THE EFFECTS OF CAFFEINE ON STRENGTH AND POWER WHILE ON A LOW CARBOHYDRATE DIET

By

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THE EFFECTS OF CAFFEINE ON STRENGTH AND POWER WHILE ON A LOW CARBOHYDRATE DIET

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Title of Study: THE EFFECTS OF CAFFEINE ON STRENGTH ON POWER WHILE ON A LOW CARBOHYDRATE DIET

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Abstract: Low carbohydrate diets, in athletes and the general population alike, can lead to hindered performance during physical activity as compared to those who eat 50-70% of daily caloric intake as carbohydrates. This leads to the question of whether or not there is a solution to compensate for reductions in power production, which could enhance performance. The purpose of this study is to compare caffeine intake 60 minutes prior to a training session to a placebo, on muscle power output. The subjects used in this study consisted of 12 individuals split into two groups; both groups were put on a low carbohydrate diet. Subjects were asked to be on the diet for a minimum of 48 hours prior to any testing. On the first day subjects completed a baseline test, on the second and third round of testing one of the two groups were given a dose of 5 mg per kg of body weight of either caffeine or a placebo consisting of a glass of water. First the subjects completed a leg extension/leg curl muscular strength and endurance test on a Biodex isokinetic machine at 180 degrees per second for 50 reps. Following the leg extension/leg curl the subject completed a vertical jump using a Tendo unit machine to measure power output, for two rounds (each round consisting of a single jump) with a one-minute break. The third week they completed the same test in a counterbalanced measure. No significance was found in any of the variables measured but the largest differences are in peak power of the vertical jump, peak torque of the quadriceps, and percent decline of the quadriceps. Peak power of the vertical jump was between 100-250 J higher during the treatment session than they were during the placebo session. Athletes and the general population alike see cutting down on carbohydrates as the quick fix to decreasing body fat, getting leaner, and gaining a competitive edge. What this study attempted to prove, and potentially can be shown with further research with a large sample size, is that a dosage of caffeine 60 minutes prior to activity can compensate for the negative effects on performance of a low carbohydrate diet that are often overlooked.

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CHAPTER I

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Introduction

Weight loss has always been a focal point of fitness as well as sports with weight requirements or sports that make it necessary for an athlete to have a low body fat percentage in order to compete at high levels. Popular diets such as Atkins, South Beach, and other Ketogenic diets call for low carbohydrate intake to promote weight loss. Low carbohydrate diets (LCD) are diets that consist of less than 50 grams of carbohydrates per day or between 5-10% of the daily caloric intake and a person is considered to be on a low carbohydrate diet after a period of 3-6 days. These diets have lead to faster success in weight loss over rival low fat diets due to the tendency of those on low carbohydrate diets to consume consistently lower amounts of calories per day and higher rates of compliancy and commitment to the diet, as well as the metabolic and hormonal adaptations that can occur with LCD which increase fat oxidation and glycogen sparring (Peters & Leblanc, 2004). However low carbohydrate diets can lead to low glycemic levels and a decreased ability to produce power during resistance training and competition (Lima-Silva et al., 2013). Low carbohydrate diets, in athletes and the general population alike, can lead to hindered performance during physical activity as compared to those who eat 50-70% of daily caloric intake as carbohydrates. This leads to the question of whether or not there is a solution to compensate for reductions in power production, which could enhance performance.

A possible solution to this problem is the ingestion of a specific amount of caffeine (mg) per kilogram (kg) of body weight. There is clear evidence that caffeine can be used as an ergogenic aid in training and in sport to enhance power during short intervals of high intensity work as well as an ability to enhance endurance performance (Burke, 2008). The research available on the affects of caffeine for performance enhancement during training and competition while in a low glycemic state is limited. One such study; they put subjects in a low glycemic state, they were put in a low glycemic state by doing submaximal cycling at 65% of their VO2 max, then given 3 mg per kg of body weight of caffeine and found that the caffeine was able to enhance performance but not at the same level as subjects on a normal carbohydrate diet (Lane et al., 2013). Therefore, caffeine may be a viable option to help reduce the amount of power lost or possibly help maintain power levels for a person or an athlete on a low carbohydrate diet.

Caffeine can be beneficial during anaerobic exercise by increasing the energy production in the skeletal muscle (Jacobs, Pasternak, & Bell 2003). Jacobs and co-authors found that subjects who were given a caffeine dosage (5 mg per kg of body weight), increased their anaerobic performance by 7-8%. Athletes have also shown an increase in performance when taking a pre-activity dosage of caffeine (250 mg) such as that seen in the increased velocity of sprint swimmers who significantly improved their 100 meter times (Collomp, Ahmaidi, Audran, Chanal, & Préfaut 1991). The energy boost from caffeine from general fitness enthusiast (Jacobs et al., 2003) to elite athletes (Collom et al., 1991) has set the foundation to show the inherent benefits on performance with caffeine use. However, elite athletes need to also abide the codes of their specific institutions in regards to caffeine usage, while attempting to capitalize on the benefits to performance provided by caffeine usage.

Research on caffeine's ability to increase power production and reduce fatigue is abundant (Duncan et al. 2013, Jordan et al. 2012, Graham et al. 2008). Perception of fatigue is not measured in this study but it is a factor that can be beneficial when using caffeine to enhance resistance training. One area that needs further research is if caffeine can affect power output in individuals on a low carbohydrate diet.

Statement of the Problem

With the popularity of low carbohydrate diets, research needs to be done to determine if caffeine can serve as a temporary ergogenic aid for the low energy levels that can accompany a lack of carbohydrates in the diet. Then it could be determined if caffeine can be coupled with a low carbohydrate diet and have the general population and athletes using the diets see no or minimal reductions in their ability to produce power during anaerobic bouts of physical activity.

Purpose of the Study

The purpose of this study is to compare caffeine intake 60 minutes prior to a training session to a placebo, on muscle power output while on a low carbohydrate diet.

Hypotheses

Null Hypothesis:

H_0= There will be no difference in the peak torque for the quadriceps for the treatment and placebo groups.

H_1= There will be a significant difference in Peak torque for the quadriceps between treatment and placebo groups.

H_0= There will be no difference in the peak torque for the hamstrings for the treatment and placebo groups.

H_1= There will be a significant difference in Peak torque for the hamstrings between treatment and placebo groups.

H_0= There will be no difference in peak power for the treatment and placebo groups.

H_1= There will be a significant difference in peak power between treatment and placebo groups.

H_0= There will be no difference in peak velocity for the treatment and placebo groups.

H_1= There will be a significant difference in peak velcoity between treatment and placebo groups.

H_0= There will be no difference in percent decline for the quadriceps for the treatment and placebo groups.

H_1= There will be a significant difference in percent decline for the quadriceps between treatment and placebo groups.

H_0= There will be no difference in percent decline for the hamstrings for the treatment and placebo groups.

H_1= There will be a significant difference in percent decline for the hamstrings between treatment and placebo groups.

Dependent and Independent Variables

Dependent Variables: Power Output

Independent Variables: Caffeine and Amount of Carbohydrates in the Diet

Delimitations of the Study

- This study will be done on college aged students who are physically active between the ages of 20 and 22.
- Only those classified as low to moderate caffeine users will be allowed to participate.
- Short powerful movements will be tested to make sure that the anaerobic energy system is the main energy system tested.

- Subjects will not have any condition that can be worsened or negatively affected by a large dose of caffeine.

Limitations of the Study

- Subjects only had one session to get familiar to the equipment used and therefore got more comfortable throughout the duration of the study.
- Statistical Power related to the number of participants in the study.
- Variances in athletic abilities of the subjects as well as possible differences in motivation to participate in the study.

Assumptions

- All subjects were honest when filling out the questionnaire.
- All subjects kept to the low carbohydrate diets and their food logs.
- All subjects put forth maximal effort.

Definitions

Low Carbohydrate Diet: A diet consisting of less than 40g of carbohydrates per day.

Joule: The work required to produce one watt of power for one second.

Muscle Glycogen: The main storage form of glucose in the body, the body's main energy source.

Low Caffeine Usage: 0 to 200 mg of caffeine per day.

Moderate Caffeine Usage: 200 to 300 mg of caffeine per day.

Habitual Caffeine Usage: 500 to 600 mg of caffeine per day.

Power: Force time distance divided by time, work performed per unit of time.

Velocity: The rate of motion in a specific direction.

Anaerobic Energy system: Energy system used during high intensity physical activity lasting from a few seconds up to two minutes.

CHAPTER II

Literature Review

Achieving the desired body composition is an important component while training whether you are training for general health or training for an athletic event. Body composition is promoted to maintain good health but it is also advantageous for optimal athletic performance and in some instances required in sports that have weight class divisions such as wrestling, gymnastics, and weight lifting. Diets that limit carbohydrates have became popular in the last decade and have maintained the status of a quick and easy way to effectively lose weight (Crowe, 2005). There has been significant research and published opinions pertaining to the effects of low carbohydrate diets and the ability to take on a training program that involves resistance training or sprint training that require glycogen, gained from consuming carbohydrates, to fuel the exercises (Peter et al., Casey et al., Paoli et al.). Previous literature has noted that once participants in a low carbohydrate diet (less than 50 grams) have become adapted to the diet there are no significant effects on their endurance or aerobic energy systems, however they will have a diminished capacity to complete anaerobic workouts and events (Phinney, 2004), including sprinting, resistance training, and plyometrics. The American College of Sports Medicine (ACSM) in its official position statement has recommended for weight loss programs to include strength training and moderate to high intensity physical activity, in order to increase fat free mass and reduce the risk of heart disease. Resistance training and high intensity exercise is important for weight loss by raising the resting metabolic rate as well as a crucial part of preparation for athletic events (Hambre et al., 2012). Hambre found that resting metabolic rate and the amount of calories burned increased even for the group eating mostly a ‘fast food’ diet. If low carbohydrate diets are being used by these weight loss and athletic populations and their ability to perform during these training sessions are being diminished (Phinney, 2004) then research needs to examine if anything can be done to minimize or all together eliminate these reductions in strength and power.

Caffeine’s ability to reduce fatigue, increase alertness, and increasing wakefulness has been recognized for centuries so people use caffeine frequently to prolong their ability to perform activities and increase their performance (Burke, 2008). Caffeine has been said to aid in exercise capacity by increasing fat oxidation and inhibiting carbohydrate oxidation, which reduces the body’s need for muscle glycogen stores during exercise and therefore the muscle glycogen stores are used at a slower rate (Graham, Battram, Dela, El-Sohemy, & Thong 2008). While on the low carbohydrate diets fats are going to be the main source of energy, so an increased ability to use fats as energy during physical activity would be desirable for those on the low carbohydrate diets and taking on an exercise program. Muscle glycogen stores are already diminished for these individuals, having the available muscle glycogen used more sparingly and at a slower rate would be beneficial (Peters & Leblanc 2004). Any advantage that can be gained to conserve muscle glycogen stores for an increased ability to produce power for short powerful movements can help with a training program.

Low Carbohydrate Diets

Carbohydrates provide the body with muscle glycogen, which is the source of energy needed to produce power during resistance and sprint training programs. Nutritional strategies that result in low levels of muscle glycogen available during resistance training lead to a decrease in power production and impair the cellular signaling environment (Philp, Hargreaves, & Baar, 2012). The body is forced to switch to metabolizing fat for energy, a slower process that is not ideal for short-powerful movements (Baker, McCormick, & Robergs, 2010). The body is not in an ideal state to participate in a resistance or sprint-training program with low muscle glycogen levels. Modifications would need to be made in order to produce the best results for a program that can most benefit weight loss and optimal performance for athletes in their particular sports.

An important factor here is that in order to promote optimum health and even optimum performance among athletes resistance training and strength development should not be sacrificed when undertaking a low carbohydrate diet. Areta's study looked at the anabolic agents and muscle protein synthesis when muscle glycogen was at low levels for the subjects. It was found that these two factors are not altered or compromised during the four-hour post-exercise recovery period (Areta et al., 2013). This shows that muscle growth is possible while muscle glycogen levels are low, the subjects in this study completed one session of eight sets and five repetitions each of the leg extension exercise at 80% of their one repetition maximum showing that they could handle multiple bouts of a resistance training exercise. If caffeine could provide a power boost so that participants could maintain high energy levels for a longer period of time and involve more exercises, then low carbohydrate diets could become a viable option for shedding weight without sacrificing muscular strength and endurance development.

Caffeine

Caffeine has widely been used as an ergogenic aid for increased energy, alertness, and increased fat oxidation. The main effect of caffeine that is of interest in this study is caffeine's ability to decrease muscle glucose uptake (Yeo, Jentjens, Wallis, & Jeukendrup, 2005). This will spare the amount of carbohydrates used up by the body and make up for any limitations in the amount of carbohydrates available. This study found that intestinal absorption of carbohydrates and the body's efficiency of carbohydrate usage was increased by ingesting 5mg per kg of body weight. The same amount of caffeine will be used in this study. Research on caffeine also shows caffeine's ability to increase epinephrine production and prolong endurance during exercise. One study found that after ingesting 4.45 mg/kg of body weight of caffeine and then observing a one-hour rest period, subjects had significant increases in levels of epinephrine and endurance was increased during a run at 85% of maximal oxygen consumption (Graham, Hibbert, & Sathasivam, 1998). Research is vast on the beneficial effects of caffeine on the body that will translate to endurance as well as exercise, however it remains to be validated if these effects will translate to anaerobic exercise events with a lack of muscle glycogen available.

Caffeine and Exercise

As discussed earlier, the low carbohydrate diet can cause unnecessary fatigue and lead to dieters being unable to perform an important aspect of weight loss and training, resistance training. Multiple sets of resistance training exercises require a certain amount of anaerobic capacity that can be difficult without carbohydrates in the diet to be burned as glycogen (Bangsbo, Graham, Kiens, & Saltin, 1992). Caffeine has shown the ability to elicit benefits when used an hour before resistance training (Kudrna, Moodie, McCartney, Bustamante, Fry, & Gallagher, 2011) and the benefits could be beneficial to problems that can arise from the low carbohydrate diet. Caffeine can delay fatigue, reduce the ratings of perceived exertion during resistance training, as well as blunt pain responses (Green et al., 2007). Subjects participating were able to complete more repetitions while using the caffeine supplement (6 mg per kg) without changes in fatigue from when they were tested without caffeine. Overall fatigue was reduced and the authors note that the effects may be more efficient for larger muscle groups. Another study showed that well conditioned males were able to increase their one repetition maximum for the bench press and the treatment group almost reached statistical significant increases in their bench press total volume as compared to the placebo group which showed negative values (Beck, 2007). Effects such as reduced rate of perceived exertion and increases in the number of repetitions done can even be seen in people who think they are receiving caffeine but are actually receiving a placebo (Duncan, Lyons, & Hankey, 2009). The physical effects as well as the mental effects of caffeine, even those seen by people who only think they are using caffeine but actually just experiencing a placebo effect, could provide the necessary boost to accompany resistance training.

Perception of Carbohydrates

Along with the new fads for carbohydrate diets can come the belief that carbohydrates are the enemy when it comes to weight loss, especially for someone who may just not know what carbohydrates do for the body's energy systems (Crowe, 2005). People will also believe that they know best and even when told by experts will not include carbohydrates in their diet, because they believe carbohydrates to be a negative factor. A sports nutritionist, Nancy Clark, notes that due to the emergence of the Atkins diet an extraordinary number of athletes are turning to this diet to become or stay lean and due to low levels of muscle glycogen are experiencing unnecessary fatigue (Cook & Haub, 2007). The negative feedback on the low carbohydrate diet centers around the low levels of energy and the fatigue that can come with the diet making it difficult for those on the diet to participate in strength and resistance training, which is widely recommended for weight loss as well as general health. Caffeine could become an addition to the diet to provide a temporary burst of energy along with sparing the use of muscle glycogen to allow participation in strength and resistance training without having to change the diet habits of those committed to the low carbohydrate diet. This provides an alternative to trying to steer people away from the ever-growing popularity of the diets that restrict carbohydrates.

Pre-Exercise Supplementation

A pre-exercise supplement including caffeine has shown to improve performance and increase results seen during a resistance-training program because of the multiple beneficial effects that caffeine can have (Graham, 2008). Effects such as increased stamina due to sparring muscle glycogen and reduced muscle pain and soreness after exercise (Hurley, Hatfield, & Riebe, 2013). In an 8 week program where one group used a pre-workout supplement with a large dosage of caffeine and one group used a non-caloric drink prior to workouts, the group using the pre-workout supplement showed greater increases in both bench press and squat power (Kurdna, et al., 2011). Another study looking at the effects of caffeine one hour prior to resistance training found that subjects were able to complete more repetitions during the fourth and fifth set of the preacher curl exercise as well as feeling significantly less muscle soreness on days two and three post resistance training (Hurley et al., 2013). The well documented evidence of the beneficial effects of caffeine resistance training lend themselves perfectly to the needs of those who would like to take part in a resistance training program while on a low carbohydrate diet. In the current study, the lack of muscle glycogen for energy and the possibility of increased muscle soreness, the data collected in this study are trending towards showing that caffeine consumption is a potential option to solve these problems but in future studies a larger sample size should be used and possibly a longer time frame.

Carbohydrates and Performance

The general conception is that low carbohydrate diets or ketogenic diets leave people with low energy levels and will have decreased performance in short-powerful movements as well as sprint training (Cook & Haub, 2007). This is of particular concern to high-level athletes whose chosen sports are made up entirely of sprints and short powerful movements. Some of these sports do have weight requirements and some athletes may turn to the low carbohydrate diets such as Atkins that have become popular. Athletes should be educated as to what these diets will do to their energy systems and the possibly consequences to performance. There are studies that show elite level athletes can maintain their strength and power while on low carbohydrate diets such as the one done by Paoli (2012) which saw elite level gymnast on a low carbohydrate diet for 30 days show no significant changes in their strength levels (Paoli et al., 2012). The recommendations from this study are that the athletes keep with the diet for only a short period of time in order to make a weight class that is required by their particular sport, in this situation no significant changes in strength performance were seen. These results should not be expected in every situation and if athletes are committed to the low carbohydrate diet they should be educated as to the possible consequences but if they can be shown an addition to the diet that can provide a boost to maintain higher levels of strength such as caffeine, it could be a viable alternative as well as addition to the diet. That provides the need to see if caffeine can fill the possible void and be the addition to these diets.

CHAPTER III

Methodology

This chapter will explain the specifics of the subjects, caffeine dosage, instrumentation, procedures, and data analysis.

Subjects:

The subjects used in this study consisted of 12 individuals split into two groups; both groups were put on a low carbohydrate diet. The subjects were numbered 1 through 12 and the even numbered subjects were placed into one group and the odd numbered subjects were placed in the other. There were 12 college students (9 male, 3 female) who participated in this study, with an average age of 20 (±2) years of age, average height of 68.61 (± 7) inches, and average weight of 82.23 (± 15) kg. The majority the subjects reported on a health questionnaire that they had been taking part in resistance training for a year or more. All subjects were screened for any issues that would be adversely affected by a large dosage of caffeine, such as high blood pressure or heart health issues. All subjects were classified as low (0 to 200mg) to moderate (200 to 300mg) caffeine users. All habitual caffeine users (500 to 600mg) were excluded from participating.

Procedures

The subjects were asked to fill out a food log (each day) to make sure they stick to the low carbohydrate diet and asked to keep their carbohydrate intake to under 40g per day. Subjects were asked to be on the diet for a minimum of 48 hours prior to any testing. On the first day of testing one of the two groups were given a dose of 5 mg per kg of body weight of either caffeine or a placebo consisting of a glass of water. This dosage is consistent with previous low caffeine research (Graham, 2008). Previous research showed dosages between 3 mg per kg of body weight on the low end to 8 mg per kg of body weight on the higher end, this study took the middle ground at 5 mg per kg of body weight. During the first week of testing the subjects were asked to complete the fitness tests described in this section to get a baseline measure. During the second and third test times, one hour after taking either the caffeine or the placebo, the subjects completed the same fitness tests that were completed during the first week. The caffeine used was a caffeine powder that was measured out specifically for each subject based on body weight (5 mg per kg of body weight). The placebo consisted of plain water, this was the best placebo because the caffeine is flavorless. First the subjects completed a leg extension/leg curl power test on a Biodex isokinetic machine at 180 degrees per second for 50 reps. Following the leg extension/leg curl the subject completed a vertical jump using a Tendo unit machine to measure power output, for two rounds with a one-minute break. The Tendo unit (Figure 1) measures peak power, peak velocity, average power and average velocity during the vertical jump. The third week they completed the same test in a counterbalanced measure.

The dependent variables that were measured in the above fitness tests will consist of peak torque for the quadriceps and hamstrings (NM), percent decline for the quadriceps and hamstrings, peak power (WATTS), peak velocity (M/S), average power (J), and average velocity. This all relates back to the main dependent variable being the overall power output of the subjects. These measures are all specific to anaerobic power.

Figure 1. Tendo Speed and Power Unit

Statistical Analysis:

Repeated measures ANOVA was used to examine differences between baseline testing, testing done while using the caffeine intervention, and testing done with the plain water placebo. Significance was based on an alpha level of $p \leq .05$. Statistical analysis was done using SPSS (Version 21).

CHAPTER IV

Results

This chapter will go over the findings of the experiment that were obtained as outlined in chapter three. The variables that were recorded and then tested are as follows, for the vertical jump with all variables being measured twice: peak power, average power, peak velocity, average velocity, and jump height were collected. For the Biodex Thorstensson (180 degrees per second for 50 reps) the test was done once and the following variables were measured: percent decline for the hamstring, percent decline for the quadriceps, peak torque for the hamstring, and peak torque for the quadriceps (Thorstensson, 1976). The objective was to find if people on a low carbohydrate diet that consumed a dosage of caffeine 60 minutes prior to participating in performance testing would be able to make up for the low levels of carbohydrates available for energy production and can produce a similar amount of power as they would with a normal carbohydrate diet.

In the tables below are all the descriptive statistics from the baseline measure (Table 1), the treatment for all the subjects (Table 2) as well as the placebo data. Included is the total number of subjects, standard deviation, maximum and minimum values, as well as the means. Notable differences within the tables occur in the means of the peak power of the vertical jump from treatment to the placebo which goes from 2062 (J) during placebo testing to 2220 (J) during the treatment, also the highest amount of power on the vertical jump was recorded during the caffeine treatment testing at 3075 (J). Many of the means including peak power, peak torque, and percent decline show slight but insignificant increases from placebo to treatment. The standard deviations remain relatively consistent meaning there is similar variations in scores during each of the three testing conditions. The results of the data are further illustrated in the accompanying graphs.

Descriptive Statistics:

Table 1. Baseline Performance Data.

	N	Minimum	Maximum	Mean	Std. Deviation
PercentDeclineQuad	12	.36	.79	.5735	.11518
PercentDeclineHamstring	12	.38	.76	.5311	.14002
PeakTorqueQuad	12	51.90	126.40	101.4667	25.03326
PeakTorqueHamstring	12	33.30	82.10	59.4917	15.46383
PeakPowerJump1	12	1262.00	3068.00	2317.0833	611.33304
AveragePowerJump1	12	590.00	2078.00	1209.0000	417.99239
PeakVelocityJump1	12	1.84	3.44	2.7558	.50293
AverageVelocityJump1	12	.86	1.86	1.4175	.30993
JumpHeightJump1	12	8.90	27.20	19.3500	5.63294
PeakPowerJump2	12	1173.00	3068.00	2323.0833	614.10933
AveragePowerJump2	12	659.00	2041.00	1251.8333	352.18870
PeakVelocityJump2	12	1.71	3.44	2.7650	.52229
AverageVelocityJump2	12	.96	1.78	1.4058	.26228
JumpHeightJump2	12	11.30	27.70	20.3583	5.37510
Valid N (listwise)	12				

Table 2. Placebo Testing Performance Data.

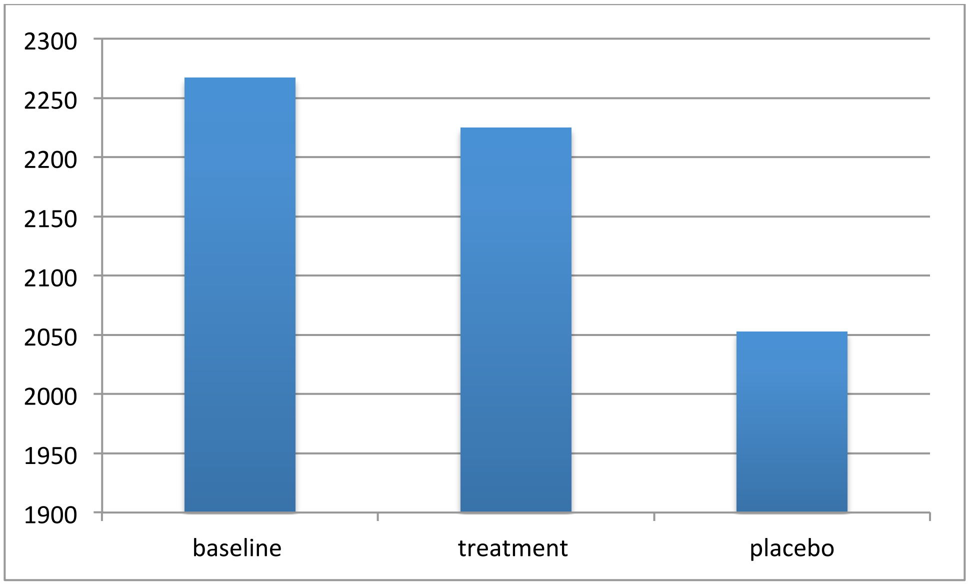
	N	Minimum	Maximum	Mean	Std. Deviation
PercentDeclineQuad	12	.09	.68	.4588	.20099
PercentDeclineHamstring	12	.30	.71	.5513	.11650
PeakTorqueQuad	12	65.20	137.20	99.2500	21.58646
PeakTorqueHamstring	12	36.90	83.80	59.0833	13.84294
PeakPowerJump1	12	741.00	2760.00	2062.9167	669.82758
AveragePowerJump1	12	556.00	1776.00	1077.4167	347.95414
PeakVelocityJump1	12	1.20	3.52	2.5250	.68963
AverageVelocityJump1	12	.90	1.66	1.3083	.24203
JumpHeightJump1	12	9.30	26.80	18.4500	5.06171
PeakPowerJump2	12	1082.00	2634.00	2093.3333	530.61582
AveragePowerJump2	12	595.00	1739.00	1113.1667	319.11948
PeakVelocityJump2	12	1.78	3.36	2.5958	.49537
AverageVelocityJump2	12	.98	1.72	1.3667	.21381
JumpHeightJump2	12	9.70	26.50	18.4083	4.94064
Valid N (listwise)	12				

Table 3. Treatment Testing Performance Data.

	N	Minimum	Maximum	Mean	Std. Deviation
PercentDeclineQuad	12	.33	.64	.5431	.09882
PercentDeclineHamstring	12	.43	.71	.5551	.08616
PeakTorqueQuad	12	56.40	126.70	103.6917	21.35873
PeakTorqueHamstring	12	38.70	84.10	63.7000	14.95405
PeakPowerJump1	12	1303.00	3075.00	2220.1667	575.72639
AveragePowerJump1	12	595.00	1568.00	1115.0833	305.35001
PeakVelocityJump1	12	2.11	3.14	2.7350	.37893
AverageVelocityJump1	12	.98	1.73	1.3725	.22025
JumpHeightJump1	12	11.20	26.70	19.5917	4.64003
PeakPowerJump2	12	1253.00	2646.00	2185.1667	541.38406
AveragePowerJump2	12	648.00	1899.00	1185.5833	331.56583
PeakVelocityJump2	12	2.03	3.24	2.7092	.46396
AverageVelocityJump2	12	1.05	1.78	1.4583	.18886
JumpHeightJump2	12	11.50	26.30	19.6833	4.98212
Valid N (listwise)	12				

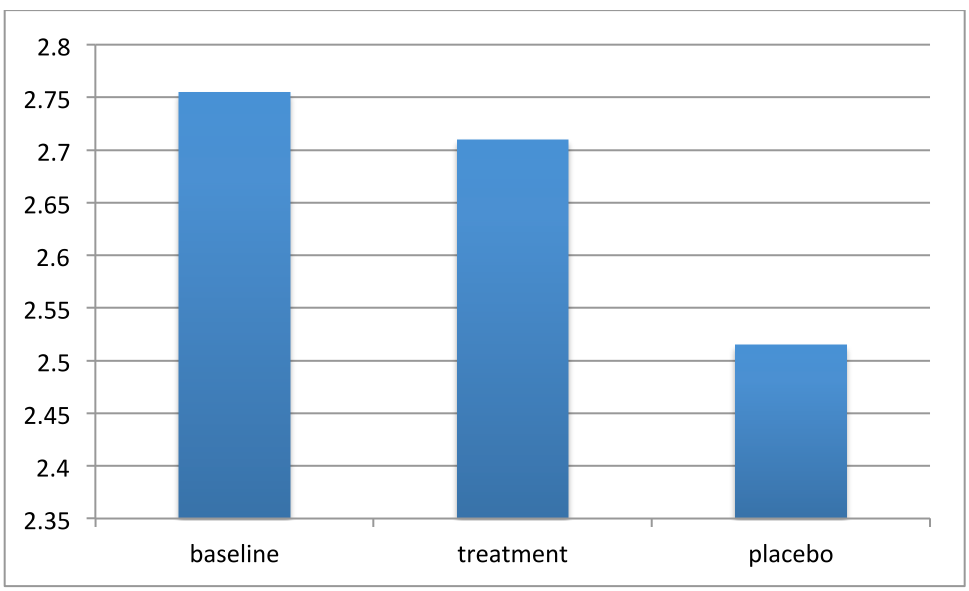
The figures below show the differences in scores that were seen between the baseline measures, treatment and placebo. No significance was found in any of the variables measured but the largest differences are in peak power of the vertical jump (Figure 1), peak torque of the quadriceps (Figure 3), and percent decline of the quadriceps (Figure 5). Peak power of the vertical jump was between 100-250 J higher during the treatment session than they were during the placebo session. Peak torque increased from anywhere between 4 and 6 NM between treatment and placebo and the percent decline seen in the quadriceps improved by as much as 12%. Although no significance was found there were slight proportional increases in performance. The other measures shown below including peak velocity for the vertical jump (Figure 2), peak torque for the hamstrings (Figure 4), and percent decline for the hamstrings (Figure 6) did not change like the first three measures did but the treatment seems to be closer in similarity to the baseline readings than the placebo but again no significance was found. Peak torque for the hamstrings in group 2 during their treatment session was an interesting measure in that it was much higher than any reading seen in baseline or placebo. In this study the data fail to reject the null hypothesis that there was no difference between groups.

- Figure 2: Peak Power of Vertical Jump



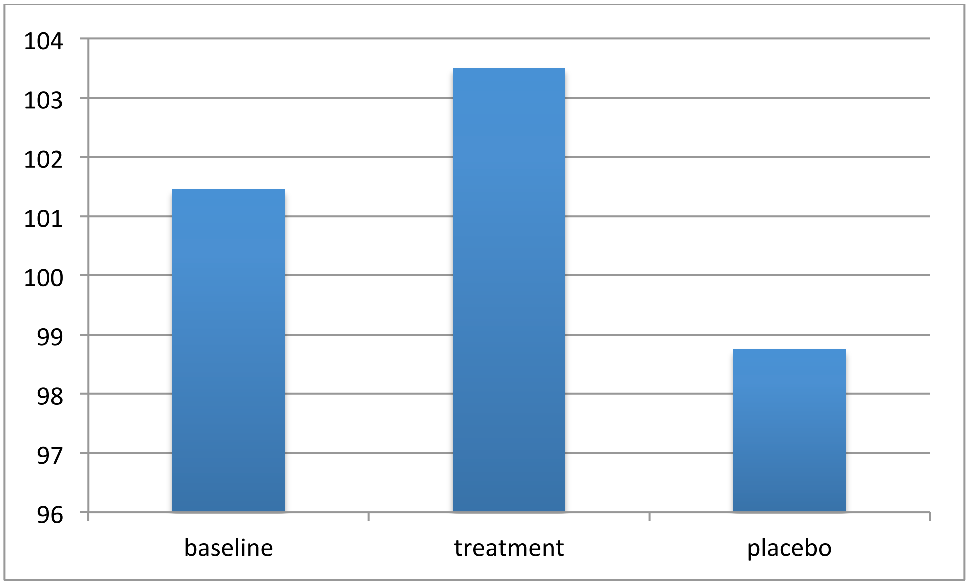
Measured in Watts (W).

- Figure 3: Peak Velocity for Vertical Jump



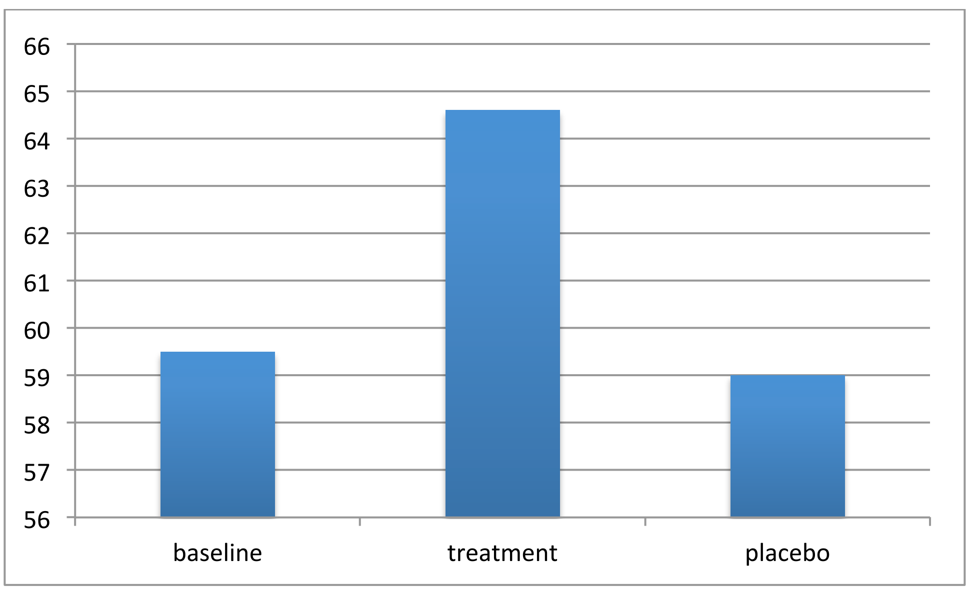
Measured in Meters per Second (M/S).

- Figure 4: Peak Torque for Quadriceps



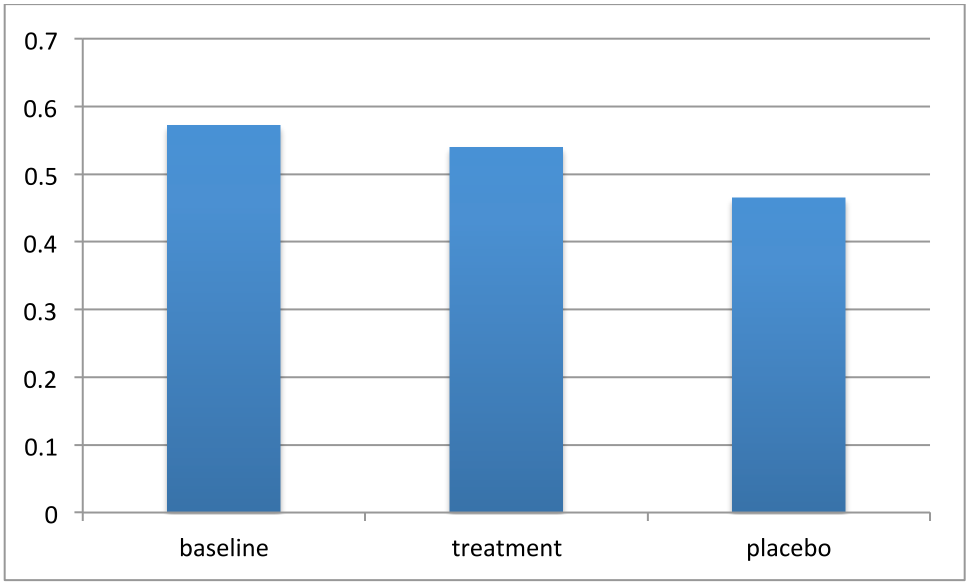
Measured in Newton Meters (NM).

- Figure 5: Peak Torque for Hamstrings



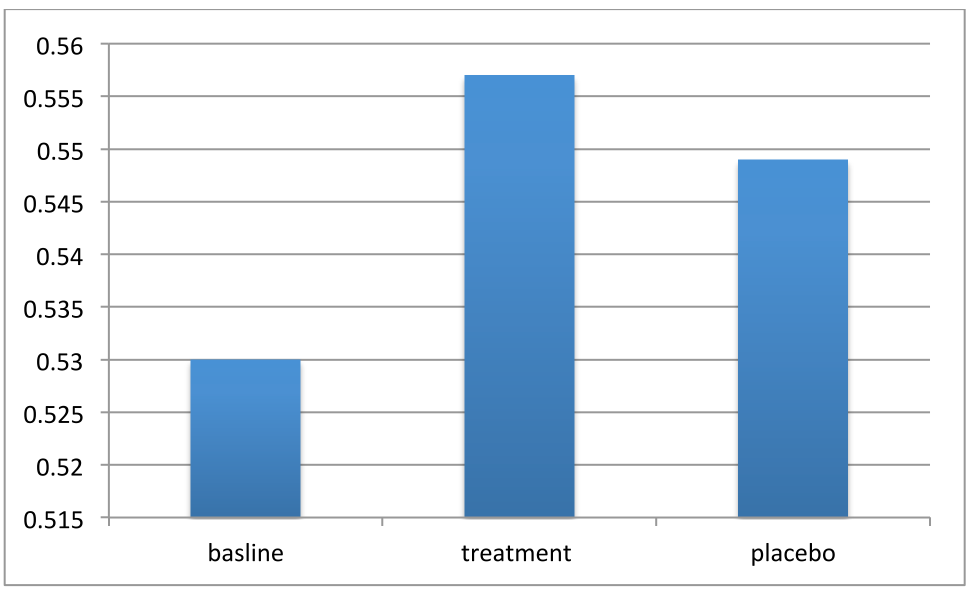
Measured in Newton Meters (N/M).

- Figure 6: Percent Decline for Quadriceps



Measured in percent from 0-100%.

- Figure 7: Percent Decline for Hamstring



Measured in percent from 0-100%.

There were no significant results for any of the testing periods. No differences were found between tests 1, 2, and 3 for all test variables measured. The caffeine did not significantly influence performance compared to the placebo. The results showed some improvements in performance but did not prove significance, further research may be able to show that caffeine is a significant ergogenic aid during a low carbohydrate diet but significance was not found in this study.

CHAPTER V

Discussion

The intent of this study was to attempt to find a supplementary solution to the popularity of low carbohydrate diets and those participating in a low carbohydrate diets which may lead to low glycogen levels which could effect strength and power performance. The results of this study did not show significance in any performance measure but the data did show some slight but not significant increased performance in the variables towards the hypothesis that although there was no significant effect found for the group consuming caffeine prior to performance the data appears to have trended towards showing there could be a potential benefit to caffeine consumption and further research is warranted. The results of this study were influenced by the sample sized and therefore there was an issue of statistical power. There is also a possibility that caffeine is not a viable solution to increase energy for those on a low carbohydrate diet. Trends do not prove that caffeine can be proved to a beneficial ergogenic aid to someone with low levels of muscle glycogen but the slight increases in some of the variables provide support for further research to be done on caffeine in this area.

Multiple variables measured in this study showed slight but no significant improvement from when the subjects were measured while on the placebo to when they consumed the 5 mg per kg of body weight of caffeine, these variables include peak torque in the quadriceps and hamstring, percent decline for quadriceps, as well as peak power and velocity during the vertical jump. Peak torque in the quadriceps improved from an average of between 98-100 NM while on the placebo to an average of between 102-104 NM while on caffeine. The ability to maintain power can be crucial for exercises placed into a program based around weight loss or even strength with someone who has lower than normal muscle glycogen stores due to a low carbohydrate diet (Cook & Haub, 2007).

Previous research has shown that caffeine can improve performance (Hurley et al., 2013), the results of this study show that with more research it could be shown that adding caffeine to a low carbohydrate diet may be able to improve power production with a lack of muscle glycogen in the system. Research is lacking on performance during resistance training with a lack of carbohydrates in the diet, despite the link between fatigue and not having carbohydrates in the diet. A study showed that adding resistance training to a low carbohydrate diet enhances weight loss, as well as limits the amount of lean body mass lost, preventing muscle atrophy (Volek, Quann, & Forsythe, 2010). In this study it was shown that while the subjects where on caffeine the percent decline of their quadriceps during a 50 repetition Thorstensson test, maximal leg extension and leg flexion improved by as much as 12% and the percent decline of the hamstrings varied but in most cases improved by 2-3%, this was not proven to be significant but the increase was promising. Caffeine’s ability to reduce fatigue did not prove to be significant but was present in this study to a certain extent showing that further research could show that caffeine can be used as a substitute for the lack of carbohydrate consumption in the diet.

This area of research is becoming more and more relevant for athletic populations as athletes start incorporating low carbohydrate diets to try and gain an athletic edge by being leaner (Cook & Haub 2007). There is a lack of knowledge as to what other ways a low amount of carbohydrates in the diet will affect aspects of performance. A sports nutritionist, Nancy Clark, has noted that now more than ever they are having trouble convincing athletes to include carbohydrates in every meal so that they can achieve optimal energy levels and optimal performance (Clark, 2004). If an athlete does choose to change the amount of carbohydrates in their diet in order to become leaner or just prefer a diet with a lower amount of carbohydrates then further research into this area showing that caffeine can be a good substitute to compensate and keep their energy and performance at optimal levels is important. This can make low carbohydrate diets viable with out as much of a potential for negative effects on performance for both athletes and recreational exercise.

When the participants in this study completed the vertical jump test the marginal means of both peak velocity and peak power increased when the participants took caffeine rather than the placebo. Peak power increased by between 100-250 J (Joules or work required to produce one watt of power for one second) over the two jumps that were completed and peak velocity increased by .2 to .3 meters per second. This can translate to proportionately increased leg power, which may increase performance during both resistance training activities and sporting events. This would be of interest to the low carbohydrate diet community as most studies report low strength and energy levels being a main concern as fatigue hits quickly with muscle glycogen being depleted (Casey, Short, Curtis, & Greenhaff, 1996). With the rise in popularity in recent years as well as the little research available looking into a solution for those on a low carbohydrate diet who want to increase their performance in physical activities, it would be beneficial for future research to a solidify a solution and caffeine consumption is a promising candidate.

The relevancy of this research will continue to come to the forefront as long as the popular diets continue to stress cutting carbohydrates as well as the belief that the best way to drop weight quickly is to cut carbohydrates. There is little research for strategies to spare muscle glycogen (Volek et al., 2010) and utilize fats as the main energy source during high intensity exercise as well as athletic competition. A study looking into men taking part in intense resistance exercise found that a lack of muscle glycogen significantly impaired performance during the first three sessions but the decline in performance flat lined after that (Casey et al., 1996). Sports nutritionists are starting to see a trend of low carbohydrate diets among athletes and the numerous diets that advise low carbohydrates, there is a definite need for glycogen sparing strategies. Other strategies have been proposed, such as the one by Dr. Volek who proposes that athletes and the general population alike change their diets to all healthy fats and proteins in order to make their body carbohydrate intolerant. Under his theory people would then rely more on fats for energy and their muscle glycogen stores would not deplete as fast. Dr. Volek's theory is right now just a theory with a lack of research behind it but research into whether caffeine is a viable solution would help fill a hole in the research.

Conclusion

The importance of this study directly relates to the rise in popularity of low carbohydrate diets. Athletes and the general population alike see cutting down on carbohydrates as the quick fix to decreasing body fat, getting leaner, and gaining a competitive edge. What this study attempted to prove, and potentially can be shown with further research with a large sample size, is that a dosage of caffeine 60 minutes prior to activity can compensate for the negative effects on performance of a low carbohydrate diet that are often overlooked.

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Oklahoma State University Institutional Review Board

Date:	Wednesday, January 22, 2014
IRB Application No	ED13190
Proposal Title:	Power while Training on a Low Carbohydrate Diet using Caffeine to Enhance Energy
Reviewed and Processed as:	Expedited

Status Recommended by Reviewer(s): Approved   Protocol Expires: 1/21/2015

Principal Investigator(s):

Allen Goddard
309 N Duck
Stillwater, OK 74075

Douglas Smith
180 CRC
Stillwater, OK 74078

The IRB application referenced above has been approved. It is the judgment of the reviewers that the rights and welfare of individuals who may be asked to participate in this study will be respected, and that the research will be conducted in a manner consistent with the IRB requirements as outlined in section 45 CFR 46.

X The final versions of any printed recruitment, consent and assent documents bearing the IRB approval stamp are attached to this letter. These are the versions that must be used during the study.

As Principal Investigator, it is your responsibility to do the following:

1.Conduct this study exactly as it has been approved. Any modifications to the research protocol must be submitted with the appropriate signatures for IRB approval. Protocol modifications requiring approval may include changes to the title, PI advisor, funding status or sponsor, subject population composition or size, recruitment, inclusion/exclusion criteria, research site, research procedures and consent/assent process or forms
2.Submit a request for continuation if the study extends beyond the approval period. This continuation must receive IRB review and approval before the research can continue.
3.Report any adverse events to the IRB Chair promptly. Adverse events are those which are unanticipated and impact the subjects during the course of the research; and
4.Notify the IRB office in writing when your research project is complete.

Please note that approved protocols are subject to monitoring by the IRB and that the IRB office has the authority to inspect research records associated with this protocol at any time. If you have questions about the IRB procedures or need any assistance from the Board, please contact Dawnett Watkins 219 Cordell North (phone: 405-744-5700, dawnett.watkins@okstate.edu).

Sincerely,

Shelia M. Kennison

Shelia Kennison, Chair
Institutional Review Board

Power while Training on a Low Carbohydrate Diet using Caffeine to enhance energy

Allen Goddard

Subject Recruitment Script

We are currently seeking subjects who would like to volunteer to participate in a research study looking at the effect of caffeine on power while on a low carbohydrate diet. This study will require three visits around 90 minutes at the research lab in the Colvin Center. Within this time you will fill out a consent form, questionnaire, take a baseline test the first visit then the second and third either the caffeine or placebo 60 minutes prior to performing tests looking at power output. For the second and third power tests, participants will be asked to be on a low carbohydrate diet of equal to or less than 40 grams of carbohydrates per day.

ADULT CONSENT FORM

OKLAHOMA STATE UNIVERSITY

Project:
Power while Training on a Low Carbohydrate Diet using Caffeine to enhance energy.

INVESTIGATORS:
Allen Goddard, Masters Student, Oklahoma State University; Dr. Doug Smith, Ph.D., Professor, Oklahoma State University

PURPOSE:
The purpose of this study is to examine if caffeine taken 60 minutes prior to training (given at the equivalent of 2-3 cups of coffee), that will involve resistance training and short powerful movements, can compensate for any reductions in the short term/powerful movement (anaerobic) energy systems caused by a low carbohydrate diet and can keep power production up. This will be a placebo study and not all participants will be given caffeine.

PROCEDURES
The research will take place in the Applied Musculoskeletal and Human Performance Laboratory located in the Colvin Recreation Center. You will be given a pre-exercise health history questionnaire, along with additional questions pertaining to caffeine use. You will be asked to fill out a food log to make sure you stick to the diet and asked to keep your carbohydrate intake to under 40g per day. Supertracker will be used to help you track food intake (www.supertracker.usda.gov), as well as guide you as to the proper foods to consume on a low carbohydrate diet, you can also contact the principal investigator at any time with any questions. You will be asked to be on the low carbohydrate diet for a minimum of 48 hours prior to any testing being done, as well as no caffeine 72 hours prior to testing. All testing will be done in the morning with at least 8 hours of fasting. The first week of testing you will be asked to complete the fitness test outline in this section to get a baseline measurement. Then the second and third week, you will complete two fitness tests. First you will complete a vertical jump using a Tendo Fitrodyne machine to measure power output, you will be given a one-minute break before completing the test again. Second, you will complete a leg extension (extending the leg at the knee)/leg curl (flexing the leg at the knee) power test on a Biodex machine using the Thorstennson protocol (leg curl for the hamstring and leg extension for the quadriceps at a resistance of 60 degrees per second for one minute), for one round. The third week you will complete the same test. The tests being completed will provide us with information on muscle strength, muscle fatigue, and muscle power.

RISKS OF PARTICIPATION:
There is a known risk with consuming caffeine at the proposed levels in this study. Possible side effects include the common side effects of caffeine which are; sleeplessness, nervousness, occasional rapid heartbeat, and blood rushing to the skin referred to as a niacin flush. There is also a possibility of muscle soreness in the thigh (hamstrings and quadriceps) from the leg extension/leg curl test. If any complications occur the individual will be immediately escorted to the health center.

BENEFITS OF PARTICIPATION:
You will gain an understanding and knowledge of how research is conducted and the importance of continually conducting new research.

CONFIDENTIALITY:
The consent forms of this study will be kept private. This is the only document that will have your name recorded. The questionnaire that you will be asked to fill out will not require your name or any information that can be used to identify you. Any data and written results will discuss group findings and will not include information that will identify you. Research records will be stored securely and only researchers and individuals responsible for research oversight will have access to the records. It is possible that the consent process and data collection will be observed by research oversight staff responsible for safeguarding the rights and wellbeing of people who participate in research.

COMPENSATION:
There will be no compensation for participating in this research study.

CONTACTS :
You may contact any of the researchers at the following addresses and phone numbers, should you desire to discuss your participation in the study, have any questions at all, and/or want to request information about the results of the study: Allen Goddard, Principal Investigator (949)413-2779, allen.goddard@okstate.edu; or Dr. Doug Smtih, doug.smith@okstate.edu. If you have questions about your rights as a research volunteer, you may contact Dr. Shelia Kennison, IRB Chair, 219 Cordell North, Stillwater, OK 74078, 405-744-3377 or irb@okstate.edu

PARTICIPANT RIGHTS:
I understand that my participation is voluntary, that there is no penalty for refusal to participate, and that I am free to withdraw my consent and participation in this project at any time, without penalty.

CONSENT DOCUMENTATION:
I have been fully informed about the procedures listed here. I am aware of what I will be asked to do and of the benefits of my participation. I also understand the following statements:
I affirm that I am 18 years of age or older.

I have read and fully understand this consent form. I sign it freely and voluntarily. A copy of this form will be given to me. I hereby give permission for my participation in this study.

____
Signature of Participant Date

I certify that I have personally explained this document before requesting that the participant sign it.

____
Signature of Researcher Date

VITA

Allen Goddard

Candidate for the Degree of

Master of Science

Thesis: THE EFFECTS OF CAFFEINE ON STRENGTH AND POWER WHILE ON A LOW CARBOHYDRATE DIET

Major Field: Health and Human Performance with an option in Applied Exercise Science

Biographical:

Education:

Completed the requirements for the Master of Science in Health and Human Performance at Oklahoma State University, Stillwater, Oklahoma in Fall, 2014.

Completed the requirements for the Bachelor of Arts in Business Economics at University of California Riverside, Riverside, CA in 2010.

Experience:

Performance Coach Intern — June 2013 to August 2013
Velocity Sports Performance – Irvine, CA

Personal Trainer — July 2011 to June 2012
24 Hour Fitness – Laguna Hills, CA

Intern — June 2010 to September 2010
Pacific Western Bank – Irvine, CA

Professional Memberships:

NSCA- Certified Strength and Conditioning Specialist

ACSM- Certified Personal Trainer