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The Effect of Caffeine Supplementation on Muscular Power in Recreationally Trained College Aged Males

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THE EFFECT OF CAFFEINE SUPPLEMENTATION ON MUSCULAR POWER IN
RECREATIONALLY TRAINED COLLEGE AGED MALES

BY

DAVID JOHN SANDERS

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
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MASTER OF SCIENCE THESIS

OF

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ABSTRACT

Background: Caffeine is a substance that is consumed regularly by approximately 90% of adults worldwide, primarily to reduce fatigue and increase wakefulness. The benefit of caffeine consumption on athletic performance in large doses (3-9 mg/kg body weight or BW) is well documented in aerobic athletes. However, the benefits of caffeine consumption on resistance training variables such as power are less clear. **Purpose:** The purpose of this study was to investigate the effect of consumption of 7 mg/kg BW of caffeine on power production in experienced, resistance trained college-aged males, who are habitual caffeine consumers. **Methods:** Eighteen young and healthy college aged males (aged 21.7 ± 2.0 yrs) were included in this double blind, placebo controlled study. Subjects performed a battery of tests that included a vertical jump (VJ), isometric squat (ISO), and Smith Machine squat (SQF) and bench press (BPF) to failure at 60% 1RM. Subjects consumed either 7 mg/kg body weight (BW) of caffeine or placebo, 60 minutes prior to testing. Test sessions were separated by 7 days. Power production during VJ, SQF and BPF exercises was evaluated. Power obtained during SQF and BPF was used to find the fatigue index (F.I.). Also, force production during an ISO was assessed. A repeated measures ANOVA was used to determine differences between treatments. Significance for all analysis was set at $p \leq 0.05$. **Results:** There were no significant differences between treatments in VJ, ISO, SQF, or BPF. **Conclusion:** Consumption of 7 mg/kg BW of caffeine does not improve measures of force, power, or fatigue during resistance training exercises in habitual caffeine users.

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PREFACE

This thesis is written to comply with the University of Rhode Island graduate school Manuscript Thesis Format. This thesis contains one manuscript: *The effect of caffeine supplementation on muscular power in recreationally trained college aged males.*

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MANUSCRIPT

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CHAPTER 1

Introduction

The stimulating effect of caffeine, characterized by reducing fatigue and increasing wakefulness has made it one of the most commonly consumed substances daily (13). Caffeine is found in a variety of products including tea and coffee, soda and energy drinks, candy and ice cream, and nutritional supplements. Evidence suggests caffeine consumption may also enhance one's athletic performance, so it is consumed as a legal way to potentially improve training or competition performance by competitive and non-competitive athletes (16,24,55). High energy supplements, such as Red Bull, have become a popular ergogenic aid because they claim to improve some aspects of performance (21). Also, it has been reported that high energy beverages and capsules that contain caffeine are among the most popular supplements used by adolescents, especially males (29,30). Research has demonstrated that large doses of caffeine have improved aerobic endurance performance in elite athletes, such as cyclists or runners (8,11,13,25,38,54). Despite the known ergogenic effect of caffeine on aerobic performance, the benefit of caffeine supplementation on improving resistance training variables, for example power and power endurance, is less clear (30,36,45).

Previous investigations of caffeine's effect on strength and power measures have been equivocal. For example, Beck and associates reported an increase in strength of recreationally trained males in the 1-repetition maximum (1RM) bench press due to the consumption of ~2.4 mg/kg of caffeine (7). Additionally, Hurley and colleagues found that a 5 mg/kg dose of caffeine resulted in an increase in bicep curl repetitions to failure in recreationally trained college aged males. In contrast, Woolf et al. reported no

improvement in bench press to failure when caffeine naïve collegiate football players consumed a dose of caffeine of 5 mg/kg of body weight. Astorino and colleagues found no improvement in bench press to failure due to a dose of 6 mg/kg of caffeine in resistance-trained males who were habitual caffeine consumers. Also, Trevino and associates reported no increase in muscle torque due to a 5 and 10 mg/kg dose of caffeine, but the authors noted that caffeine did have an effect on motor unit firing rate (51). The discrepancies in the literature could be attributed to the use of different exercise testing protocols, dosage of caffeine, subject characteristics, subject caffeine consumption history, and/or subject training status. Also, the current literature focuses on repetitions as a marker of performance, as opposed to other fundamental measures of performance, such as power and force.

Power is a vital component to athletic performance because it takes into account the speed at which an object is moved ($\text{Power} = \text{Force} \times \text{Velocity}$) (5,46). Explosive power output is a primary determinant of performance in singular movements, such as jumping or throwing (46). Simply put, the more power one can produce, the higher one can jump or the faster one can throw a ball. Also, in activities with multiple movements, the maintenance of high power output is needed. Thus, power endurance results from the combination of aerobic and anaerobic energy pathways, resulting in the maintenance of strength and power during aerobic activity, such as in soccer or hockey (2,48). Therefore, if caffeine can improve or maintain the force produced and velocity of movement, it is probable that power and power endurance are positively affected.

Concurrent measurement of force and velocity allows for the examination of power and power endurance. Power production can be accurately measured by a

portable force plate for tests such as the vertical jump (VJ) (9,44,53). Testing of this nature measures the power produced from the ATP-PCr energy system, the immediate energy supply, and reflects a persons explosive power capabilities via rate of force development (5,46). Because caffeine has been suggested to decrease the electrical threshold for muscular contraction, an increase in the rate of force development may be detected (25,39).

Traditionally, anaerobic endurance is evaluated from a Wingate Anaerobic Test (WAnt), during which the fatigue index (F.I.) is measured (6). A novel assessment of anaerobic endurance, or power endurance, during weight training can be evaluated from a linear transducer that measures the power produced during individual repetitions, and calculating F.I. while performing a lifting exercise to failure, thus a quantitative measure of power endurance is produced.

Although some studies have reported an improvement in measures of strength, there are few investigations studying the acute effects of caffeine on power production while weight training, and no known studies investigating the fatigue attenuating effect of caffeine on power production (7,35). Therefore, a primary purpose of this study was to test the effect of consuming 7 mg/kg BW of caffeine on power and force output in experienced, resistance trained college aged males. We hypothesized that caffeine consumption would increase power production during a VJ and force production during an isometric squat (ISO). A secondary purpose of this study was to investigate caffeine's effect on fatigue while lifting weights, and we hypothesized that caffeine would decrease F.I. during a set of maximal repetitions of squat and bench press.

CHAPTER 2

Review of the Literature

Resistance Training Variables

Force

Newtonian physics defines force as the product of mass and acceleration ($F=ma$) (5). When resistance training, muscles must contract with a force that is greater than the mass of an object, in order to successfully lift the object (37). Muscle contraction can be described by dynamic movement (concentric/shortening or eccentric/lengthening) and static movement (isometric/no change) actions (37).

Testing is useful to measure changes in muscle force production capabilities due to a training or drug intervention. Specifically, isometric tests are preferred because of their high test-retest reliability (9). Isometric testing allows for the assessment of neuromuscular function via peak force (43). Peak force is the highest force produced during a static or dynamic maximal effort, and is an indication of maximal strength (43). Peak force is validly assessed by a portable force plate (53). Blazeovich and associates noted that when choosing an isometric test to use, the isometric test must be identical to the dynamic exercise performed (9). As our testing protocol also utilized dynamic squat testing, an ISO was used to measure the effect of caffeine on force production. Researchers reported reliability of the IS to be very high, ICC= 0.97 (9).

When performing an ISO test, subject knee angle must be taken into account. Marcora and Miller reported a knee angle of 120° during IS testing was significantly correlated to the rate of force development found during squat jump and counter-movement jump performance, and peak force approached significance in the same

measure, $P=0.053$ and $P=0.067$ (43). The investigators reported no significant relationships of IS performed at 90° , and recommended using a greater joint angle to help mitigate any pain that may occur during the exercise (43). Force is an essential variable of the resistance training paradigm, and is commonly reported in the literature as a marker of performance (42).

Power

Power (P) is defined as the rate of performing work, i.e. the product of force (F) and velocity (v) ($P = Fv = \text{work/time}$) (37,46). Power, or explosive power output, is a primary determinant of performance in many athletic events (46). For example, power is required for high performance in short duration activities, such as jumping, in which the height of the jump is determined by the take off velocity of the athlete (46). Also, power is needed during longer activities, e.g. soccer or ice hockey, in which these athletes will move (run or skate) at full velocity, then perform other tasks that require power (shoot, pass, hit, etc...). Therefore, power endurance is the maintenance of power output, whether it is over the course of a series of events or a game. Power endurance occurs due to the combination of aerobic and anaerobic energy pathways (2,48). An example is the ability to produce and maintain a high power output for many repetitions during a single set of exercise. Power endurance is vital in various athletic events where an increase in power output is needed to complete a task, such as running uphill or sprinting towards a finish line at the end of a race.

Power of the lower extremities is measured by performing a VJ on a portable force plate (44,53). Markovic et al. stated that the use of reliable and valid testing procedures is useful for monitoring the effects of training, thus would be beneficial in

testing the effects of drug supplementation (44). Markovic and associates extensively tested the reliability and validity of the counter movement jump (CMJ) on 93 college-aged males (44). The investigators reported an average inter-trial correlation coefficient (AVR), Crohnbach's alpha reliability coefficient (α), and coefficient of variation (CV%) of 0.94, 0.98, and 2.8% respectively, concluding that CMJ is the most reliable jumping test for estimation of explosive power in the lower limbs, compared to 6 other jump tests (44). Also, the researchers reported the highest r of 0.87 for the CMJ, and concluded that the CMJ, with hands on the hips, is the most valid jump for measuring explosive power (44).

Power Endurance

Traditionally, power endurance, or anaerobic endurance, is evaluated by performing a Wingate Anaerobic Test (WAnt) on a cycle ergometer (5,6). The glycolytic energy system is the primary source of energy for a test of this nature, and the F.I.% is the measure of endurance, i.e. a lower % equals higher endurance and vice versa (5,6,12). The FI% is calculated by the following

equation: $\left\{ \frac{(Peak\ Power - Minimum\ Power)}{Peak\ Power} \right\} \times 100$, where peak and minimum power can be the absolute value measured or averages from 5-second intervals of the WAnt (6).

When resistance training, the number of repetitions performed each set of an exercise is dependent on the exercise intensity (5). Typically, the lighter the weight, the more repetition, and vice versa (5). Based on the "RM continuum" proposed by Fleck and Kraemer, power is trained with 1-5 repetitions (at 75-90% 1RM) and endurance is trained with ≥ 12 repetitions (at $\leq 67\%$ 1RM) (20,49). Shimano and associates

investigated the relationship between repetitions to failure and exercise intensity (60%, 80%, and 90% of 1RM) in the back squat, bench press, and arm curl exercises in trained and untrained men (49). The investigators reported that more repetitions were completed with larger muscle groups (squat > bench press > arm curl), and that more repetitions were completed with lighter weight (60% > 80% > 90%) (49). The researchers propose that asynchronous motor unit recruitment attenuates fatigue during submaximal exercise loads, thus larger muscle groups (legs vs. arms) have a greater absolute number of motor units, allowing for more overall rest for muscle fibers (49). Therefore the results are in agreement with the RM continuum (20,49). Interestingly, the training status of the subject did not have an effect on the number of repetitions to fatigue at 60% and 80% 1RM in all exercises (49). This indicates that when using lighter training loads ($\leq 80\%$ 1RM), subjects of different training statuses will complete a similar amount of repetitions before failure. The researchers suggest this may occur due to a lighter absolute resistance being used (49). Also, Shimano et al. reported a significant difference in mean power between groups in all exercises and at all intensities ($p < 0.05$) (49). It was expected that the trained subjects produce more power than untrained subjects because the trained subjects were using greater loads, which require greater power (49).

Power can also be directly measured by a linear transducer that measures the displacement of a barbell and time via an internal timing mechanism, thus calculating velocity of movement and power (32,49). Hori et al. compared four different methods of measuring power output during the hang power clean and weighted squat jump exercises (32). The authors used a combinations of a linear transducer and force plate to

measure ground reaction force (GRF) and barbell displacement (32). Method 1 measured the power applied to the barbell only using a linear transducer and methods 2, 3, and 4 measured the power applied to the system (barbell + body) using a linear transducer and force plate (32). The authors reported the use of a linear transducer (method 1) as a reliable means of power assessment for peak and mean power in the hang power clean and weighted squat jump (Peak power $r = 0.7$ & 0.74 , $p < 0.01$) (mean power $r = 0.65$ & 0.81 , $p < 0.01$), when compared GRF (method 2) (32). The authors recommend using a linear transducer when estimating the power output applied to a barbell (32). Additionally, Hori and colleagues stated that a linear transducer can reliably be used to measure power for upper body resistance training exercises, including the bench press and shoulder press (33).

As training intensity (% of 1RM) effects repetitions performed and power output, specifically peak power, it is necessary to establish the correct intensity for training and testing power endurance (5,46). When measuring power, FI% may be evaluated during weight-lifting exercises by the proper equipment. A linear transducer is a reliable means of measuring the power output of individual repetitions of weight training exercises (32,49). Because a maximum and minimum power is found, the FI formula can be utilized. Therefore, power endurance may be evaluated for weight-training activities by applying the F.I. formula to measures of power obtained from a linear transducer, when the primary outcome measure is specifically the power applied to the barbell (32).

Evaluating power endurance by applying the F.I. to power and velocity measured during weight lifting exercises is a novel approach to studying the effect of an

intervention (resistance training or drug). When using this approach, it is necessary that exercise intensity be selected that allows for a sufficient number of repetitions to be completed to evaluate power endurance. Therefore, using 60% of 1RM is most appropriate because (a) it is a recommended training load for muscular endurance, thus allowing the completion of more repetitions than at higher training loads (5,20,49), (b) training status will not effect the amount of repetitions completed (49), and (c) greater peak power and peak velocity can be achieved than at higher training loads (46).

Caffeine

Physiology

Caffeine (1,3,7-trimethylxanthine) is often consumed daily because of its stimulating effects, i.e. increase wakefulness and reduce fatigue, and ability to improve mental and physical performance (13,19). Athletes consume caffeine prior to training or competition because evidence supports that caffeine consumption, at a minimum of 5 mg/kg will enhance athletic performance (16,24,47,55).

A review article by Stephen Dodd, Robert Herb, and Scott Powers outlines three potential cellular mechanisms that could explain caffeine's ergogenic effects on performance (19). The researchers indicate: (a) elevated myofilament affinity for Ca^{2+} and/or increased Ca^{2+} release from the sarcoplasmic reticulum (SR) of skeletal muscle; (b) cellular actions caused by accumulation of cyclic-3'-5'-adenosine monophosphate (cAMP) in skeletal tissue and adipocytes; and (c) competitive inhibition of adenosine receptors in the central nervous system and somatic cells (19).

Dodd and associates state that caffeine consumption can lead to increased myofilament affinity for Ca^{2+} , an increased sequestering of Ca^{2+} from the SR, or a

combination of the former and the latter (19). Caffeine was found to increase twitch tension development, which supports greater myofilament affinity for Ca^{2+} (26). In an *in vitro* experiment, Kovacs and Szucs reported an increase in skeletal muscle contraction force due to a large dose of caffeine (39). The investigators also stated that caffeine enhances Ca^{2+} release from the SR membrane or the junction between the T-tubule and terminal cisternae, without effecting the rate of Ca^{2+} re-uptake (39). Therefore, there is greater potential for Ca^{2+} binding to troponin, and a consequential increase in actin-myosin filament cross-bridging that results in greater force production by the muscle (5).

Research also indicates that caffeine decreases the charge needed to reach the muscular contraction threshold, thus the electrical threshold for muscular contraction is lowered (25,39). From the above findings, caffeine is presumed to affect myofilament affinity for Ca^{2+} and the release of Ca^{2+} from the SR (19).

Dodd and colleagues state that caffeine can increase cAMP levels via two potential mechanisms; (a) increasing levels of blood catecholamine; and (b) inhibition of the enzyme phosphodiesterase (19). Catecholamines, e.g. epinephrine, increase cAMP levels by activating adenylate cyclase, which stimulates the formation of cAMP from ATP in the cell (12,19). Then: (a) cAMP stimulates the release of hormone sensitive lipase (HSL); (b) HSL increases lipolysis and levels of free fatty acids (FFA); (c) FFA's increase mitochondrial activity and β -Oxidation, which is part of the Krebs cycle and electron transport chain (12). Investigators have reported that xanthine compounds increase the half-life of cAMP due to sensitization of central catecholamine

receptors and inhibition of phosphodiesterase, which increases the availability of FFA's and results in the aforementioned increase in mitochondrial activity (19,23,52).

Caffeine's chemical structure is similar to that of adenosine, and functions as an adenosine receptor antagonist (19,23). Therefore, caffeine can bind to adenosine receptors in the brain and peripheral tissues, block the binding of adenosine, which results in a myriad of interacting responses (19,22,25). The most notable effect of caffeine in this nature is its stimulating effect on the central nervous system. Holtzman and colleagues suggests that the stimulating effects of caffeine are due to binding to brain adenosine receptors, as opposed to adenosine analogues that would cause behavioral depression (19,31).

Considering caffeine's various physiological mechanisms, the following sections of the literature review will review investigations of caffeine's effect on aerobic and anaerobic athletic performance.

Aerobic Performance

The effects of caffeine consumption on aerobic performance have been thoroughly investigated and reviewed by numerous researchers. The consensus amongst the review articles is that caffeine consumption has an ergogenic effect on aerobic performance (14,19,25).

Pasman and associates investigated the effect of different caffeine dosages (5, 9, 13 mg/kg) on cycling time to exhaustion (TTE) (47). Subjects were instructed to cycle at 80% of maximal power output (W_{max}) until exhaustion or pedaling frequency was less than 50 rpm (47). The researchers measured maximal oxygen uptake (VO_{2max}) and free fatty acids (FFA) via blood samples (47). The investigators reported a significant

increase in performance TTE, +27%, with all caffeine doses ($p < 0.05$), and a significant increase in FFA concentration at exercise onset (T0), 5 min (T5), 10 min (T10), and 15 min (T15) ($p < 0.05$) (47). Pasman et al. suggest that the improved performance is due to the increase in FFA concentration at exercise onset, which causes a glycogen sparing effect (47). Therefore, glucose and glycogen are preserved for the latter stages of exercise when carbohydrate dependent energy systems are the primary source of ATP (10).

Douglas G. Bell and Tom M. McLellan investigated the effect of caffeine (5 mg/kg) on cycling performance 1, 3, and 6 hours post consumption in caffeine users and nonusers (8). The subjects pedaled to exhaustion at 80% of VO_2max at a self selected pedal frequency between 60-100 rpm (8). The investigators reported a significant increase in TTE in caffeine users (+19%) and nonusers (+28%) at 1 and 3 hours post consumption, and in nonuser 6 hours post consumption ($P \leq 0.05$) (8). Additionally, it was reported that a significant increase in VO_2max and heart rate (HR) occurred during the caffeine trial compared to the placebo trial (8). Thus an ergogenic effect of caffeine consumption is observed, maybe due to an increase in HR and VO_2max .

To test the effect of a smaller dose of caffeine (3 mg/kg body weight) in a field setting, Bridge and Jones had subjects perform an 8km run (11). The researchers reported an improved performance by an average of 23.8 seconds (95% CI= 13.1-34.5) (11). Thus, and ergogenic effect of caffeine occurs with as small of a dose as 3 mg/kg.

While an ergogenic effect of caffeine is found with as small of a dose as 3 mg/kg, other research suggests there is a dose-response relationship, and larger doses (9 mg/kg) are more effective at enhancing performance (11,47). The ergogenic effect of

different doses of caffeine on aerobic performance reported in the literature concurs with the physiological mechanisms reported by Dodd, Freedholm, Waldeck, and Holtzman (8,19,22,31,47,52). Researchers have attributed performance improvement in aerobic activities due to the glycogen sparing and alterations in metabolic variables (14,25). In addition, although the ergogenic effect of caffeine on aerobic performance is conclusive, the benefit of caffeine for anaerobic performance is less clear.

Anaerobic Performance

The discrepancies in the literature concerning caffeine's effect on anaerobic performance can be attributed to varying exercise testing procedure, caffeine dose, subject demographics, and subject caffeine habituation. Beck and colleagues studied the effect of a caffeine (~2.4 mg/kg) containing supplement on muscular strength, endurance, anaerobic capacity in resistance trained men (7). The only significant improvement reported due to caffeine was bench-press 1RM, i.e. upper body force production (7). A primary reason for a lack of improvement could be due to the low dose of caffeine (~2.4 mg/kg), which is below the minimum dose that yields aerobic improvements (7,19). Also, fatigue could be a limiting factor for the muscular endurance testing because during one testing session, subjects performed all test (WAnt, bench press and leg extension 1RM, and bench press and leg extension reps to failure) (7). Additionally, the researchers used 80% of 1RM to test muscular endurance, but 80% is the NSCA recommendation for strength training, which is greater than their recommendation for muscular endurance training of $\leq 67\%$ (5,7). Finally, using a lower body exercise that utilizes more muscles, such as the squat, is better suited for evaluating muscular endurance because of the effect of asynchronous motor unit

activation described by Shimano and associates (49). Compared to using the leg extension, using the squat may have resulted in a significant increase in total volume of weight moved, and increased fatigue potential.

Forbes and associates studied the effect of Red Bull, 2 mg/kg of body weight, on WAnt performance and bench-press repetitions to failure in physically active men (21). The subjects performed 3-sets of bench-press to failure at 70% of 1RM, with 1-minute rest intervals, followed by 3-30 seconds Wingate tests, with 2-minute rest intervals (21). Akin to Beck, the dose used in this study is below the recommended dose for ergogenic effects in aerobic performance. The investigators reported no significant effect on peak or average power for the WAnt, but a significant improvement in cumulative bench-press repetitions (34 ± 9 vs. 32 ± 8 , $P=0.031$) (21). The latter finding is in contrast to Beck and colleagues' report on bench press muscular endurance (7). This could have occurred because of the use of 70% of 1RM, as opposed to 80%, which is closer to the recommended training intensity for muscular endurance ($\leq 67\%$ 1RM) (5,7,20,21).

Astorino and associates studied the effect of 6 mg/kg of caffeine on resistance training exercises in habitual caffeine users (3). The subjects performed 4 sets of bench press and shoulder press (at 70% 1RM), and leg press and lat row (at 80% 1RM) to failure (3). In contrast to Forbes and in agreement to Beck, no improvement was reported in bench press to failure (3,7,21). However, the investigators reported a significant increase in reps to failure during the first 2 sets of the leg press only ($p < 0.05$) (3). Despite a significant increase in reps, the researchers stated the improvement in lower body muscular endurance is of little practical significance because only 1-2 more repetitions were performed (3).

Conclusion

As previously stated, anaerobic power is traditionally measured using the Wingate anaerobic test (WAnt). Peak power typically occurs within the first 5-seconds of the test, and is indicative of the maximal power produced via the ATP-PCr energy system (15). Anaerobic capacity is evaluated from the average power produced during the 30-second test, which reflects the power of the glycolytic energy system (15,56). Therefore, anaerobic capacity, or power endurance, during resistance training can be defined as the maintenance of power throughout the repetitions of a set of exercises. In light of this, the F.I. formula can be utilized during weight training to evaluate power endurance.

Currently, the information published in the literature on the effects of caffeine on resistance training variables is insufficient in terms of concluding whether or not caffeine has an ergogenic effect on high repetition resistance training; which may partly be due to inadequate caffeine dosage. Also, there are no publications that investigate power endurance or FI in the context of resistance training. Additionally, to our knowledge, there is limited research on caffeine's effects for resistance training in habitual caffeine users. Thus, this research was conducted to test the effect of an adequate dose of caffeine, at 7 mg/kg, and that used appropriate methodology (19,25).

CHAPTER 3

Methodology

Study Design

After approval from the University of Rhode Island's Institution Review Board, college aged males from the University of Rhode Island were recruited to participate in this cross-over design study. The effect of caffeine consumption on power production while performing weight training exercises was examined. The participants read and signed the informed consent form (Appendix A) prior to the start of the study.

Participants

Eighteen college-aged males (19-25 years old) who are experienced weight lifters were recruited from the University of Rhode Island. Participants were included if they weight trained for at least 6 months prior to the start of the study two times per week or more. Subjects also had to be regular caffeine consumers (~142 mg/day, or 12 oz. of coffee). Participants were excluded if they were inexperienced weight lifters (i.e. less than six months of training), or did not regularly consume caffeine.

Procedures

First, subjects completed a pre-screening questionnaire (Appendix B), which asked questions in regards to exercise time per week, weightlifting experience, and caffeine consumption to determine eligibility. Then, eligible participants met with test conductors to go over the informed consent form. Subjects asked any questions about the study they had at this time, and then signed the informed consent form. Next, subjects completed the pre-testing protocol. Participants then returned for two experimental testing sessions that were conducted one week apart at the same time of

day. During one session they consumed the placebo; the other they consumed caffeine, in randomized order. Participants were told to refrain from exercise and caffeine consumption for 24 hours prior to experimental testing sessions.

Pre-Test Protocol

Pre-test measures included anthropometrics (height and weight), body composition (body fat %), and strength via 1RM in bench press and squat exercises. Figure 1 summarizes the study variables measured, which will be described below.

Exercise Testing Protocol

Experimental test measures included VJ power, ISO force (N), number of bench press repetitions to failure, and number of squat repetitions to failure. Power and velocity were also measured during the bench press and squat exercises. Rating of perceived exertion (RPE) was collected before and after each exercise. Figure 1 summarizes the study variables measured. Figure 2 summarizes test day timeline.

Questionnaires

In addition to pre-screening questionnaires, subjects filled out a health history questionnaire (Appendix C).

Anthropometrics

Height was measured to the closest tenth of a centimeter using a Seca 216 stadiometer (Seca Instruments, Hanover, MD). The measurement was taken with shoes off, from the floor to the top of the head, and with feet together and flat on the floor. The subject's head, shoulders, buttock, and heels were in contact with the stadiometer. The participant looked straight ahead, inhaled, and held his breath when the measurement was taken. Weight was measured with the Bod Pod scale (Cosmed,

Concord, CA). The scale was calibrated prior to each participant. Participants removed their shoes, jewelry, and extra clothing prior to measurement. Subjects stood in the center of the scale during measurement. Duplicate measures were performed and rounded to the nearest tenth of a kilogram. The average was calculated and recorded.

Body Composition

Body composition was measured by air displacement plethysmography using a Bod Pod (Cosmed, Concord, CA) and its companion software, according to the manufacturer's instructions. The Siri equation was used to compute body fat percentage from the measured body volume.

Muscular Strength

One-RM strength testing for bench press and squat exercises was conducted during pre testing. One-RM testing adhered to the National Strength and Conditioning Association (NSCA) protocol, via previously described methods (5,40).

Muscular Force and Power

Muscular force and power were assessed via VJ and ISO using a force plate (AMTI, Watertown, MA) and associated software (Accupower, Park City, UT). Prior to testing, subjects were familiarized with both protocols. For the VJ, participants performed three consecutive, maximal effort jumps, with their hands on their hips. Subjects performed three trials, with 2-3 minutes of rest between each trial. The highest force, power, and jump height of each trial was recorded. The highest VJ power of the 9 jumps was used for analysis.

For the ISO, subjects aligned themselves on the force plate in a quarter squat position, under a Smith machine squat bar. The quarter squat knee angle ranged from

100-135 degrees, was measured with a goniometer, and was the same for both experimental testing sessions (27). When situated, the participant maximally pushed against the stationary bar for 10 seconds.

Muscular Endurance and Power

Sixty percent of each subject's 1RM was used to assess muscular endurance for the Smith machine squat and bench press exercises. The subjects performed each exercises to failure. A Certified Strength and Conditioning Specialist (CSCS), was present to ensure proper form was used and count the number of repetitions completed correctly. Power and velocity of each repetition was assessed by a Tendo Measurement System (Tendo Sports Machines, Slovak Republic). The Tendo Measurement System collected data on at least 95% of the repetitions performed. F.I. was calculated by the following formula.

$$\left\{ \frac{(\text{Peak Power} - \text{Minimum Power})}{\text{Peak Power}} \right\} \times 100$$

Rating of Perceived Exertion

The participants were instructed in the use of the Borg CR-10 scale prior to the start of testing. Subjects selected their perceived exertion on a scale from 0 (nothing at all), to 11 (Absolute Maximum). Subject RPE was asked immediately before and immediately after each exercise (10).

Caffeine and Placebo Administration

Caffeine dosage was 7 mg/kg BW for each subject. Placebo capsules were filled with an isocaloric amount of white flour, in order to resemble caffeine's color and texture. Caffeine and placebo were prepared in capsules by a trained pharmacist at Bayview Pharmacy (Saunderstown, RI). The pharmacist informed the researchers of the

contents of the capsules after the completion of all data collection. The capsules were consumed one hour prior to the start of experimental trials in order to achieve maximum plasma concentration (25). During the hour wait period, participants read magazines or watched TED Talks. Participants were not permitted to do school work of any kind.

Statistical Analysis

Data were analyzed using SPSS (version 21; SPSS, Inc., Chicago, IL). A repeated measures ANOVA was used to analyze the primary and secondary hypothesis. Linear assumptions were tested for and met. Assumptions for normality were tested for and met. In the case of a significant F score in the ANOVAs, a Bonferroni Post Hoc test was performed to determine where significant differences lay. Significance for all analysis was set at $p \leq 0.05$.

CHAPTER 4

Findings

Demographics

Subject characteristics are presented in Table 1.

Performance Results

A repeated measures ANOVA was used to determine differences between treatments in power during the VJ, force during the ISO, and velocity/power during the squat and bench press repetitions. There were no significant differences between conditions in any of the tests, as shown in Table 2. No significant relationships between caffeine consumption and performance were observed, Figures 3-6. Power was small to medium for the data assessed.

CHAPTER 5

Conclusion

The results of this study indicate that consumption of 7 mg/kg BW of caffeine does not improve measures of power, force, or fatigue index in resistance trained college-aged males who are habitual caffeine users, when consumed 1 hour before testing.

The VJ is a widely used laboratory and field test to assess power (1). To our knowledge, this is the first study to measure the effect of caffeine ingestion on VJ performance. The results indicate that caffeine had no effect on VJ performance (Figure 3). Woolf and associates investigated the effect of 5 mg/ kg BW of caffeine on anaerobic exercise performance in caffeine naïve collegiate football players (55). Although they did not administer a VJ test, Woolf et al. reported no improvement in 40-yard dash time (55). Even though the test are different, both tests primarily assess the power producing capability of the ATP-PCr energy system because they are completed in ≤ 10 seconds (5).

The current investigation reported no increase in peak force production during the ISO (Figure 4). Although no previous studies have used an ISO to measure caffeine's effect on force, the results of this research are consistent with Beck et al., where the authors reported no increase in leg extension 1RM due to consumption of ~ 2.4 mg/kg of caffeine (7). Additionally, Astorino et al. concluded that 6 mg/kg BW of caffeine was insufficient to significantly increase 1RM bench press and leg press in resistance trained men who were habitual caffeine consumers, compared to placebo (4). The results of this study, in addition to others' research, indicate that caffeine ingestion

does not yield a meaningful increase in force production in the lower extremities when measured by a 1RM or ISO.

Previous research has established that caffeine consumption causes an increase in Ca^{2+} release from the sarcoplasmic reticulum (S.R.), in myofilament sensitivity to Ca^{2+} , or a combination of both (19,39). Also, caffeine has been reported to increase twitch tension development of myofilaments (26). Thus, there is an increase in Ca^{2+} binding to troponin, and a consequential increase in actin-myosin filament cross-bridging that results in greater force and power production by the muscle (5). However, from the lack of change in VJ power and ISO force, it can be deduced that the aforementioned mechanism did not occur, and/or had no effect on the muscle's force or power producing capability. Since both exercises tested were completed in 10 seconds or less, the ergogenic effect may not have been observed because there was already a surplus of Ca^{2+} present in the muscle necessary for the exercise demands. Additionally, although the participants were recreationally trained, they may not have been trained for the specific demands of performing a VJ or ISO. Due to a lack of training specificity, the participants may not have recruited as many muscle fibers, and would not benefit from more Ca^{2+} or sensitivity to Ca^{2+} , as a trained athlete would (42). Harris and associates demonstrated that training for high force or high power will result in performance improvement specific to the associated movement, i.e. 1RM squat vs. VJ (27).

A novel measure of this study was the application of the F.I. formula to weight training exercises. F.I. was calculated from the peak power and lowest power obtained during the exercises, via a tendo measurement system. There was no threshold of

completed repetitions needed for inclusion in the analysis. No meaningful changes were observed in fatigue due to treatment (Figures 5 and 6). This is in contrast to other studies that reported an increase in repetitions completed due to caffeine consumption, which indicates fatigue attenuation (3,35,41). Although Astorino and associates reported a significant increase in leg press performance, the authors stated that the increase is of little practical significance because there was only an improvement of ~2 reps in sets 1-2 and no difference in sets 3-4 (3). Additionally, Kraemer and colleagues tested ~0.78 mg/kg BW of caffeine, in conjunction with other ingredients, and indicated that the increase in performance they reported can be attributed to combination of ingredients in the supplement, i.e. caffeine alone did not cause improvement (41).

A lack of significant fatigue reduction in the present study may have occurred because only one set of large muscle group, squat and bench press, exercises were performed. Previous research has reported an improvement in repetitions completed during multiple sets of small muscle group exercises. Hurley et al. reported a significant increase in repetitions performed during the final set of a fatiguing bicep curl protocol (35). The subjects in that study performed 5 sets of bicep curls at ~75% of their 1RM, with the first four sets to 10 repetitions and the last set to failure (35). Therefore, the improvement observed was dependent on the repetitions completed when the muscle group was fatigued, as opposed to a measure of power endurance of the whole set. Because the number of repetitions was not analyzed in the present study, a lack of significance may have occurred due to using the F.I. formula. If the difference between the peak power and lowest power remained the same between treatments, then there would be no difference between treatments. In other words, if the subjects produced a

greater power due to caffeine ingestion, it may have been offset by producing a lower power at the end of the set due to completing more repetitions. Additionally, as a muscular endurance training load was used (60% 1RM), Type I muscle fibers were recruited, which may have allowed for the asynchronous recruitment of neural motor units (28). Asynchronous recruitment would allow for more repetitions to be completed, but at a lower power output. However, electromyography was not performed in this study, so it difficult to discern the differences in muscle fiber recruitment.

The ergogenic effect of caffeine on aerobic performance has been attributed to its glycogen sparing properties (19,25). The Randle cycle describes the interaction between hormones and adipose tissue, which controls substrate concentration in circulation and the fuel utilized by muscles (34). Researchers have postulated that during aerobic activity, caffeine causes an increase in hormone sensitive lipase (HSL) and fat metabolism, thus down regulating carbohydrate metabolism, via inhibition of phosphofructokinase (PFK) and reducing glycolytic flux (17,19). Because the squat and bench press to failure exercises are anaerobic activities, the fatigue attenuating effect of glycogen sparing was not observed due to a single set of resistance training exercises and glycogen was not depleted.

To the knowledge of the researchers, the literature on caffeine consumptions effect on resistance training in habitual caffeine users is sparse. Even though habitual caffeine users were used in this investigation, previous research indicates the effect of caffeine habituation to be minimal (25). Dodd and co-workers compared performance during a graded exercise bike test (GXT) in caffeine users versus non-users (18). At rest, non-users had an increase in heart rate and oxygen consumption, but no differences

were reported during the GXT (18). Similarly, Tarnopolsky and Capido reported a similar contraction force to low frequency (20 Hz) stimulation in caffeine users and non-users (50). So, the findings of the current investigation should be expected to be similar if it was re-performed to compare caffeine users versus non-users.

In humans, caffeine consumption may elicit ergogenic effects on a myriad of athletic events, most definitively in aerobic events (19,25). Previous research has shown caffeine to increase in vitro muscle force production in frog muscle, due to an enhanced sequestering of Ca^{2+} from the S.R. (39). Additionally, caffeine has been reported to attenuate RPE during weight training, thus diminishing perception of effort (35,41). Therefore, it can be speculated that one can do more work due to caffeine consumption (35). However, in contrast to previous publications, we report no significant difference in post exercise RPE due to treatment.

Although these reports may lead one to believe that caffeine consumption may enhance one's weight lifting performance, i.e. increased power and force, or decreased fatigue, the findings of this study do not suggest an ergogenic effect of caffeine consumption for resistance and power exercises in the muscular endurance continuum in habitual users. Future studies should examine the effect of caffeine on power and fatigue during repeat bouts of squat and bench press exercise. This would also enable results to be generalized to team sports, such as soccer or ice hockey, where multiple bouts of maximal exertion occur throughout the event.

Limitations

In the current investigation there were several limitations. First, the weight training experience of the subject pool ranged greatly, even though all subjects met the

minimum requirement needed in order to participate. The subject training experience ranged from the minimum requirement to amateur power lifter. Thus, a lack of significant results could have occurred because it has been shown that caffeine provides a greater ergogenic effect in better trained individuals (25). However, participants were told to refrain from exercise for 24 hours prior to testing, so they could perform their best on test day. Next, during a few trials, the tendo-unit failed to record a repetition on the bench press exercise. This occurred on the shorter subjects, as the movement from the bottom of the lift to the top of the lift may have been too short to be recognized by the equipment as a repetition. When this occurred, subjects were instructed to bring the bar all the way down to their chest, and push as high as they can. If two consecutive misses occurred, the testing was terminated. Misses did not affect the F.I. calculation because they occurred in the middle of the exercise, so they were not the peak power or the lowest power of the set. Also, because all data from the tendo-unit were hand recorded, the rest period between the squat to failure and bench press to failure exercises was not standardized for all subjects. Despite this, all subjects did receive a minimum of 3 minutes of rest between all test exercises, which is standard to replenish ATP-PCr stores (5,12). Additionally, some subjects reported discomfort when using the Smith machine because they are accustomed to using a free weight barbell for squat and bench press exercises.

In contrast to the limitations, there were many strengths to study. First, the study was a double blind, cross-over design. Neither the tester nor the subject was aware of what treatment they received, so their test performance was not affected by what treatment was taken. Also, each subject acted as his own control, so the placebo group

was age and training level matched. Next, the subjects were randomized into groups, i.e. caffeine or placebo on test day 1. Participants test sessions were scheduled at the same time of day to control for diurnal hormonal fluctuations. Additionally, subject hydration level was tested to ensure that the participants were adequately hydrated. Prior to testing all participants met a minimal level of hydration (urine specific gravity < 1.025). Finally, the same trained tester conducted the participants test sessions. This was done to insure all measures were taken in an identical manner.

Practical Applications

The effectiveness of caffeine supplementation as a means to improve anaerobic performance is unclear in the literature. The results of this investigation show that caffeine does not increase measures of power or force, or attenuate fatigue during lower intensity resistance training in habitual users. Future studies on caffeine and anaerobic performance variables will need to focus on repeated bouts of exercise to understand caffeine's effect on performance throughout the duration of a resistance-training workout or athletic event. Researchers must be mindful of the %1RM used, as this would have an effect on the recommended rest interval. Also, investigations in team sports should utilize sport specific exercise and in-game rest intervals to appropriately mimic the physiological demands of the sport.

TABLES

Table 1: Subject Characteristics

Characteristics of male participants (n= 18). 1RM Squat= 1 repetition maximum in squat exercise, 1RM BP= 1 repetition maximum in bench press exercise.

	Mean $\pm$ SD
Age (years)	21.7 $\pm$ 2.0
Height (cm)	175.4 $\pm$ 6.1
Weight (kg)	79.7 $\pm$ 10.6
BF (%)	15.6 $\pm$ 6.6
1RM Squat (kg)	122 $\pm$ 20.9
1RM BP (kg)	99.1 $\pm$ 20.5

Table 2: Test result means ($\pm$ SD)

Mean ($\pm$ SD) values of vertical jump power (VJ), isometric squat force (ISO Force), and fatigue index (F.I.) in squat and bench press (BP). No significant difference between treatment $p \leq 0.05$. $n=18$.

	Caffeine	Placebo
VJ Power (W)	3924.2 $\pm$ 617.1	3930.9 $\pm$ 627.5
ISO Force (N)	2512.3 $\pm$ 555.8	2585.3 $\pm$ 528.2
F.I. Squat (%)	36.9 $\pm$ 12.6	33.6 $\pm$ 10.6
F.I. BP (%)	40.5 $\pm$ 12.5	42 $\pm$ 8.3

FIGURES

Figure 1: Study Timeline

Figure 2: Test Day Timeline

Figure 3: Vertical Jump Power

Vertical jump power output (W) (Mean $\pm$ SD) measured at least 60 minutes post treatment consumption. Testing was performed 7 days apart. No significant difference between treatment $p \leq 0.05$. $n=18$.

Figure 4: Isometric Squat Force

Peak isometric squat force (N) (Mean $\pm$ SD) measured at least 60 minutes post treatment consumption. Testing was performed 7 days apart. No significant difference between treatment $p \leq 0.05$. $n=18$.

Figure 5: Squat F.I.

Smith machine squat to failure fatigue index (F.I.) (Mean $\pm$ SD) measured at least 60 minutes post treatment consumption. Testing was performed 7 days apart. No significant difference between treatment $p \leq 0.05$. $n=18$.

Figure 6: Bench Press F.I.

Bench press to failure fatigue index (F.I.) (Mean $\pm$ SD) measured at least 60 minutes post treatment consumption. Testing was performed 7 days apart. No significant difference between treatment $p \leq 0.05$. $n=18$.

APPENDICES

Appendix A Participant Consent Form for Research

The University of Rhode Island
Department of Kinesiology
Kingston, RI 02881

The Effect of Caffeine on Muscular Endurance and Power in College Male Athletes

You are being invited to take part in a research project described below. The researcher will explain the project to you in detail. You should feel free to ask questions. If you have more questions later, Dr. Kathleen Melanson, the person mainly responsible for this study, (Phone 401-874-4477); Dr. Disa Hatfield, a co-investigator in the Kinesiology department, (Phone 401-874-5183); or Dr. Kelly Matson, a co-investigator in the Pharmacy department, (Phone 401-874-5811), will discuss them with you. You must be at least 18 years old to be in this research project.

Description of the project:

You have been asked to take part in the study that tests the potential effect of a high caffeine dosage on muscular endurance and power.

What will be done:

1. Height, weight, and 1-repetition maximum (the maximum amount of weight that can be moved with one repetition) estimates will be taken.
2. The study will consist of two test days, one week apart, where you will perform repetitions with weights equal to approximately 60% of your respective 1-repetition maximum until failure in two exercises (Smith machine squat and bench press).
3. 24-hours prior to the test day, participants are asked to abstain from consuming caffeine-containing products.
4. On the test day, a capsule(s) containing either a placebo or a pre-made caffeine supplement equal to 7 milligrams per kilogram of body weight will be provided to the subject for consumption (for example, if a participant weighs 75 kilograms, they will receive capsules equivalent to 525 milligrams of caffeine). Twelve fluid ounces of water will be provided to aid in pill ingestion.
5. Participants will remain stationary to allow absorption for one hour after consuming the pill(s).
6. A brief questionnaire will be provided to be completed throughout the testing process.
7. The following tests will be performed:
 - Bench press to failure using weight equivalent to 60% of the 1-repetition maximum weight (calculated from the bench press value obtained during the first visit)

- Smith machine squat to failure using weight equivalent to 60% of the 1-repetition maximum weight (calculated from the leg press value obtained during the first visit)
- Force plate test
- Vertical jump test

8. Participants are to consistently keep a log for three days following the test procedure. No dietary restrictions will be in place at this time; however, 24-hours prior to the second test day, participants will be asked to abstain from caffeine-containing products.

9. One week later, participants will return to perform the same procedure, consuming the alternative capsule(s). Throughout the study, both the subject and the researchers will be unaware as to whether you have consumed the caffeine capsule(s) or the placebo until after all testing has been completed.

Risks or discomfort:

Caffeine is a stimulant, and this test involves the consumption of a significant dosage of caffeine. While the amount consumed is well within the safe limit, there is a risk of: increased blood pressure, reduced control of fine motor movements, and risk of insomnia. Risk is greater in non-habitual consumers. Caffeine withdrawal can also produce headache, fatigue, and decreased alertness. In addition, caffeine has been used as a diuretic, which can be detrimental to athletes performing in long-term endurance events.

In addition to caffeine use, there is risk of injury in performing any form of strength training exercises. This study requires testing for 1-repetition maximum and performing repetitions to failure in different muscle groups.

The amount of caffeine used in this study is well within the safe limits of consumption for healthy, adult males. In addition, many previous studies testing the effect of caffeine on healthy adults during physical activity have incorporated caffeine with doses at and exceeding the dosage used in this study (7 milligrams of caffeine per kilogram of body weight). In order to maintain safety of all participants, the following criteria warrants exclusion from the study: those with diagnosed high blood pressure, known or suspected allergies/negative reactions to caffeine, and/or known or suspected heart conditions.

Benefits of this study:

Although there will be no direct benefit to you for taking part in this study, the researcher may learn more about caffeine supplementation in regards to strength athletes. Currently, there is significant data to demonstrate the benefit of caffeine consumption prior to cardiorespiratory endurance activities (running, cycling). However, little data is currently available in regards to muscular strength/endurance.

Confidentiality:

Your participation in this study is strictly confidential. None of the results or collected data will identify you by name. All records will be stored in a locked cabinet and viewed solely within the Energy Balance Lab located in Ranger Hall. Data entered in

any computer programs will not contain information identifiable back to you. Please note, all data is subject to inspection by federal, state, and local agencies, such as the Food and Drug Administration (FDA).

In case there is any injury to the subject: (If applicable)

In the event of an injury during the testing process, the URI emergency medical services will be contacted at (401)-874-5255. If this study causes you any injury, you should write or call the office of the Vice President for Research, 70 Lower College Road, University of Rhode Island, Kingston, Rhode Island, telephone: (401) 874-4328.

Decision to quit at any time:

Participation in this study is up to you. You are in no way required to participate. If you decide to take part in the study, you may quit at any time. Whatever you decide will in no way be recorded, penalize you, affect enrollment status and/or grades. If you wish to quit, you simply inform the lab (Ranger 310, phone 401-874-2067) of your decision.

Rights and Complaints:

If you are not satisfied with the way this study is performed, you may discuss your complaints with Dr. Kathleen Melanson (401-874-4477), Dr. Disa Hatfield (401-874-5183), or Dr. Kelly Matson (401-874-5811) anonymously, if you choose. In addition, you may contact the office of the Vice President for Research, 70 Lower College Road, Suite 2, University of Rhode Island, Kingston, Rhode Island, telephone: (401) 874-4328.

You have read the Consent Form. Your questions have been answered. Your signature on this form means that you understand the information and you agree to participate in this study.

I, _____
residing at _____ (zip) _____
telephone _____ age _____ (date of birth) _____
agree to participate in this research project.

Signature of participant

Signature of Researcher

Typed/printed Name

Typed/printed Name

Date

Date

Please sign both consent forms, keeping one for yourself.

Appendix B

Pre-Screening Questionnaire

How would you describe your weightlifting routine?

0-1 2-3 4-5 5+ (days per week)

How long have you consistently participated in weight-bearing exercise?

<1 month 1-3 months 4-5 months 6-12 months +1 year

Are bench-press exercises incorporated in your typical weight-bearing routine?

yes no

Are leg-press exercises incorporated in your typical weight-bearing routine?

yes no

How would you describe your typical coffee intake (caffeinated)?

0 1 2 3 4 5+ (8 fl oz cups per day)

How would you describe your typical soda intake (caffeinated)?

0 1 2 3 4 5+ (8 fl oz cups per day)

Appendix C

Personal Health History Questionnaire

Please complete this as accurately and completely as possible. If you would like clarification on any question, please feel free to ask.

Name: _____ Age: _____ Gender _____

Mailing address: _____

Phone number: _____ Today's date: _____

Email address: _____

Approximate weight: _____ Approximate height: _____

Ethnic Background (circle one)

- African-American
- Asian-American
- Caucasian
- Hispanic-American
- Other _____

General Medical History

Circle One

Do you currently have any medical complaints? Yes No

(please specify) _____

Do you take any prescribed or over-the-counter medication? Yes No

(please specify) _____

Dietary History

Please list any food allergies, intolerances or specific foods you avoid

Do you experience caffeine withdrawal symptoms if you do not consume it in the morning. (i.e., headache)?

Are you able to abstain from alcohol consumption for several days in a row?

Please describe your diet history. Make sure to specify if you are or have been vegetarian, if you are or have been on a self-prescribed or medical-prescribed special diet, or if you have participated in bingeing, crash diets, cyclic dieting, or were anorexic

and/or bulimic: _____

The following questions address body weight history.

What is the length of time you have maintained your present weight? _____

How much would you like to weigh? _____

How many times has your weight fluctuated by at least 5 lbs in the last year? _____

Please describe any long-term weight changes you have experienced (e.g., lost 50 lb. in 1995): _____

How would you describe the typical weight of *your parents* over the last few years?

	Under-weight	Just right	Over-weight	Obese	Unknown
Your Mother	☐	☐	☐	☐	☐
Your Father	☐	☐	☐	☐	☐

General History: Have you had or do you have:

Adrenal disease	Yes	No
Hypoglycemia (low blood sugar)	Yes	No
Seizures	Yes	No
Kidney or bladder problems	Yes	No
Stomach ulcers	Yes	No
Diabetes	Yes	No
Family history of diabetes	Yes	No
Thyroid Diseases	Yes	No
Any chronic illness that might cause weight loss	Yes	No
Atrial Fibrillation (irregular heart rate)	Yes	No
Tachycardia (fast heart rate)	Yes	No
Other	Yes	No

Explain any Yes responses: _____

Do you have any close blood relatives have or had type 2 diabetes (parents, grandparents, siblings, aunts or uncles)?

Yes No

Do you have any close blood relatives have or had heart disease? Yes No

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