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Effect of Caffeine Supplementation on Vertical Jump Performance, Heart Rate Variability, and Electromyography

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EFFECT OF CAFFEINE SUPPLEMENTATION ON VERTICAL JUMP PERFORMANCE,
HEART RATE VARIABILITY, AND ELECTROMYOGRAPHY

by

Collin T. Garner

A thesis submitted to the Graduate College
in partial fulfillment of the requirements
for the degree of Master of Science
Human Performance and Health Education
Western Michigan University
August 2019

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Collin T. Garner

EFFECT OF CAFFEINE SUPPLEMENTATION ON VERTICAL JUMP PERFORMANCE, HEART RATE VARIABILITY, AND ELECTROMYOGRAPHY

Collin T. Garner, M.S.

Western Michigan University, 2019

Research into caffeine's ability to improve anaerobic performance is inconclusive. Eleven anaerobically trained individuals (mean age: 23.45 ± 1.51 years) participated in this study. Assessments of resting heart rate variability (HRV), exercise heart rate variability, surface electromyography (sEMG), static vertical jump (SJ), and countermovement vertical jump (CMJ) were conducted before and after administration of placebo and caffeinated treatments. Three trials of each vertical jump technique were performed before and after treatment administration. A 60-minute absorption period was utilized for absorption of the treatment following its ingestion. All participants performed testing on two separate occasions, once under the placebo condition and once under caffeinated condition.

Statistically significant improvements were found between pre and post-treatment measures of peak CMJ height ($p=0.001$), peak CMJ power ($p<0.001$), eccentric utilization ratio ($p=0.025$) in the caffeine condition and eccentric utilization ratio ($p=0.013$) in the placebo condition as well as between conditions for peak CMJ height ($p=0.018$) and peak CMJ power ($p<0.001$). No significant differences were found between pre and post-treatment nor conditions for peak sEMG, high and low frequency power of HRV, peak SJ height, and peak SJ power ($p>0.05$). This study concluded that caffeine does appear to improve performance of the vertical jump but does not appear to significantly change peak sEMG or frequency domain measures of HRV.

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INTRODUCTION

Caffeine as an Ergogenic Aid

Caffeine is a commonly used stimulant that is often found in many beverages, foods, and supplements. Many supplements marketed to fitness enthusiasts claim to improve exercise performance or exercise quality. Some supplements are referred to as a pre-workout supplement and include caffeine as an ingredient. The current body of research focusing on caffeine's performance enhancement has demonstrated its ergogenic effects on aerobic exercise performance (Graham & Spriet, 1991). However, the research focusing on the efficacy of caffeine as an ergogenic aid to the performance of anaerobic exercise is inconclusive. Researchers have suggested that caffeine does not benefit the performance of anaerobic exercise (Pfeifer et al., 2017; Anderson et al., 2018; Greer, Morales, and Coles, 2006). However, results from various studies have suggested that caffeine may provide significant benefits to anaerobic exercise performance in individuals that regularly perform anaerobic training (Glaister et al., 2008; Bellar et al. 2011; Bloms et al., 2016; Chen et al., 2015). Several studies have assessed caffeine supplementation as an ergogenic aid for performance of the vertical jump. Such studies report caffeine's efficacy for improvement of vertical jump performance that are somewhat mixed as the research focuses on other modes of anaerobic performance. On one hand, caffeine has been suggested to be an effective ergogenic aid to vertical jump performance (Foskett, Ali, and Gant, 2009; Del Coso, et al., 2014; and Bloms, et al., 2016). On the other hand, caffeine was reported to be ineffective as an ergogenic aid to vertical jump performance (Pfeifer et al., 2017). This study will assess pre-exercise caffeine ingestion on heart rate variability, electromyography,

and vertical jump performance. Each of these variables will be defined and explained in relation to caffeine and its effect on anaerobic performance.

Heart Rate Variability (HRV)

HRV is the measurement of the variations in the amount of time that elapses between individual beats of the heart (Bigger et al., 1996) via analysis of heart rate monitoring. Data referring to the standard deviation of the amount of time that occurs between the beats of the heart is referred to as time-domain data. In addition to time-domain data, analysis of HRV provides information related to the activity of the autonomic nervous system; referred to as frequency-domain data (Bigger et al., 1996; Tarvainen et al., 2014; Lopes and White, 2006). The frequency-domain data present spectral estimations that communicate the influences of autonomic nervous activity (Lopes and White, 2006). The spectral estimations consist of three frequency bands: high (0.15-0.4 Hz), low (0.04-0.15 Hz), and very-low (0-0.04 Hz). The high frequency band is considered to represent parasympathetic activity, the low frequency band is thought to be representative of a combination of parasympathetic and sympathetic activity, and the very low frequency band is thought to be indicative of alterations in heart rate that are influenced by thermoregulatory, vasomotor, and circadian factors (Lopes & White, 2006). The measure of absolute power, reported in ms^2 units, of each individual frequency band, as well as the total power, reported in ms^2 units, of all frequency bands, are recorded. The normalized units (n.u.), calculated using the powers of the individual frequency bands and the total power, are calculated for the high frequency and low frequency bands. The calculation of the normalized units of the high frequency and low frequency bands requires the absolute power of the very-low frequency band to be subtracted from the total power.

HRV has been related to skeletal muscle health and functioning by research that has found a relationship between HRV and risk of musculoskeletal injury. (Gisselman et al., 2016; Williams et al., 2017). The results of a study using CrossFit™ athletes conducted by Williams and colleagues (2017) suggests that decreases in the natural logarithm of the root mean square of the standard deviation of R-R intervals (Ln RMSSD) is accompanied by an increased risk of overuse injury. Another study conducted by Borchini and colleagues (2018) found that nurses classified as perceiving the stress levels of their work as high showed significant decreases in the powers of both high and low frequency measures of HRV. Recently, research has identified HRV as a useful tool for monitoring recovery, establishing training loads, and estimating risk of acute injury (Williams et al., 2017; Kiviniemi et al., 2007). The prior research on HRV suggests that HRV may be associated with the functioning of several aspects of the nervous system; including elements that may be linked with performance of exercise.

Additionally, caffeine has been shown to directly affect the frequency domain indices of heart rate variability. The results of Yeragani and colleagues' (2005) research suggested that caffeine increases the power of the high frequency measures following the performance of exercise and low frequency power during exercise when compared to a placebo treatment; suggesting that caffeine ingestion can alter frequency domain measures of heart rate variability by causing greater vagal withdrawal and stimulating the sympathetic nervous system.

Alternatively, a study assessing the acute effects of caffeine on heart rate variability suggests that caffeine ingestion results in a decrease in both high and low frequency power (Sondermeijer et al., 2002). A study conducted by Porges (1973) builds further upon the relationship between measures of HRV and other aspects of nervous system functioning as the participants within the study that had the highest measurements of HRV had the fastest reaction times. HRV is regarded

as a valuable measure for drawing inferences of cardiac health, and the frequency domain measures provide insight into the functioning of the parasympathetic and sympathetic divisions of the autonomic nervous system (Lopes and White, 2006). The growing popularity of using HRV measures to monitor recovery and set training loads has resulted in the development of numerous commercial products that monitor HRV and, in some instance, even provide information to the user of the product regarding readiness for physical activity. Little research has been conducted with the purpose of identifying the effects of caffeine on HRV at rest or during ballistic activities; the primary focus of research into how caffeine affects HRV are on HRV during and after bouts of aerobic exercise or special populations that may be at elevated risk of autonomic dysfunction. Given the nature of the previous research relating to HRV, it was determined that further investigations into HRV's relationship to performance and the effect that caffeine supplementation may have on the frequency domain measures of HRV are required. This study explored whether frequency domain measures of HRV may be associated with anaerobic performance via caffeine supplementation and vertical jump assessments.

Caffeine and Electromyography

Research focusing on caffeine's effects on electromyographic activity has produced varied results. One study conducted by Greer, Morales, and Coles (2006) that sought to investigate whether caffeine supplementation results in increased motor unit excitability during maximal intensity anaerobic exercise (specifically, the Wingate Anaerobic Test) reported that no electromyographic increases in the vastus lateralis and gastrocnemius at time points that corresponded with peak or minimum power were observed. Alternatively, several studies have reported that caffeine supplementation does result in a significant increase in electromyographic activity (Collier, Hardy, Millard-Stafford, and Warren, 2015; Bazzucchi, Felici, Montini, Figura,

and Sacchetti, 2011; & Chen, Wang, Tung, and Chao, 2015). It may be the case that significant increases in electromyographic activity may be observed only when significant improvements in performance occur, thus limiting the detection of increased electromyographic activity to scenarios where concurrent improvements in force production or power output occur.

Significance of This Research

The mechanisms underlying aerobic performance enhancement via caffeine supplementation have been thoroughly explored. However, due to the ambiguity of caffeine's benefits to anaerobic performance, the efficacy of caffeine supplementation as an ergogenic aid benefitting anaerobic performance is a topic of debate and the potential mechanisms underlying any performance enhancement require further research. This study provides additional research regarding the efficacy of caffeine's supplementation with the intention of improving anaerobic performance. Analysis of data related to physiological mechanisms may suggest what mechanisms produced any observed performance enhancements.

The Purpose of This Study

Given the inconclusive nature of research focusing on caffeine's efficacy as a supplement capable of enhancing anaerobic performance, more research into the matter could provide insight into efficacy and provide data pertinent to understanding what mechanisms play a role in performance enhancements. This study was conducted with the purpose of assessing the affect that caffeine supplementation has on the anaerobic performance of individuals that are anaerobically trained. Additionally, proposing potential mechanisms underlying any improvements detected during data collection by assessing surface electromyography (sEMG) of

the vastus lateralis and medial head of the gastrocnemius, autonomic nervous system activity via HRV, and vertical jump performance.

METHODOLOGY

Subject Recruitment

Participants were recruited from Western Michigan University's student body and the surrounding community. The criteria for participation required that prospective participants be individuals over the age of 18 years that engage in regular training focused on improving anaerobic performance. Individuals that met this requirement reported engaging in 30 minutes of anaerobic training – e.g. Olympic style weight lifting, High Intensity Interval Training (HIIT) that utilized powerful muscular contractions, sport specific training for anaerobic activities such as sprinting, shot put, football, basketball, high jump, and martial arts, or any training that placed an emphasis on maintaining or improving power output – at least three times per week. Additionally, participants were required to be generally healthy with no injuries to the lower extremities occurring within the 6 months prior to participation and no health conditions that warrant abstinence from caffeine ingestion.

Eleven young adults (demographic data reported in Table 1) determined to fit the training criteria for participation within this study were asked to visit the Human Performance Research Laboratory located within the Student Recreation Center at Western Michigan University on two separate occasions separated by at least 48 hours. It was requested that participants abstain from ingesting any products or supplements containing caffeine for 48 hours prior to their scheduled data collection sessions. Upon entering the laboratory for the first session of data collection, subjects were immediately presented with the informed consent form for review and signing.

Once the subjects agreed to participate and signed the informed consent form, the PAR-Q+ and ACSM Health Screening form were administered. The protocol of this study was approved by Western Michigan University's HSIRB.

Table 1: Demographics of Participants

N=11 (10 males; 1 female)	Mean	Standard Deviation
Age (years)	23.45	1.51
Height (meters)	1.76	.058
Mass (kilograms)	83.77	12.25
Body Mass Index (kg/m²)	26.93	3.87

Equipment

EKG recordings were collected using a 3-lead BIONOMADIX EKG module (*Biopac Systems, Inc.*). HRV was derived from EKG recordings using *acqKnowledge* (*Biopac Systems, Inc.*) sampling at 2,000 HZ. Surface EMG was measured using DTS Lossless wireless surface EMG modules (*Noraxon USA, Inc.*). Data collected via sEMG measurements were analyzed with myoMUSCLE software module and processed through rectification and waveform smoothing. Lastly, vertical jump height was measured via the *Just Jump or Just Run* (*Probotics, Inc.*) mat.

Treatments

Capsules containing caffeine anhydrous USP (*NutraBio Labs, Inc.*) were used to create the caffeinated treatment. For the caffeinated treatment, the contents of caffeine capsules were emptied into a weighing tray placed on a scale until the appropriate amount for the participant's body mass was accumulated in the tray ($6 \text{ mg} \cdot \text{kg}^{-1}$) and then mixed into 16 ounces (oz.) of tap water flavored with Mio Liquid Enhancer – Original (Kraft Foods, H.J. Heinz Company Brands LLC.). The placebo treatment consisted of flavored tap water (16 oz.) with no caffeine added to it.

Experimental Procedures

Once determined to fit the criteria for participation, subjects had EKG electrodes in a CM5-lead configuration and two sEMG modules placed on their dominant leg; one located over the vastus lateralis and one located over the medial head of the gastrocnemius. Once all equipment for data collection was placed, a 5-minute resting EKG recording was performed for assessment of pre-treatment HRV. Immediately following the EKG recording, the participants performed a 5-minute warm-up focusing on the musculature involved in the performance of a vertical jump. The warm-up consisted of 3 minutes of treadmill walking that began at a speed of 1.5 miles per hour which progressed in increments of .5 miles per hour at the completion of each minute, 45 seconds of butt-kickers, 45 seconds of high knees, and 30 seconds of bodyweight squats at a self-selected depth and pace. Following the completion of the warm-up, subjects began the pre-intervention vertical jump assessments. Jumps were performed on a *Just Jump or Just Run* jump mat (*Probotics, Inc.*), and the subjects were instructed to jump as high as possible with their hands placed on their hips to avoid any influence of upward momentum, generated via upward arm swinging, on vertical jump height. The jump protocol consisted of 3 static vertical jump trials with each jump trial being separated by 2 minutes of rest, a 5-minute resting period, and then 3 countermovement vertical jump trials with each jump trial being separated by 2 minutes of rest. The order in which jumps of the specified techniques were performed was not counterbalanced. During the duration of each jumping technique, EKG was recorded – with one recording being performed during the static vertical jump trials and another recording being performed during the countermovement vertical jump trials. Individual EMG measurements were recorded during each vertical jump trial. Upon the completion of the pre-intervention vertical jumps, the participants were given a 16-ounce beverage that contained either a placebo

treatment or a treatment containing 6 mg·kg⁻¹ of caffeine. The order in which treatments were administered was randomized, and subjects were blinded to the treatment order. Subjects were given 5 minutes to consume the beverage. Once the beverage was consumed, a 60-minute absorption period began in which the participants were instructed to remain in the lab without performing any physical activity. Upon the completion of the absorption period, a 5-minute resting EKG recording, 5-minute warm-up, and the post-intervention jump assessments were performed with adherence to the same protocol as the pre-intervention warm-up and vertical jump assessments.

Jump Technique

Vertical jump height is determined by the amount of force that an individual can generate during the phase of the movement in which the individual propels his/her body upwards – the more force that is generated, the greater the height of the vertical jump. The depth of the squat performed immediately prior to upward propulsion may influence vertical jump height. However, only one study performed with human subjects and simulation modelling by Domire and Challis (2007) that sought to assess the influence of squat depth on vertical jump height could be found. Domire and Challis (2007) reported no difference in vertical jump performance when comparing squat depths. Due to the lack of research regarding optimal squat depth for performance of the vertical jump and the focus of our study, which did not involve identifying the optimal squat depth for achieving maximal vertical jump height, participants were allowed to self-select the depth to which they squatted when performing vertical jumps. When performing static vertical jump trials, participants were instructed to pause for 1 second once their desired squat depth was reached and avoid squatting down further after the pause period prior to initiating upward propulsion to ensure that no countermovement was incorporated into the static

vertical jump. Any static vertical jump trial during which participants added countermovement to the jump was thrown out, and participants were asked to repeat the trial. Additionally, all vertical jumps were performed with the participants hands placed upon their hips. This ensured that no upward directed force that may influence vertical jump height was generated via upward directed arm swinging. Lastly, the vertical jump assessment protocol was similar to one previous study conducted by Bloms, Fitzgerald, Short, and Whitehead (2016). The protocol of our study's vertical jump assessments differed from that which was utilized by Bloms and colleagues, as our study incorporated pre-intervention assessments of vertical jump, 2 minutes of rest between trials of the same vertical jump technique, and 5 minutes of rest between jumping techniques. The protocol of our study provided 2 minutes for recovery following the performance of each individual jump trial and 5 minute between the series of jump trials for each jumping technique in an effort to eliminate any influence of fatigue on the performance of each jump trial that was subsequent to a previous trial.

Variables Analyzed

The frequency domain indices of HRV derived from EKG recordings performed prior to the standardized warm-ups and during the assessments of vertical jump, vertical jump height, peak power (calculated using the Harman equation (Harman et al., 1991)), and sEMG were compared for differences between pre and post-intervention assessments and across conditions. Stretch shortening cycle utilization was assessed by calculating the eccentric utilization ratio (McGuigan, Doyle, Newton, Edwards, Nimphius, and Newton, 2006).

Statistical Analysis

Paired-samples T-tests were used to assess the data collected for significant differences between postintervention data from both conditions (placebo vs. caffeine treatment). Significance was determined using two-tailed tests with the significance set *a priori* at $p < 0.05$. Additionally, paired-samples T-tests were performed on pre-intervention and post-intervention data for each condition.

RESULTS

Vertical Jump Height

Significant difference (Figure 1) in post-treatment peak countermovement vertical jump height between conditions was found (mean \pm s.d.: placebo; 56.3 ± 9.33 cm; caffeine; 58.5 ± 8.36 cm; $p=0.018$, $t= -2.822$, $df=10$). Significant differences were found between pre and post-intervention measures of peak countermovement vertical jump height (pre: 55.83 ± 8.26 cm; post: 58.50 ± 8.36 cm; $p=0.001$, $t=-4.707$, $df=10$) in the caffeine condition (Figure 2). No significant differences in post-treatment peak static vertical jump height (cm) between conditions were detected (mean \pm s.d.: placebo; 53.34 ± 9.85 ; caffeine; 55.35 ± 7.88 ; $p>0.05$). No significant differences ($p>0.05$) were detected for pre and post-intervention measures of peak static vertical jump under the caffeine condition. Additionally, no significant differences in pre and post-intervention measures for both peak countermovement vertical jump height and peak static vertical jump height under the placebo condition were detected.

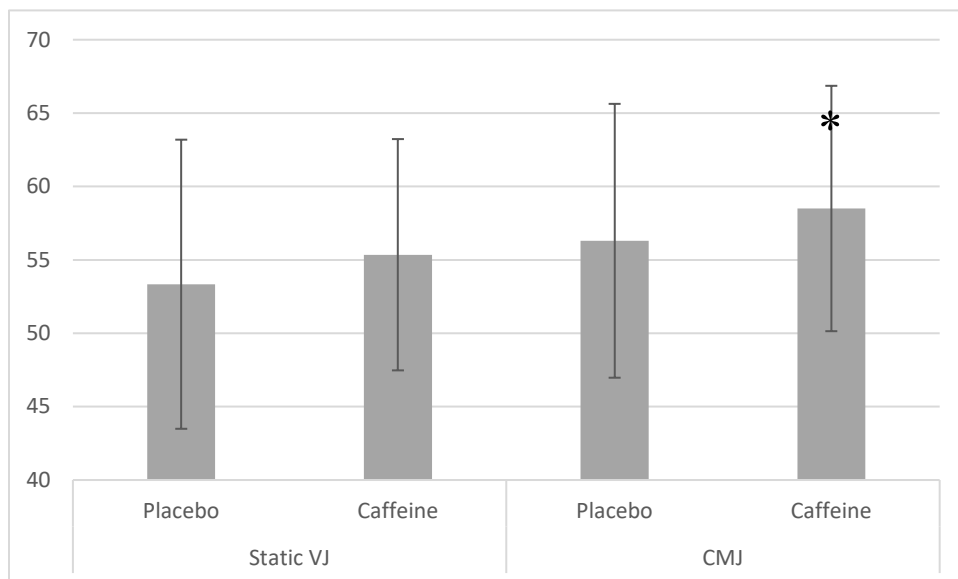


Figure 1: Post-Treatment Vertical Jump Height Data by Condition

CMJ = countermovement vertical jump technique; Static VJ = static vertical jump technique

* $p = 0.018$ when compared to post-treatment peak countermovement vertical jump height in the placebo condition, $N = 11$

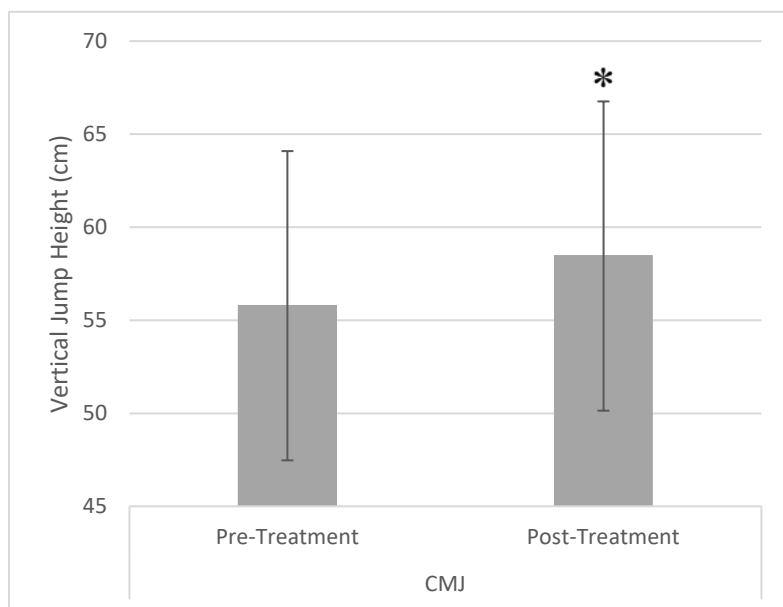


Figure 2: Pre and Post-Treatment Vertical Jump Height – Caffeine Condition

CMJ = countermovement vertical jump technique

* $p = 0.001$ when compared to pre-treatment CMJ height in the caffeine condition, $N = 11$

Peak Power Calculations

Significant differences (Figure 3) in post-treatment peak power output (W) between conditions for countermovement vertical jump (placebo; 8204.7 ± 577.5 ; caffeine; 8638.5 ± 543.1 ; $p < 0.001$, $t = -6.739$, $df = 10$) were observed. Also, significant differences (presented in Figure 3) were found for pre and post-treatment assessments of peak power within the countermovement vertical jump (pre: 8154.5 ± 511.5 ; post: 8638.5 ± 543.1 ; $p < 0.001$, $t = -6.842$, $df = 10$) in the caffeine condition. No significant differences were found between any measures of static vertical jump power ($p > 0.05$).

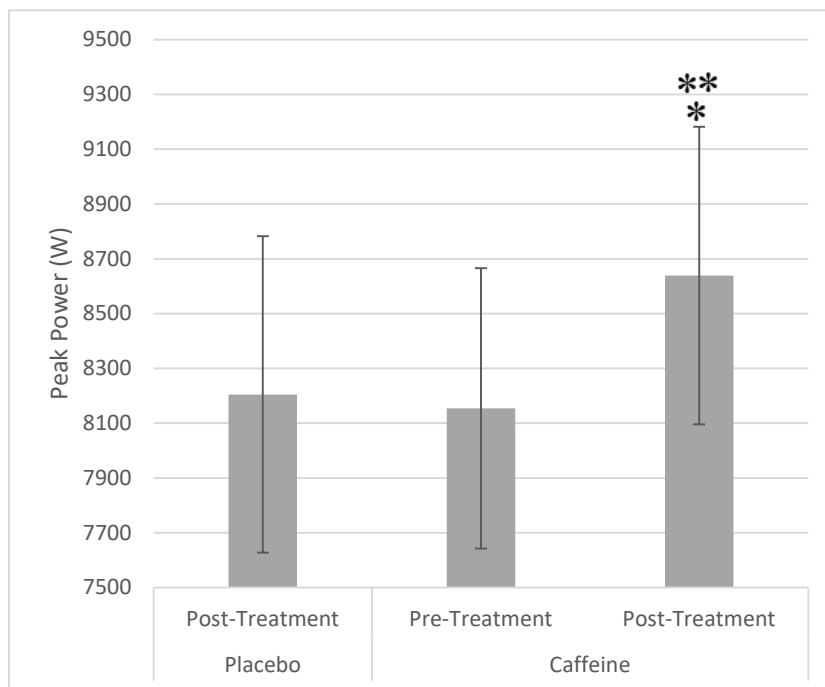


Figure 3: CMJ Peak Power by Condition

CMJ = countermovement vertical jump technique; W = Watts

* $p < 0.001$ when compared to post-treatment peak CMJ power from placebo condition, $N = 11$

** $p < 0.001$ when compared to pre-treatment peak CMJ power from caffeine condition, $N = 11$

Stretch Shortening-Cycle Utilization

No differences between post-treatment calculations of eccentric utilization ratio ($p>0.05$) were detected. However, significant differences (Figure 4) between the pre and post-treatment eccentric utilization ratios were present in both the placebo (mean \pm s.d; pre: 1.014 ± 0.0496 ; post: 1.060 ± 0.0728 ; $p=0.013$, $t= -3.017$, $df=10$) and caffeine (pre; 1.027 ± 0.0843 ; post; 1.060 ± 0.083 ; $p=0.025$, $t= -2.641$, $df=10$) conditions.

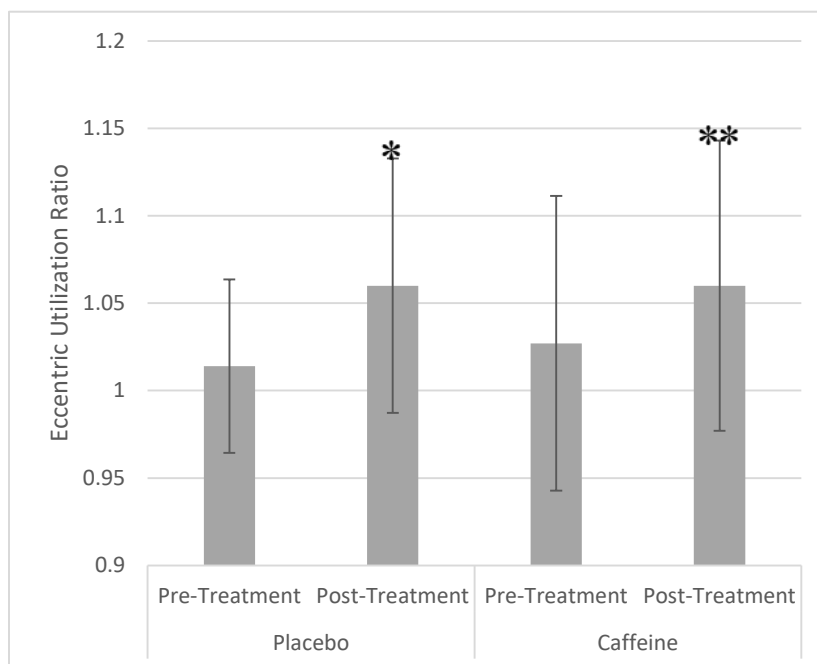


Figure 4: Stretch-Shortening Cycle Utilization

* $p=0.013$ when compared to pre-treatment eccentric utilization ratio in the placebo condition, $N=11$

** $p=0.025$ when compared to pre-treatment eccentric utilization ratio in the caffeine condition, $N=11$

HRV and Surface Electromyography

No significant differences ($p>0.05$) of sEMG measures at the site of the vastus lateralis or gastrocnemius were detected between conditions nor pre and post-treatment measures. No

significant differences ($p>0.05$) between conditions, nor between pre and post-intervention measures, were detected when analyzing the frequency domain measures of HRV.

DISCUSSION

Effect of Caffeine Ingestion on Frequency Measures HRV

Analysis of the data collected during this study found that caffeine ingestion did not significantly affect the frequency domain measures of HRV. These findings were inconsistent with the previous research that could be found focusing on caffeine's effect on HRV. The dosage of caffeine that was utilized in this study ($6\text{mg}\cdot\text{kg}^{-1}$) was greater than the dosages utilized in similar research that found significant differences in HRV measures, so it had been hypothesized that alterations in HRV would have been observed in this study. However, no information was collected regarding participant's caffeine usage. If the participants in study were habitual caffeine users, desensitization to caffeine's effects may explain the lack of significant changes in frequency domain measures of HRV. Dividing participants into habitual and non-habitual caffeine users to compare the effects of caffeine ingestion on HRV measures of participants from each classification could be the goal of future research.

Effect of Caffeine Ingestion on Surface Electromyography

This study's results suggest that caffeine has no significant effect on measures of peak sEMG. Since peak amplitude of sEMG did not significantly change at either site, the vastus lateralis or gastrocnemius, the observed improvements in peak power and peak countermovement vertical jump height do not appear to be the result of significant alterations in muscle activation. Caffeine is understood to have a stimulatory effect on the central nervous system (Dunwiddie, 1985) and has been suggested to cause an increase in excitation of motor

neurons (Bazzucchi et al., 2011). The lack of significant increases in peak sEMG measures via caffeine supplementation may be due to the participants' habits regarding caffeine usage; it may be the case that desensitization to caffeine's effects may have limited changes in sEMG measures. As was mentioned in the discussion of this study's data related to frequency domain measures of HRV, future research could focus on identifying how caffeine may differ in its effects on sEMG measures performed on habitual and non-habitual caffeine users.

Effect of Caffeine Ingestion on Measures of Vertical Jump Performance

It was hypothesized that caffeine ingestion would result in significant increases in vertical jump height, peak power output, stretch-shortening cycle utilization, and frequency measures of HRV. It was thought that increases in frequency measures of HRV as a result of caffeine supplementation would be indicative of greater nervous system reactivity and be accompanied by improvement in countermovement vertical jump performance; induced by increased muscle spindle reactivity to the stretch of the muscles of the lower extremity during eccentric phase of the countermovement vertical jump. Although this study found no significant effect of caffeine on peak static vertical jump performance, analysis of vertical jump data found that caffeine supplementation resulted in a significant improvement in peak countermovement vertical jump height and peak power calculations (placebo vs. caffeine and pre- vs. post-treatment for countermovement vertical jump in the caffeine condition). These results do not appear to be in full agreement with other studies that reported an improvement in vertical jump performance as a result of caffeine supplementation. For instance, a study conducted by Bloms and colleagues (2016) and a study conducted by Del Coso and colleagues (2014) both reported a significant improvement in static and countermovement vertical jump performances when participants received a treatment containing, respectively, 5 mg·kg⁻¹ and 3 mg·kg⁻¹ of caffeine. The disparity

between enhancements of vertical jump performance resulting from caffeine supplementation is intriguing because it would be assumed that any alterations caused by caffeine that would increase the capability for force production would be evident regardless of jumping technique. As this was not the case, it suggests that caffeine had an effect that improved the ability of the eccentric phase of the movement to facilitate force production during the jump's concentric phase.

The improvements in vertical jump performance that were observed during this study do not appear, based upon the data collected and analyzed within this study, to be caused by an increase in peak muscle activation of two major muscles contributing to knee extension and plantar flexion as no statistically significant differences in sEMG measurements were observed between the placebo and caffeine condition, nor when comparing pre and post-treatment sEMG measures within the caffeine condition. However, caffeine's known stimulatory effect on the nervous system may suggest an alternative mechanism through which countermovement vertical jump performance, but not static vertical jump performance, was improved. The muscle spindles are thought to contribute to the power produced during concentric phases of movements that occur immediately after an eccentric phase via afferent signals that travel to the spinal cord from the muscle spindles which facilitates muscle contraction (Trimble, Kukulka, and Thomas, 2000). In Trimble and colleagues' study (2000), simulating afferent signals from muscle spindles during maximal voluntary isometric contractions of the soleus and gastrocnemius resulted in a significant increase in sEMG recordings measured over the soleus and lateral gastrocnemius. Considering Trimble and colleagues' findings, improvements in countermovement vertical jump performance that were elicited via caffeine supplementation and unaccompanied by improvements in static vertical jump may be produced, in part, by strengthening of the afferent

signals originating at the muscle spindles of muscles involved in performance of the vertical jump. However, this suggestion is brought into question by the lack of data collected regarding afferent activity of muscle spindle activity.

Additionally, research using animal models has suggested that caffeine increases the release of calcium by the sarcoplasmic reticulum and increases force of contraction (Fryer and Martin, 1989). Additionally, a study by Allen and Westerblad (1995) found that in the presence of caffeine, myofibrillar proteins were more sensitive to calcium. It may be possible that enhancement in the performance of ballistic actions (e.g. vertical jump) is the result of muscular contraction and force generation being supported via a combination of increased release of calcium by the sarcoplasmic reticulum and increased myofibrillar proteins' sensitivity to the elevated levels of calcium. However, if this were the sole explanation of the findings from our study, it could be expected that significant improvements in both techniques of vertical jump rather than countermovement vertical jump alone would have been observed. Though performance of both vertical jump techniques did improve, the fact that the performance of the countermovement vertical jump displayed the greatest improvement suggests that alterations in the functioning of components involved in the stretch-shortening cycle were major factors contributing to the observed performance enhancements. However, no data was collected in an attempt to quantify afferent signals produced by the muscle spindles throughout the stretch-shortening cycle. Although the variables measured in this study did not include calcium release by the sarcoplasmic reticulum, myofibrillar sensitivity to calcium, nor afferent signals from muscle spindles, the nature of the observed differences within this study leads us to posit that, perhaps, a synergistic effect of strengthening of the muscle spindles' afferent signals in response to the eccentric phase of the countermovement jump increased calcium release by the

sarcoplasmic reticulum and increased sensitivity of the myofibrillar proteins to calcium, thus resulting in greater force production during the concentric phase of the countermovement vertical jump and greater peak countermovement vertical jump height.

CONCLUSION

The results of this study suggest that caffeine supplementation is beneficial to the performance of anaerobic activities by individuals that perform regular training focused on improving anaerobic performance. Though statistical significance was only achieved in the improvement in countermovement vertical jump performance, investigation of the data collected presents increases in the mean static vertical jump height with caffeine supplementation. Simple interpretation of the data collected during this study finds improvements in the measures of anaerobic performance with the greatest enhancements being limited to movements that incorporate the stretch-shortening cycle.

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Appendix A: Physical Activity Readiness Questionnaire

2018 PAR-Q+






The Physical Activity Readiness Questionnaire for Everyone

The health benefits of regular physical activity are clear; more people should engage in physical activity every day of the week. Participating in physical activity is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

GENERAL HEALTH QUESTIONS

Please read the 7 questions below carefully and answer each one honestly: check YES or NO.	YES	NO
1) Has your doctor ever said that you have a heart condition <input type="checkbox"/> OR high blood pressure <input type="checkbox"/> ?	<input type="checkbox"/>	<input type="checkbox"/>
2) Do you feel pain in your chest at rest, during your daily activities of living, OR when you do physical activity?	<input type="checkbox"/>	<input type="checkbox"/>
3) Do you lose balance because of dizziness OR have you lost consciousness in the last 12 months? Please answer NO if your dizziness was associated with over-breathing (including during vigorous exercise).	<input type="checkbox"/>	<input type="checkbox"/>
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)? PLEASE LIST CONDITION(S) HERE: _____	<input type="checkbox"/>	<input type="checkbox"/>
5) Are you currently taking prescribed medications for a chronic medical condition? PLEASE LIST CONDITION(S) AND MEDICATIONS HERE: _____	<input type="checkbox"/>	<input type="checkbox"/>
6) Do you currently have (or have had within the past 12 months) a bone, joint, or soft tissue (muscle, ligament, or tendon) problem that could be made worse by becoming more physically active? Please answer NO if you had a problem in the past, but it does not limit your current ability to be physically active. PLEASE LIST CONDITION(S) HERE: _____	<input type="checkbox"/>	<input type="checkbox"/>
7) Has your doctor ever said that you should only do medically supervised physical activity?	<input type="checkbox"/>	<input type="checkbox"/>

 **If you answered NO to all of the questions above, you are cleared for physical activity. Please sign the PARTICIPANT DECLARATION. You do not need to complete Pages 2 and 3.**

-  Start becoming much more physically active – start slowly and build up gradually.
-  Follow International Physical Activity Guidelines for your age (www.who.int/dietphysicalactivity/en/).
-  You may take part in a health and fitness appraisal.
-  If you are over the age of 45 yr and NOT accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.
-  If you have any further questions, contact a qualified exercise professional.

PARTICIPANT DECLARATION

If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness centre may retain a copy of this form for records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.




NAME _____ DATE _____

SIGNATURE _____ WITNESS _____

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER _____

 **If you answered YES to one or more of the questions above, COMPLETE PAGES 2 AND 3.**

Delay becoming more active if:

-  You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
-  You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at www.eparmedx.com before becoming more physically active.
-  Your health changes - answer the questions on Pages 2 and 3 of this document and/or talk to your doctor or a qualified exercise professional before continuing with any physical activity program.

2018 PAR-Q+

FOLLOW-UP QUESTIONS ABOUT YOUR MEDICAL CONDITION(S)

1. Do you have Arthritis, Osteoporosis, or Back Problems?	
If the above condition(s) is/are present, answer questions 1a-1c If NO <input type="checkbox"/> go to question 2	
1a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer NO if you are not currently taking medications or other treatments) YES <input type="checkbox"/> NO <input type="checkbox"/>
1b.	Do you have joint problems causing pain, a recent fracture or fracture caused by osteoporosis or cancer, displaced vertebra (e.g., spondylolisthesis), and/or spondylolysis/pars defect (a crack in the bony ring on the back of the spinal column)? YES <input type="checkbox"/> NO <input type="checkbox"/>
1c.	Have you had steroid injections or taken steroid tablets regularly for more than 3 months? YES <input type="checkbox"/> NO <input type="checkbox"/>
<hr/>	
2. Do you currently have Cancer of any kind?	
If the above condition(s) is/are present, answer questions 2a-2b If NO <input type="checkbox"/> go to question 3	
2a.	Does your cancer diagnosis include any of the following types: lung/bronchogenic, multiple myeloma (cancer of plasma cells), head, and/or neck? YES <input type="checkbox"/> NO <input type="checkbox"/>
2b.	Are you currently receiving cancer therapy (such as chemotherapy or radiotherapy)? YES <input type="checkbox"/> NO <input type="checkbox"/>
<hr/>	
3. Do you have a Heart or Cardiovascular Condition? This includes Coronary Artery Disease, Heart Failure, Diagnosed Abnormality of Heart Rhythm	
If the above condition(s) is/are present, answer questions 3a-3d If NO <input type="checkbox"/> go to question 4	
3a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer NO if you are not currently taking medications or other treatments) YES <input type="checkbox"/> NO <input type="checkbox"/>
3b.	Do you have an irregular heart beat that requires medical management? (e.g., atrial fibrillation, premature ventricular contraction) YES <input type="checkbox"/> NO <input type="checkbox"/>
3c.	Do you have chronic heart failure? YES <input type="checkbox"/> NO <input type="checkbox"/>
3d.	Do you have diagnosed coronary artery (cardiovascular) disease and have not participated in regular physical activity in the last 2 months? YES <input type="checkbox"/> NO <input type="checkbox"/>
<hr/>	
4. Do you have High Blood Pressure?	
If the above condition(s) is/are present, answer questions 4a-4b If NO <input type="checkbox"/> go to question 5	
4a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer NO if you are not currently taking medications or other treatments) YES <input type="checkbox"/> NO <input type="checkbox"/>
4b.	Do you have a resting blood pressure equal to or greater than 160/90 mmHg with or without medication? (Answer YES if you do not know your resting blood pressure) YES <input type="checkbox"/> NO <input type="checkbox"/>
<hr/>	
5. Do you have any Metabolic Conditions? This includes Type 1 Diabetes, Type 2 Diabetes, Pre-Diabetes	
If the above condition(s) is/are present, answer questions 5a-5e If NO <input type="checkbox"/> go to question 6	
5a.	Do you often have difficulty controlling your blood sugar levels with foods, medications, or other physician-prescribed therapies? YES <input type="checkbox"/> NO <input type="checkbox"/>
5b.	Do you often suffer from signs and symptoms of low blood sugar (hypoglycemia) following exercise and/or during activities of daily living? Signs of hypoglycemia may include shakiness, nervousness, unusual irritability, abnormal sweating, dizziness or light-headedness, mental confusion, difficulty speaking, weakness, or sleepiness. YES <input type="checkbox"/> NO <input type="checkbox"/>
5c.	Do you have any signs or symptoms of diabetes complications such as heart or vascular disease and/or complications affecting your eyes, kidneys, OR the sensation in your toes and feet? YES <input type="checkbox"/> NO <input type="checkbox"/>
5d.	Do you have other metabolic conditions (such as current pregnancy-related diabetes, chronic kidney disease, or liver problems)? YES <input type="checkbox"/> NO <input type="checkbox"/>
5e.	Are you planning to engage in what for you is unusually high (or vigorous) intensity exercise in the near future? YES <input type="checkbox"/> NO <input type="checkbox"/>

2018 PAR-Q+

6. Do you have any Mental Health Problems or Learning Difficulties? *This includes Alzheimer's, Dementia, Depression, Anxiety Disorder, Eating Disorder, Psychotic Disorder, Intellectual Disability, Down Syndrome*
If the above condition(s) is/are present, answer questions 6a-6b If **NO** ☐ go to question 7

6a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) YES ☐ NO ☐

6b. Do you have Down Syndrome **AND** back problems affecting nerves or muscles? YES ☐ NO ☐

7. Do you have a Respiratory Disease? *This includes Chronic Obstructive Pulmonary Disease, Asthma, Pulmonary High Blood Pressure*
If the above condition(s) is/are present, answer questions 7a-7d If **NO** ☐ go to question 8

7a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) YES ☐ NO ☐

7b. Has your doctor ever said your blood oxygen level is low at rest or during exercise and/or that you require supplemental oxygen therapy? YES ☐ NO ☐

7c. If asthmatic, do you currently have symptoms of chest tightness, wheezing, laboured breathing, consistent cough (more than 2 days/week), or have you used your rescue medication more than twice in the last week? YES ☐ NO ☐

7d. Has your doctor ever said you have high blood pressure in the blood vessels of your lungs? YES ☐ NO ☐

8. Do you have a Spinal Cord Injury? *This includes Tetraplegia and Paraplegia*
If the above condition(s) is/are present, answer questions 8a-8c If **NO** ☐ go to question 9

8a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) YES ☐ NO ☐

8b. Do you commonly exhibit low resting blood pressure significant enough to cause dizziness, light-headedness, and/or fainting? YES ☐ NO ☐

8c. Has your physician indicated that you exhibit sudden bouts of high blood pressure (known as Autonomic Dysreflexia)? YES ☐ NO ☐

9. Have you had a Stroke? *This includes Transient Ischemic Attack (TIA) or Cerebrovascular Event*
If the above condition(s) is/are present, answer questions 9a-9c If **NO** ☐ go to question 10

9a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments) YES ☐ NO ☐

9b. Do you have any impairment in walking or mobility? YES ☐ NO ☐

9c. Have you experienced a stroke or impairment in nerves or muscles in the past 6 months? YES ☐ NO ☐

10. Do you have any other medical condition not listed above or do you have two or more medical conditions?
If you have other medical conditions, answer questions 10a-10c If **NO** ☐ read the Page 4 recommendations

10a. Have you experienced a blackout, fainted, or lost consciousness as a result of a head injury within the last 12 months **OR** have you had a diagnosed concussion within the last 12 months? YES ☐ NO ☐

10b. Do you have a medical condition that is not listed (such as epilepsy, neurological conditions, kidney problems)? YES ☐ NO ☐

10c. Do you currently live with two or more medical conditions? YES ☐ NO ☐

PLEASE LIST YOUR MEDICAL CONDITION(S) AND ANY RELATED MEDICATIONS HERE: _____

GO to Page 4 for recommendations about your current medical condition(s) and sign the PARTICIPANT DECLARATION.

2018 PAR-Q+



If you answered NO to all of the FOLLOW-UP questions (pgs. 2-3) about your medical condition, you are ready to become more physically active - sign the PARTICIPANT DECLARATION below:

- ▶ It is advised that you consult a qualified exercise professional to help you develop a safe and effective physical activity plan to meet your health needs.
- ▶ You are encouraged to start slowly and build up gradually - 20 to 60 minutes of low to moderate intensity exercise, 3-5 days per week including aerobic and muscle strengthening exercises.
- ▶ As you progress, you should aim to accumulate 150 minutes or more of moderate intensity physical activity per week.
- ▶ If you are over the age of 45 yr and **NOT** accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.



If you answered YES to one or more of the follow-up questions about your medical condition:

You should seek further information before becoming more physically active or engaging in a fitness appraisal. You should complete the specially designed online screening and exercise recommendations program - the **ePARmed-X+** at www.eparmedx.com and/or visit a qualified exercise professional to work through the ePARmed-X+ and for further information.



Delay becoming more active if:

- ✓ You have a temporary illness such as a cold or fever; it is best to wait until you feel better.
- ✓ You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at www.eparmedx.com before becoming more physically active.
- ✓ Your health changes - talk to your doctor or qualified exercise professional before continuing with any physical activity program.

- You are encouraged to photocopy the PAR-Q+. You must use the entire questionnaire and NO changes are permitted.
- The authors, the PAR-Q+ Collaboration, partner organizations, and their agents assume no liability for persons who undertake physical activity and/or make use of the PAR-Q+ or ePARmed-X+. If in doubt after completing the questionnaire, consult your doctor prior to physical activity.

PARTICIPANT DECLARATION

- All persons who have completed the PAR-Q+ please read and sign the declaration below.
- If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that the community/fitness center may retain a copy of this form for records. In these instances, it will maintain the confidentiality of the same, complying with applicable law.

NAME _____ DATE _____

SIGNATURE _____ WITNESS _____

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER _____

For more information, please contact

**www.eparmedx.com
Email: eparmedx@gmail.com**

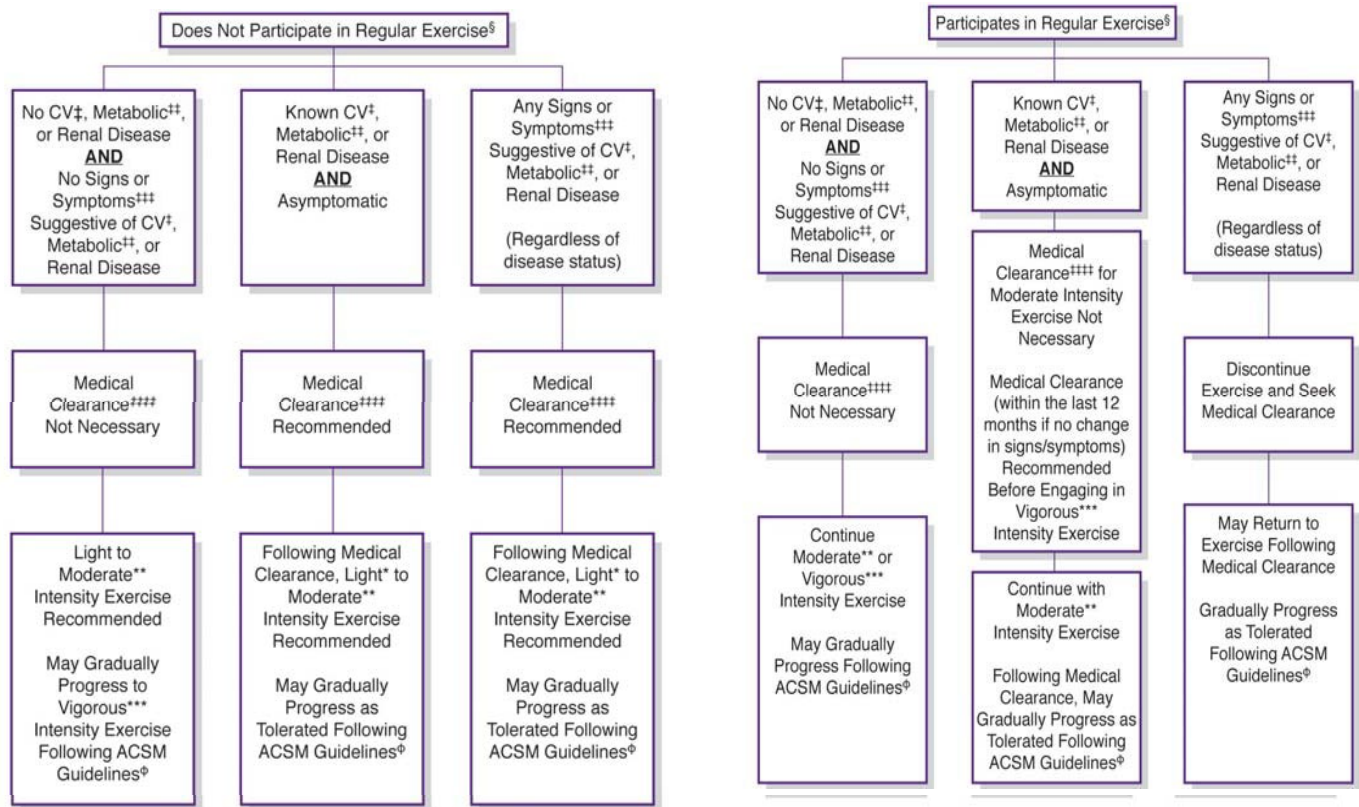
Citation for PAR-Q+
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Key References

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The PAR-Q+ was created using the evidence-based AGREE process (1) by the PAR-Q+ Collaboration chaired by Dr. Darren E. R. Warburton with Dr. Norman Gledhill, Dr. Veronica Jamnik, and Dr. Donald C. McKenzie (2). Production of this document has been made possible through financial contributions from the Public Health Agency of Canada and the BC Ministry of Health Services. The views expressed herein do not necessarily represent the views of the Public Health Agency of Canada or the BC Ministry of Health Services.

Appendix B: ACSM Pre-Participation Health Screening Form



[§]Exercise Participation

Performing planned, structured physical activity at least 30 min at moderate intensity on at least 3 d · wk⁻¹ for at least the last 3 mo

*Light Intensity Exercise

30%–39% HRR or $\dot{V}O_2R$, 2–2.9 METs, RPE 9–11, an intensity that causes slight increases in HR and breathing

**Moderate Intensity Exercise

40%–59% HRR or $\dot{V}O_2R$, 3–5.9 METs, RPE 12–13, an intensity that causes noticeable increases in HR and breathing

***Vigorous Intensity Exercise

≥60% HRR or $\dot{V}O_2R$, ≥6 METs, RPE ≥14, an intensity that causes substantial increases in HR and breathing

[‡]Cardiovascular (CV) Disease

Cardiac, peripheral vascular, or cerebrovascular disease

^{††}Metabolic Disease

Type 1 and 2 diabetes mellitus

^{†††}Signs and Symptoms

At rest or during activity. Includes pain, discomfort in the chest, neck, jaw, arms, or other areas that may result from ischemia; shortness of breath at rest or with mild exertion; dizziness or syncope; orthopnea or paroxysmal nocturnal dyspnea; ankle edema; palpitations or tachycardia; intermittent claudication; known heart murmur; unusual fatigue or shortness of breath with usual activities.

^{††††}Medical Clearance

Approval from a health care professional to engage in exercise

[¶]ACSM Guidelines

See ACSM's *Guidelines for Exercise Testing and Prescription*, 10th edition, 2018

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[§]Exercise Participation

Performing planned, structured physical activity at least 30 min at moderate intensity on at least 3 d · wk⁻¹ for at least the last 3 mo

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At rest or during activity. Includes pain, discomfort in the chest, neck, jaw, arms, or other areas that may result from ischemia; shortness of breath at rest or with mild exertion; dizziness or syncope; orthopnea or paroxysmal nocturnal dyspnea; ankle edema; palpitations or tachycardia; intermittent claudication; known heart murmur; unusual fatigue or shortness of breath with usual activities.

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Approval from a health care professional to engage in exercise

[¶]ACSM Guidelines

See ACSM's *Guidelines for Exercise Testing and Prescription*, 10th edition, 2018

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Appendix C: Data Collection Form

Participant I.D. : _____

Date: _____

Height: _____ cm Weight: _____ kg

Treatment (A or B): _____

Absorptive-Period Initiation Time: _____

Static Jump		
<u>Trial #</u>	<u>Vertical Jump Height (Inches)</u>	
	<u>Pre-Intervention</u>	<u>Post-Intervention</u>
1		
2		
3		

Countermovement Jump		
<u>Trial #</u>	<u>Vertical Jump Height (Inches)</u>	
	<u>Pre-Intervention</u>	<u>Post-Intervention</u>
1		
2		
3		

Appendix D: Participant Master Sheet

[illegible]

Research Participants Needed!

Improve understanding of the effects of caffeine on heart rate variability and the performance of anaerobic activity, and investigate correlations between nervous system activity and force production

What You Can Learn By Participating

What Will Be Required Of You

1. Have electromyographic sensors, which measure muscle activation, placed on your thigh and calf and EKG electrodes placed on your chest
2. Perform vertical jumps on jump mat
3. Drink a liquid containing either a placebo treatment or caffeine
4. Wait 60 minutes for the absorption of the treatment contained within the liquid (you can do homework, study, read, etc. during this waiting period)
5. Perform vertical jumps on jump mat again

1. Electromyographic activity
 2. Peak power
 3. Jump height
4. Heart rate variability - frequency domain measures

Email Collin Garner to express interest in participating or request more information

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Date: March 15, 2019

To: Timothy Michael, Principal Investigator
Sangwoo Lee, Co-Principal Investigator
Collin Garner, Student Investigator for thesis

From: Amy Naugle, Ph.D., Chair

Re: IRB Project Number 18-12-01

This letter will serve as confirmation that the changes to your research project titled “Effect of Caffeine Supplementation on Vertical Jump Performance, Heart Rate Variability, and Electromyography” requested in your memo received March 13, 2019 (to revise the number of data collection sessions from 3 to 2; to change EMG module to Noraxon; to change electrode placement to chest; to add warm-up prior to post-intervention jump; to perform EKG and EMG recordings for 5 minute intervals prior to warm up and after 60 minute absorption period; to calculate peak power using body mass and vertical jump data; to remove 3mg/kg caffeine condition; to increase session time by 10 minutes; to revise variables due to equipment change; to revise recruitment and consent materials to reflect these changes) have been approved by the WMU Institutional Review Board.

The conditions and the duration of this approval are specified in the Policies of Western Michigan University.

Please note that you may **only** conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the IRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination:


January 9, 2020

Office of the Vice President for Research
Research Compliance Office
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WEBSITE: wmich.edu/research/compliance/hsirb



Date: January 17, 2019

To: Timothy Michael, Principal Investigator
Sangwoo Lee, Co-Principal Investigator
Collin Garner, Student Investigator for thesis

From: Amy Naugle, Ph.D., Chair 

Re: IRB Project Number 18-12-01

This letter will serve as confirmation that the change to your research project titled “Effect of Caffeine Supplementation on Vertical Jump Performance, Heart Rate Variability, and Electromyography” requested in your memo received January 15, 2019 (to change caffeine powder supplier to NutraBio Labs, Inc. and water flavoring to Original MiO Liquid Enhancer [from Kraft Foods, H.J. Heinz Company Brands LLC]) has been approved by the WMU Institutional Review Board.

The conditions and the duration of this approval are specified in the Policies of Western Michigan University.

Please note that you may **only** conduct this research exactly in the form it was approved. You must seek specific board approval for any changes in this project. You must also seek reapproval if the project extends beyond the termination date noted below. In addition if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the IRB for consultation.

The Board wishes you success in the pursuit of your research goals.

Approval Termination:

January 9, 2020



Date: January 10, 2019

To: Timothy Michael, Principal Investigator
Sangwoo Lee, Co-Principal Investigator
Collin Garner, Student Investigator for thesis

From: Amy Naugle, Ph.D., Chair

Re: IRB Project Number 18-12-01

This letter will serve as confirmation that your research project titled “Effect of Caffeine Supplementation on Vertical Jump Performance, Heart Rate Variability, and Electromyography” has been **approved** under the **expedited** category of review by the Western Michigan University Institutional Review Board (IRB). The conditions and duration of this approval are specified in the policies of Western Michigan University. You may now begin to implement the research as described in the application.

Please note: This research may **only** be conducted exactly in the form it was approved. You must seek specific board approval for any changes to this project (e.g., ***you must request a post-approval change to enroll subjects beyond the number stated in your application under “Number of subjects you want to complete the study”***). Failure to obtain approval for changes will result in a protocol deviation. In addition, if there are any unanticipated adverse reactions or unanticipated events associated with the conduct of this research, you should immediately suspend the project and contact the Chair of the IRB for consultation.

Reapproval of the project is required if it extends beyond the termination date stated below.

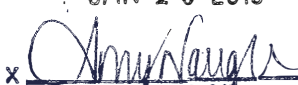
The Board wishes you success in the pursuit of your research goals.

Approval Termination:

January 9, 2020

Appendix I: Informed Consent Form

Western Michigan University
IRB
Approved for use for 1 year from this date:

JAN 10 2019
x 
WMU IRB Office

Western Michigan University Human Performance Health Education

Principal Investigator: Dr. Timothy Michael

Co-Principle Investigators: Dr. Nicholas Hanson & Dr. Sangwoo Lee

Student Investigator: Collin Garner & Kyle Derosia

Title of Study: Effect of caffeine supplementation on vertical jump performance, heart rate variability, and electromyography

You have been invited to participate in a research project titled **“Effect of caffeine supplementation on vertical jump performance, heart rate variability, and electromyography”**. This consent document will explain the purpose of this research project and will go over all of the time commitments, the procedures used in the study, and the risks and benefits of participating in this research project. Please read this consent form carefully and completely and please ask any questions if you need more clarification.

What are we trying to find out in this study?

We wish to find out more about how caffeine affects the frequency domain indices of heart rate variability and aspects of vertical jump (vertical jump height, peak power, and stretch-shortening cycle).

Who can participate in this study?

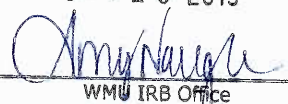
You must be 18 years or older. You may not have sustained a lower extremity musculoskeletal injury (i.e. sprained ankle etc.) or surgery within the last 6 months. You must be able to engage in maximal exertion vertical jump assessments. An American College of Sports Medicine (ACSM) health screening document will be filled out to determine the level of risk you are classified for cardiovascular disease (CVD). If you have too many risk factors, you will not be able to participate in this study. You will also complete a PAR-Q+ (the Physical Activity Readiness Questionnaire +); a questionnaire that was developed as a screening tool to be used to determine whether an individual is healthy enough to participate in physical activity.

Where will this study take place?

This study will take place in the Human Performance Research Lab located in the lower level of Western Michigan University's Student Recreational Center.

What is the time commitment for participating in this study?

We will ask you to come to the lab on two occasions. The time commitment for each visit will be approximately 1 hour and 30 minutes. For 60 of these minutes, you must remain in the lab, but you can do whatever you like that does not involve physical activity (reading, homework, tasks for work, etc.).

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What will you be asked to do if you choose to participate in this study?

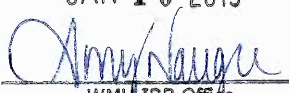
We will measure your height and weight. You will then have EMG modules placed over the vastus lateralis and gastrocnemius of your dominant leg and EKG electrodes placed on your chest prior to any data collection. Once all instruments are placed on the body, you will perform a 5-minute warm-up and then the pre-intervention jump assessments will be performed. The vertical jump techniques that will be performed are static vertical jump and countermovement vertical jump, in this order. The 3 static vertical jumps will be performed with 2 minutes separating each jump. After the third static jump, you will rest for 5 minutes and then perform the 3 countermovement jumps, each separated by 2 minutes of rest. You will then ingest the treatment-containing beverage – containing either a placebo treatment or $6 \text{ mg} \cdot \text{kg}^{-1}$ of caffeine – within 5 minutes, and then wait 60 minutes for absorption of the treatment. For a 150 pound, or 68 kilogram, individual, $6 \text{ mg} \cdot \text{kg}^{-1}$ of caffeine would be equal to approximately 4 cups of lightly caffeinated coffee. Once the 60 minutes of the absorption period have elapsed, you will perform a warm-up and then the post-intervention jump assessments using the same procedure as the pre-intervention jump assessments. Once all jump assessments are completed, you will perform a 5-minute cool-down and then be free to go once all equipment is removed from your body.

What information is being measured during the study?

We will be measuring your vertical jump height using a jump mat. We will then determine your vertical jump height, peak power, and stretch-shortening cycle utilization (a comparison between static and countermovement vertical jump performance). As you perform the assessments, heart rate variability and electromyography will be assessed via the EMG modules placed on your legs and EKG modules placed on your chest. We will perform assessments of variance in your vertical jump performance, heart rate variability, and electromyography between the pre-intervention and post-intervention jump assessments. We will also assess for correlations among the alterations of these variables.

What are the risks of participating in this study and how will these risks be minimized?

As in all research, there may be unforeseen risks to the subject. If an accidental injury occurs, appropriate emergency measures will be taken; however, no compensation or additional treatment will be made available to you except otherwise stated in this consent form. The risks in this study are considered minimal. These include musculoskeletal or joint injuries, general muscle soreness, and dehydration. We will provide the individuals with water if needed. A proper warm up and cool down will be implemented to reduce risk of musculoskeletal injury and muscle soreness. With caffeine consumption, there is the risk of nausea, anxiety, dehydration, accelerated heart rate, increased blood pressure, sleeplessness, shakiness, headache, and, in rare instances, cardiac arrest and stroke. The dosages of caffeine used within this study will not exceed $6 \text{ mg} \cdot \text{kg}^{-1}$, which is not an unusual dosage used in similar research.

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What are the benefits of participating in this study?

You will be informed of your peak power and vertical jump height. You will also gain insight into whether caffeine supplementation benefits your performance, and to what extent.

Are there any costs associated with participating in this study?

There are no costs associated with participating in this study besides any parking fees (should you not have a parking pass and park on campus) and the time required to participate.

Is there any compensation for participating in this study?

There will be no compensation associated with participating in this study.

Who will have access to the information collected during this study?


The student investigators (Collin Garner & Kyle Derosia), the principal investigator (Dr. Timothy Michael), the co-principle investigators (Dr. Nicholas Hanson & Dr. Sangwoo Lee) will be the only individuals to have access to the data collected during this study. The information will be coded with numbers and not the participants' name. All information collected during the study will be locked in a file cabinet in the primary investigator's office.

What if you want to stop participating in this study?

You can choose to stop participating in the study at any time for any reason. You will not suffer any prejudice or penalty by your decision to stop your participation. You will experience NO consequences either academically or personally if you choose to withdraw from this study.

The investigator can also decide to stop your participation in the study without your consent.

Should you have any questions prior to or during the study, you can contact the primary investigator, Dr. Timothy Michael at 269-387-2691 or tim.michael@wmich.edu. You may also contact the Chair, Human Subjects Institutional Review Board at 269-387-8293 or the Vice President for Research at 269-387-8298 if questions arise during the course of the study. This consent document has been approved for use for one year by the Human Subjects Institutional Review Board (HSIRB) as indicated by the stamped date and signature of the board chair in the upper right corner. Do not participate in this study if the stamped date is older than one year.

JAN 10 2019
x 
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I have read this informed consent document. The risks and benefits have been explained to me.
I agree to take part in this study.

Please Print Your Name

Participant's signature

Date