 40 day period. Most of his findings, including beneficial motor and mental effects from 65 to 130 mg. caffeine and tremor, poor motor performance, and insomnia caused by 390 mg. caffeine have been confirmed repeatedly over the past 60 years (7). Hollingsworth (40) required subjects to hold a metal stylus in a hole without touching the sides. He observed a pronounced unsteadiness that reached its peak about 3 to 4 hours after the administration of 360 mg. caffeine. Other investigations have confirmed these results. Hull (41) found increased tremor after 300 mg. caffeine citrate. Steadiness was impaired also after 300 mg. of caffeine sodium benzoate, or after a cup of coffee

(37). Adler (42) found increased hand tremor after 420 mg. of caffeine sodium benzoate. Lehmann and Csank (43) noted a significant decrease in steadiness after 600-900 mg. of caffeine citrate. Smith et al. (38) also found that caffeine exerted deleterious effects on hand steadiness and caused tremor. Winter (44) using caffeine naive subjects with a mean daily caffeine intake of 100 ($\pm$ 74.6) mg. tested the effects of selected doses of caffeine following fasting on hand steadiness, tracing ability, kinesthetic sense, and manual dexterity. Each subject was tested on three occasions and received 0 milligrams per kilogram of body weight (mg/kg bwt.) caffeine, 2.5 mg/kg bwt. caffeine, and 5.0 mg/kg bwt. caffeine. The experiment used a double-blind placebo controlled design. Subjects were pre-tested, administered an oral dose of caffeine randomly, and post-tested each session. When recording data, hand steadiness was divided into error time and count. Tracing was divided also into total time of the completion of the task, error off time, and error count. The subjects fasted five hours prior to testing and fasted from caffeine 24 hours prior to testing. She found that hand steadiness time was significantly impaired ($p \leq 0.05$) after the ingestion of 5.0 mg/kg bwt. caffeine but not after 2.5 mg/kg bwt. Hand steadiness count was impaired significantly after 2.5 mg/kg bwt. and 5.0 mg/kg bwt. Tracing count was impaired significantly after 5.0 mg/kg bwt. but not after 2.5 mg/kg bwt. Manual dexterity was impaired significantly after 5.0 mg/kg

bwt. but not after 2.5 mg/kg bwt. Tracing time, tracing off time, and kinesthetic sense were not affected significantly after any caffeine dose.

In contrast, Wharrad, Birmingham, Macdonald, Inch, and Mead (45) indicated no finger tremor as a result of 150 mg. taken three times daily in conjunction with normal diet. Furthermore, Goldstein, Kaiser, and Warren (46) found no impairment of coordination as a result of 150 mg. and 300 mg. of caffeine. Finally, Seashore and Ivy (47) reported no effect on steadiness, but their subjects were fatigued and this may account for the difference in results (39).

Summary

Currently no available investigations have explored the dose response curve as it applies to hand steadiness or manual dexterity in regular caffeine consumers. The results of studies regarding the effects of caffeine on hand steadiness and manual dexterity are inconsistent. These inconsistencies may be attributed to many variables including individual sensitivity to caffeine, differences in experimental protocol, differences in dose administrations, and in subject's previous caffeine consumption. It would be a valuable addition to literature to investigate the effects of caffeine on hand steadiness and manual dexterity in regular caffeine consumers.

CHAPTER III

METHODOLOGY

Subjects

Eight healthy female volunteer subjects ranging in age from 20 to 26 that resided in a rural midwestern college town were used in this study. The subjects were volunteers and were chosen on the basis of availability. They do not represent a sample of a stratified group within the population. They were not chosen from a particular class or organization. The mean age of the subjects was 22.0 ($\pm$ 2.1) years and the mean weight was 58.6 ($\pm$ 8.5) kilograms. All subjects were briefed thoroughly on the scope of the study, informed of the nature and the procedures of the experiment, including any possible risks or ill effects of the ingested caffeine. After the subjects assured the investigators that they understood the purpose of the study, each subject read and signed an informed consent document as stipulated and approved by the Institutional Review Board at Oklahoma State University (Appendix A). The form was signed also by a witness (graduate student) and the principal investigator. All responses made by the subjects were held in strict confidence and filed with the principal investigator.

As a precautionary measure, a physical screening and a

medical history questionnaire were administered to each subject. The physical screening consisted of a pre-test blood pressure. Any subject exhibiting above 140 mm Hg systolic pressure and/or 95 mm Hg diastolic pressure and/or tachycardia was eliminated from the study. The medical history questionnaire (Appendix B) included questions pertaining to pregnancy, high blood pressure, current medication, cardiac or vascular disorders, and intestinal disorders. If any of the subjects indicated a positive response to the aforementioned symptoms prior to testing, they were eliminated from the study. Each subject also completed a caffeine consumption questionnaire which indicated the average amount of caffeine each subject ingested daily. Tolerance or non-tolerance then could be estimated from the subjects responses.

Preliminary Procedures

Prior to testing, the subjects were asked to fast from caffeine a minimum of 24 hours and from food a minimum of five hours. A 24 hour fast from caffeine was utilized to avoid a reduction in tolerance and to prevent residual caffeine from interfering with the study. After the necessary documents were completed and an explanation of the experiment was given, the subject's blood pressure was taken and recorded.

Subjects were assigned randomly either a placebo or a caffeine dosage; 2.5 mg/kg bwt. or 5.0 mg/kg bwt. The

subject's body weight, which was determined by oral inquiry, was used to calculate the amount of caffeine in individual gelatin capsules. These dosages were prepared by a licensed pharmacist. Prior to each testing session each subject completed a caffeine update questionnaire (Appendix C) which determined if the subject was experiencing a lack of sleep, illness, a high level of stress, or pre-menstrual syndrome. If a subject indicated a positive response to any of the above questions she was given the opportunity to reschedule the test session.

Equipment and Testing Procedure

The study used a double-blind placebo controlled design. Neither the subject nor the principal investigator had knowledge of which dosage was ingested. In a counterbalanced design such as this, all subjects received all treatments (dosages) but in different order. The order in which the subjects received treatment (dosages) was determined randomly. Subjects also were randomly assigned to testing stations to avoid an order effect. Prior to the subject's ingestion of either the placebo or a caffeine dose, she was pre-tested on the following apparatus: 1) tracing pattern interfaced with an automatic timer and counter for hand steadiness, 2) Lafayette model 32001 Steadiness tester (hole type, hole size 3 millimeters) with automatic timer and counter and hand held stylus, 3) kinesthesiometer used in conjunction with opaque goggles

which served as a blinder for kinesthetic sense, and 4) Lafayette O'Connor Dexterity tweezer-pin placement apparatus for fingertip dexterity and speed capacity of simple but rapid coordinated movement. Two time trials were recorded for each variable and then averaged with the exception of kinesthetic sense. Two variables were recorded when subjects were tested for hand steadiness. The first was hand steadiness time (HST) which was the amount of time (in seconds) during a 60 second test in which the subjects contacted the stylus with the plate. The second variable was hand steadiness count (HSC), which was the number of times during a 60 second time frame the subject contacted the plate with the stylus.

Three variables were recorded for the tracing task. The first variable was total tracing time (TT), which was the total amount of time it took the subject to trace the pattern from start to finish. Secondly, tracing error (off) time (TOF) was recorded. This variable was the amount of time the subject was not in contact with the pattern. Lastly, tracing count (TC) was tested which indicated the number of times the subject was not in contact with the pattern.

The value recorded when subjects were tested for kinesthetic sense (K) represented the difference between the correct angular position previously placed by the researcher and the angular placement by the subject in an attempt to duplicate the researcher's placement. The three angular

displacements utilized were angles of 45, 30, and 60 degrees.

The value that was recorded for manual dexterity (D) was the total amount of time it took the subjects to complete the first three rows of the tweezer-pin placement apparatus. The subjects started in the left hand corner and proceeded to fill the rows from left to right as quickly as possible.

Subjects were assigned randomly to testing order and testing stations. Subjects were given identical verbal instructions for task completion at each testing station by the researcher. Two trials were recorded at each testing station with the exception of the kinesthesiometer which was recorded only once for each angle.

After subjects were pre-tested at all four stations, they were administered an oral dose of either a placebo or 2.5 mg/kg bwt. or 5.0 mg/kg bwt. caffeine. The placebo consisted of a gelatin capsule filled with lactose powder. Both placebo and caffeine doses were administered with cold tap water. Immediately after the caffeine was ingested, the time was recorded so that post-testing could be performed no less than one hour after ingestion. During the one hour waiting period, subjects were asked to relax and to refrain from food, beverages containing caffeine, and strenuous activity.

Testing was conducted in a quiet isolated room with dividers between each station in an attempt to avoid any

outside visual or auditory distractions. All testing was performed in the Exercise Physiology lab on the Oklahoma State University campus. Pre- and post-test values were recorded for each one of the three dosages (Appendix E). Both time trials were averaged for pre-test and post-test scores. The mean of the two scores was determined for all pre-test and post-test data collected for each test of fine motor skill.

Post Procedure

Immediately following the post-test session each subject was asked to complete a perceived ingestion question to determine to amount of caffeine she believed she had consumed. It took approximately 1.5 hours to complete each testing session. The total time for all testing sessions was approximately 4.5 hours. Subjects were encouraged to eat immediately after the post-test session but were forewarned that the ingestion of spicy or greasy food could result in stomach upset or nausea. Any subject who had any ill feeling was instructed to contact the principal investigator immediately.

CHAPTER IV

RESULTS AND DISCUSSION

Results

This investigation involved the testing of seven hypotheses at a (alpha level) significance at the .05 level. A hypothesis for each of the following was tested: hand steadiness time, hand steadiness count, tracing time, tracing off time, tracing count, kinesthetic sense, and manual dexterity. The hypotheses were questioned to see if a difference occurred between post-tests when 0 mg/kg bwt., 2.5 mg/kg bwt., and 5.0 mg/kg bwt. caffeine was ingested.

Hypothesis 1-3

The first three hypotheses stated there would be no difference between the placebo and two levels of caffeine post-tests on hand steadiness after consumption of placebo, 2.5 mg/kg bwt. and 5.0 mg/kg bwt. caffeine in regular caffeine consumers.

Hypothesis 4-6

The fourth through sixth hypotheses stated there would be no difference between the placebo and two levels of caffeine post-tests on tracing after consumption of placebo,

2.5 mg/kg bwt. and 5.0 mg/kg bwt. caffeine in regular caffeine consumers.

Hypothesis 7-9

The seventh through ninth hypotheses stated there would be no difference between the placebo and two levels of caffeine post-tests on the kinesthesiometer testing kinesthetic sense after consumption of placebo, 2.5 mg/kg bwt. and 5.0 mg/kg bwt. caffeine in regular caffeine consumers.

Hypothesis 10-12

The tenth through twelfth hypotheses stated there would be no difference between the placebo and two levels of caffeine post-tests on fingertip dexterity and speed capacity of simple but rapid coordinated movement after consumption of placebo, 2.5 mg/kg bwt. and 5.0 mg/kg bwt. caffeine in regular caffeine consumers.

The daily caffeine consumption of the subjects ranged between 320 and 573 mg. with a mean of 415 ($\pm$ 96.5) mg. Although given the opportunity, no subject indicated a desire to reschedule any testing session due to a lack of sleep, an unusually high amount of stress, or any other item on the caffeine update questionnaire (Appendix C). The mean and standard deviations for each variable can be found in Table III. A 2 x 3 repeated measures analysis of variance (ANOVA) was performed for all variables with the three levels of administered doses (0 mg., 2.5 mg/kg bwt., and 5.0 mg/kg bwt.) serving as the grouping factor and the two-level trial factor consisting of the pre-test and post-test measurements. This repeated measures analysis of variance was used in analyzing the pre-test data. No significance ($p < .05$) was found for any variable in the pre-test. A repeated measures analysis of variance also was used in analyzing post-test data and once again, no significance ($p < .05$) was found. Therefore all hypotheses failed to be rejected as no significance was found between post-tests on any variable.

When subjects were administered the placebo the majority perceived to have ingested 0 mg/kg bwt. When subjects ingested 2.5 mg/kg bwt. caffeine (small dose) they perceived they had ingested a moderate amount. Lastly, when subjects ingested a moderate dose of 5.0 mg/kg bwt. caffeine they perceived to have ingested a moderate dose. In

conclusion, the author suggests that when subjects received a caffeine dose (not including placebo) they could not differentiate between a small dose and a moderate dose.

Discussion of Results

Based on the results of this investigation hand steadiness time, hand steadiness count, tracing time, tracing off time, kinesthetic sense, and manual dexterity are not impaired after the ingestion of 2.5 mg/kg bwt caffeine or 5.0 mg/kg bwt. caffeine. Therefore, the author suggests that those individuals who ingest large quantities of caffeine daily acquire a tolerance and the variables listed above are not significantly affected.

In contrast to previous studies (7,37,38,39), the findings of this investigation are not consistent in that hand steadiness is not affected by caffeine. However, it is difficult to compare the results of this study to previous studies because in this study the dosages were given according to the subject's body weight (not a blanket dose which is often performed in caffeine research). Also, all subjects were female and well above the national average for caffeine consumption per day with a mean daily intake of 415 ($\pm$ 96.5) mg. per day. Subjects also were asked to fast from food five hours prior to testing and caffeine 24 hours prior to testing. It was not mentioned if these variables were considered in previous studies therefore making it difficult to make a comparison.

This study replicated the protocol of Winter's investigation (44) in regard to testing procedure and caffeine dosages. The major difference, however, was the fact that subjects in Winter's study were caffeine naive with a mean daily caffeine intake of 100 (± 74.6) mg. and the subjects who participated in this study were regular caffeine consumers with a mean daily caffeine intake of 415 (± 96.5) mg. Winters found that fine motor skills were significantly impaired at 2.5 mg./kg. bwt. and 5.0 mg./kg. bwt. caffeine in caffeine naive subjects. However, regular caffeine consumers utilized in this study did not exhibit deleterious effects on fine motor skills after either caffeine dose. This lack of impairment on fine motor skills in subjects in this study is due to caffeine tolerance not exhibited by those in Winter's study.

TABLE II

ANALYSIS OF VARIANCE

HAND STEADINESS TIME

	Sum of Square	D.F.	Mean of Squares	F Ratio	F Prob.
Condition	9.0149	2	4.50750	0.32	0.7283
Error	194.57152	14	13.89797		
Time	9.99187	1	9.99187	1.47	0.2647
Error	47.58310	7	6.79759		
C x T	15.96501	2	7.98251	1.93	0.1818
Error	57.89496	14	4.13535		

HAND STEADINESS COUNT

	Sum of Squares	D.F	Mean of Squares	F Ratio	F Prob.
Condition	2816.79167	2	1408.39583	1.26	0.3131
Error	15608.54167	14	1114.89583		
Time	2200.52083	1	2200.52083	2.22	0.1799
Error	6940.64583	7	991.52083		
C x T	2959.54167	2	1479.77083	2.83	0.0927
Time	7313.79167	14	522.41369		

TABLE II (Continued)

TRACING TIME

	Sum of Squares	D.F.	Mean of Squares	F Ratio	F Prob.
Condition	1327.99879	2	663.99939	2.14	0.1547
Error	4345.69634	14	310.40688		
Time	99.47522	1	99.47522	9.5	0.0177
Error	73.26643	7	10.4663		
C x T	22.73288	2	11.36644	.32	0.7334
Error	501.93046	14	35.85218		

TRACING OFF TIME

	Sum of Squares	D.F.	Mean of Squares	F Ratio	F Prob.
Condition	10.71541	2	5.35771	0.77	0.4836
Error	97.99459	14	6.99961		
Time	0.00083	1	0.00083	0.00	0.9745
Error	5.31583	7	0.75940		
C x T	3.01292	2	1.50646	1.38	0.2827
Error	15.23041	14	1.08789		

TRACING COUNT

	Sum of Squares	D.F.	Mean of Squares	F Ratio	F Prob.
Condition	152.54167	2	76.27083	1.43	0.2732
Error	749.12500	14	53.50893		
Time	16.33333	1	16.33333	1.25	0.3001
Error	91.33333	7	13.04762		
C x T	31.29167	2	15.64583	0.80	0.4679
Error	273.04167	14	19.50298		

TABLE II (Continued)

KINESTHETIC SENSE

	Sum of Squares	D.F.	Mean of Squares	F Ratio	F Prob.
Condition	16.16667	2	8.08333	1.42	0.2750
Error	79.83333	14	5.70238		
Time	0.33333	1	0.33333	0.08	0.7906
Error	30.66667	7	4.38095		
C x T	7.16667	2	3.58333	1.03	0.3834
Error	48.83333	14	3.48810		

MANUAL DEXTERITY

	Sum of Squares	D.F.	Mean of Squares	F Ratio	F Prob.
Condition	1279.89533	2	639.94766	1.24	0.3204
Error	7248.13228	14	517.72373		
Time	322.40338	1	322.40338	1.09	0.3315
Error	2073.67642	7	296.23949		
C x T	59.18781	2	29.59391	0.24	0.7930
Error	1756.52249	14	125.46589		

TABLE III

MEAN TIMES ± STANDARD DEVIATIONS OF VARIABLES

HAND STEADINESS TIME

Group	Post Test	Standard Deviation
1. 0 mg./kg. bwt.	6.00	±6.52
2. 2.5 mg./kg. bwt.	5.36	±2.92
3. 5.0 mg./kg. bwt.	7.38	±2.60

HAND STEADINESS COUNT

Group	Post Test	Standard Deviation
1. 0 mg./kg. bwt.	66.50	±39.44
2. 2.5 mg./kg. bwt.	78.13	±33.78
3. 5.0 mg./kg. bwt.	101.75	±41.00

TRACING TIME

Group	Post Test	Standard Deviation
1. 0 mg./kg. bwt.	31.47	±15.41
2. 2.5 mg./kg. bwt.	20.47	±11.29
3. 5.0 mg./kg. bwt.	30.26	±12.99

TRACING OFF TIME

Group	Post Test	Standard Deviation
1. 0 mg./kg. bwt.	4.11	±3.05
2. 2.5 mg./kg. bwt.	3.55	±2.43
3. 5.0 mg./kg. bwt.	5.13	±1.80

TABLE III (Continued)

TRACING COUNT

Group	Post Test	Standard Deviation
1. 0 mg./kg. bwt.	18.13	±6.31
2. 2.5 mg./kg. bwt.	21.63	±7.09
3. 5.0 mg./kg. bwt.	23.75	±3.20

KINESTHETIC SENSE

Group	Post Test	Standard Deviation
1. 0 mg./kg. bwt.	3.50	±1.41
2. 2.5 mg./kg. bwt.	5.63	±2.50
3. 5.0 mg./kg. bwt.	4.38	±2.67

MANUAL DEXTERITY

Group	Post Test	Standard Deviation
1. 0 mg./kg. bwt.	98.96	±31.84
2. 2.5 mg./kg. bwt.	109.87	±48.46
3. 5.0 mg./kg. bwt.	113,79	±48.78

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS FOR FURTHER STUDY

Summary

Eight regular caffeine consuming females ranging in age from 20 to 26 were tested for the effects that selected doses of caffeine have on hand steadiness, tracing ability, kinesthetic sense, and manual dexterity. Each subject was tested three times and was administered either 0 mg/kg bwt., 2.5 mg/kg bwt., or 5.0 mg/kg bwt. caffeine randomly. Each time a subject was tested a different dosage was administered. Subjects performed a pre-test prior to each ingestion. Approximately 60 minutes after the ingestion of either the placebo or caffeine dose a post-test was performed by each subject.

Conclusions

The findings of the study suggest that hand steadiness, tracing ability, kinesthetic sense, and manual dexterity are not impaired after ingestion of 2.5 mg/kg bwt. or 5.0 mg/kg bwt. in regular caffeine consuming subjects. Winter (44), in a previous study utilizing the same protocol as this study, found that hand steadiness time was impaired at 5.0

mg/kg bwt. but not 2.5 mg/kg bwt. Secondly, hand steadiness count was impaired at both 2.5 and 5.0 mg/kg bwt. Also, tracing count was impaired at 5.0 mg/kg bwt. caffeine. Finally, manual dexterity was impaired at 5.0 mg/kg bwt. caffeine level but not 2.5 mg/kg bwt. caffeine level. However, subjects participating in Winter's study were caffeine naive and well below the national daily average of caffeine consumed which is 206 mg. (38).

The findings of this study are consistent with previous studies regarding caffeinism in that individuals do indeed build up a tolerance to caffeine over an extended period of time.

Recommendations for Further Study

In an attempt to further study the effects of selected doses of caffeine the author suggests utilizing the same protocol in this study using more subjects and adding one more dosage higher than 5.0 mg/kg bwt. (ie. 7.5 mg/kg bwt.) in an attempt to identify a dose response curve and/or the saturation level in the subjects. Also, it would be interesting to utilize the protocol in Winter's study using caffeine naive subjects and add a caffeine dosage in between 2.5 mg/kg. bwt. and 5.0 mg./kg. bwt. to identify at what point fine motor skills become impaired by caffeine. Another investigation which could benefit caffeine research would involve the testing of subjects on a full stomach. This study would attempt to determine if deleterious effects

of caffeine are avoided, decreased, or delayed as a result of a full stomach.

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APPENDIXES

APPENDIX A

INDIVIDUAL'S CONSENT FOR PARTICIPATION IN A RESEARCH PROJECT

Individual's Consent for Participation in a Research Project

Oklahoma State University

I, _____, voluntarily agree to participate in this study entitled: The Effects Caffeine on Hand Steadiness, Tracing Ability, Kinesthetic Sense and Manual Dexterity in Regular Caffeine Consumers.

1. PURPOSE: This study involves research that will be carried out under the supervision of Bert H. Jacobson, Ed. D. and Stacy Renee' Thurman. The purpose of this study will be to ascertain the effects of 2.5 mg./kg. bwt. and 5.0 mg./kg. bwt. caffeine on hand steadiness, tracing ability, kinesthetic sense, and manual dexterity. Such qualities are often necessary and / or vital for occupations today. Given that one cup of coffee contains 100 mg. caffeine, it is safe to assume that many professionals consume up to 400 mg. caffeine prior to or during work time. However, casual consumption is not all in one dose. This study will attempt to find if deleterious effects follow a single dose of 2.5 mg./kg. bwt. and 5.0 mg./kg. bwt. caffeine consumption.

2. STATUS ON INVESTIGATIONAL DRUG PROCEDURES: Caffeine may alter blood pressure, heart rate, respiration and metabolic rate. Caffeine may also induce tremors, nervousness, and anxiety.

3. DESCRIPTION OF STUDY: This study will involve a prescreening consisting of blood pressure. Additionally a medical history questionnaire containing the following items will be administered: oral contraceptive use, medication use, current illnesses, pregnancy, hang over, and history of heart disease. Further, a caffeine consumption questionnaire will be administered to ascertain the average amount of caffeine consumed per day and week. Any subject indicating a blood pressure reading above 140 mm. Hg systolic pressure and/or 60 mm. Hg diastolic pressure and/or tachycardia will be eliminated from the study. Also, any positive response on the medical history questionnaire will result in elimination.

Subjects will be asked to fast from food for 5 hours and fast from caffeine for 24 hours prior to testing. Subjects will be pre-tested for hand steadiness, tracing ability, kinesthetic sense, and manual dexterity. Following the pre-test, each subject will be given on of three solutions containing 1) 0 mg. caffeine, 2) 2.5 mg./kg. bwt. or 3) 5.0 mg./kg. bwt. caffeine on a double blind format.

Following a one (1) hour waiting period, all subjects will be post-tested using the pre-test protocol. The full duration of this study will take approximately one and a half (1.5) hours.

I understand that I will be given 0 mg., 2.5 mg./kg. bwt. and 5.0 mg./kg. bwt. caffeine. Neither I nor the investigator will know which dosage I have been administered during each test but that information can be obtained if necessary.

4. BENEFITS: No direct benefit in the consumption of caffeine may be expected. However, observable physical changes may lead to a change in attitude toward caffeine consumption and a greater awareness of products containing caffeine may ensue.

5. POSSIBLE RISKS: Caffeine ingestion in the quantities described in this study may increase nervousness, irritability and anxiety. Respiration, blood pressure and heart rate may also be magnified. Additionally, nausea may appear if the meal following caffeine consumption includes spicy and/or greasy food. STAY AWAY FROM PIZZA! If you become nauseous or feel ill, you will be retained for observation and transported to the University Health Center.

I recognize that the primary risk is the possibility of experiencing some side effects. Those that have been observed in the past for caffeine consumption include:

Hyperactivity
Upset stomach after eating pizza

If I have any side-effects, I will report them immediately to the investigator, my physician or his/her associates. If side-effects are severe, I may be removed from the study.

6. ALTERNATE PROCEDURES: None

7. SUBJECT ASSURANCES: Whereas no assurance can be made concerning results that may be obtained (because results from investigational studies cannot be predicted with certainty), the principal investigator will take every precaution consistent with best scientific practice.

By signing this consent form, I acknowledge that my participation in this study is voluntary. I also acknowledge that I have not waived any of my legal rights or released this institution from liability for negligence.

I may revoke my consent and withdraw from this study at any time without penalty or loss of benefits. My treatment by, and relations with the investigators and staff at Oklahoma State University, now and in the future, will not be affected in any way if I refuse to participate, or if I

enter the program and later withdraw.

Records of this study will be kept confidential with respect to any written or verbal reports making it impossible to identify me individually. All records will be held in a locked file belonging to the PI.

If I have any questions about my rights as a research subject, I may take them to the office of University Research Services, 001 Life Sciences East. Phone: 744-9991.

8. SIGNATURES:

_____	_____
Date	Research Subject
_____	_____
Date	Witness
_____	_____
Date	Principal Investigator

Any questions regarding the research may be addressed to Bert Jacobson, 102 Colvin Center. Phone: 744-5493. Subjects will receive a copy of this consent form following the study.

APPENDIX B

CAFFEINE RESEARCH QUESTIONNAIRE

CAFFEINE RESEARCH QUESTIONNAIRE

Caffeine Consumption History
Vital Statistics
Medical History

Name_____ Age_____ Weight_____

Height_____ Pre BP:_____

Caffeine Consumption History

Coffee: Cups/day _____ average

Soft drinks: (Coke, Pepsi, Diet Coke, etc.)/day_____

Tea: Cups/day_____ Glasses/day_____

Other: Explain_____

How does caffeine affect you?_____

_____

Medical History

Have you ever experienced or know of:
Heart trouble _____ Stomach disorders_____
Intestinal disorders _____ High blood pressure_____
High heart rate _____ Mental/emotion. dis._____
Are you presently on medication? _____
Are you suffering from a hangover? _____
Do you think you are pregnant? _____
Are you currently taking oral contraceptives?_____
Are you currently suffering from lack of sleep? _____

Have you fasted for five hours? _____
Last meal was _____ hours ago.
Last caffeine was consumed _____ hours ago in the form of _____.

Time of ingestion _____
Time of testing _____
Group _____

APPENDIX C

CAFFEINE RESEARCH QUESTIONNAIRE UPDATE

CAFFEINE RESEARCH QUESTIONNAIRE UPDATE

Caffeine Consumption Update
Vital Statistics
Medical Update

Name_____ Session_____

Pre BP_____ Post BP_____

1. Are you presently on medication? If so, what?
_____

2. Are you suffering from a hangover?_____

3. Do you think you are pregnant?_____

4. Are you taking oral contraceptives?_____

5. Are you suffering from lack of sleep?_____

6. Are you currently experiencing a high level of stress?__
If so, would you prefer to reschedule this session?_____

7. Are you currently experiencing PMS?____ If so, would you like to reschedule this session?_____

8. Have you suffered an illness since your previous test session?(flu, cold, etc.) If so, what?_____

9. Has your average caffeine consumption per day changed since you previous test session?_____ If so, what is it?_____

Have you fasted from food for five hours?_____

Your last meal was _____ hours ago?

Your last caffeine was consumed _____ hours ago in the form of_____

Time of ingestion _____
Time of testing _____
Group _____

APPENDIX D

INSTRUCTIONS FOR TESTING

INSTRUCTIONS FOR TESTING

INSTRUCTIONS FOR HAND STEADINESS

1. Hold stylus like you would a pencil.
2. Do not rest fingers or arm on table or brace arm against your body in any way.
3. Hold tip of stylus in hole which has two black stripes above it.
4. You will perform this test for 60 seconds.
5. Every time you touch the sides a buzzer will sound. Do not be alarmed by it.

INSTRUCTIONS FOR TRACING

1. Hold stylus as you would a pencil.
2. Do not rest or brace fingers or arm on table.
3. Trace the pattern on the board, working from the bottom of the pattern to the top.
4. This is not a race for time.
5. The stylus should remain in contact with the pattern at all times. Do not lift the stylus from the board and try to replace it if you move off the pattern.

INSTRUCTIONS FOR KINESTHETIC SENSE

1. Place the blindfold on your head.
2. Place your right arm in the tray.
3. Grasp knob with your little finger.
4. The tester will move your arm to a designated spot and back to the point of origin.
5. With your eyes closed you will attempt to move your arm to the exact point the tester did and stop at that position.

INSTRUCTIONS FOR MANUAL DEXTERITY

1. Hold the tweezers with your thumb and forefinger with your palm surface on top of the tweezers.
2. Using the tweezers, pick up a pin from the bowl and place it in the first row, first hole on the left side.
3. Work from left to right. When you complete the first row move to the second and complete it as you did the first. You are to fill the first three rows.
4. Complete the designated number of rows as quickly as possible.

APPENDIX E

RAW DATA RECORD SHEET

RAW DATA RECORD SHEET

Name_____ Session_____

PRE			POST		
Hand Steadiness (60 sec)			**Hand Steadiness (60 sec)**		
	Time	Count		Time	Count
1.	_____	_____	1.	_____	_____
2.	_____	_____	2.	_____	_____
Tracing			**Tracing**		
	Total Time	Off Time Count		Total Time	Off Time Count
1.	_____	_____ _____	1.	_____	_____ _____
2.	_____	_____ _____	2.	_____	_____ _____
Kinesthesiometer			**Kinesthesiometer**		
1.	(45)	_____	1.	(45)	_____
2.	(30)	_____	2.	(30)	_____
3.	(60)	_____	3.	(60)	_____
O'Connor Dexterity			**O'Connor Dexterity**		
1.		_____	1.		_____
2.		_____	2.		_____

Perceived Ingestion

None Small Moderate Large

0 10

Place an X at the point you feel most indicates your perception of caffeine ingestion.

APPENDIX F

POST TEST RAW DATA

POST TEST RAW DATA

0.0 mg./kg. bwt caffeine

Subject	HST	HSC	TT	TOF	TC	K	D
1	04.5	099	40.5	02.5	17	01	098.9
2	03.1	027	13.1	02.3	17	04	082.7
3	04.4	065	33.8	03.8	18	03	077.5
4	01.0	028	61.4	02.3	18	05	091.7
5	21.6	144	33.9	06.2	31	04	116.0
6	04.5	049	16.6	10.9	20	02	170.0
7	02.3	046	20.7	02.6	16	04	082.8
8	06.6	074	31.8	02.3	08	05	072.1

2.5 mg./kg. bwt. caffeine

1	04.8	112	35.6	05.5	28	03	086.1
2	04.2	053	16.8	02.4	15	04	111.6
3	08.5	117	34.6	05.5	34	07	081.0
4	02.0	068	04.3	00.8	21	05	081.5
5	07.4	098	20.2	02.7	25	11	155.7
6	07.4	071	12.0	07.8	14	06	209.3
7	00.7	015	12.5	02.2	21	05	071.0
8	08.0	091	27.8	01.5	15	04	082.8

POST TEST RAW DATA (Cont.)

5.0 mg./kg. bwt. caffeine

Subject	HST	HSC	TT	TOF	TC	K	D
1	08.5	115	39.4	06.2	24	01	079.3
2	09.7	101	13.6	03.8	24	07	091.7
3	07.5	093	33.6	04.0	18	07	088.6
4	08.2	178	55.3	07.0	21	08	116.1
5	09.8	100	28.7	04.8	28	04	182.8
6	04.2	053	23.7	07.6	27	04	196.9
7	02.6	049	18.6	02.2	23	02	073.7
8	08.5	125	29.2	05.4	25	02	081.2

APPENDIX G

MEANS OF PRE AND POST TEST DATA FOR EACH CAFFEINE DOSE

MEANS OF PRE AND POST TEST DATA FOR EACH CAFFEINE DOSE

2.5 mg./kg. bwt. caffeine

	PRE	POST
HAND STEADINESS TIME	4.98	5.38
HAND STEADINESS COUNT	61.63	78.13
TRACING TIME	22.34	20.48
TRACING OFF TIME	3.74	3.55
TRACING COUNT	18.75	21.63
KINESTHETIC SENSE	4.38	5.63
MANUAL DEXTERITY	114.11	109.88

5.0 mg./kg. bwt. caffeine

	PRE	POST
HAND STEADINESS TIME	4.86	7.36
HAND STEADINESS COUNT	70.63	101.75
TRACING TIME	35.09	30.26
TRACING OFF TIME	4.45	5.13
TRACING COUNT	22.13	23.75
KINESTHETIC SENSE	4.88	4.38
MANUAL DEXTERITY	116.85	113.79

VITA

Stacy Renee' Thurman

Candidate for the Degree of

Master of Science

Thesis: THE EFFECTS OF CAFFEINE ON HAND STEADINESS, TRACING ABILITY, KINESTHETIC SENSE, AND MANUAL DEXTERITY IN REGULAR CAFFEINE CONSUMERS

Major Field: Health, Physical Education, and Recreation

Biographical:

Personal Data: Born in Starkville, Mississippi, July 15, 1966, the daughter of Dr. and Mrs. Charles W. Thurman.

Education: Graduated from Perkins-Tryon High School, Perkins, Oklahoma, in May 1984; received Bachelor of Science Degree from Oklahoma State University in May, 1989; completed requirements for the Master of Science degree at Oklahoma State University in May 1991.