2011

Does Caffeine Consumption Effect Exercise Performance in Healthy Adults?

Meaghan E. Jones

Philadelphia College of Osteopathic Medicine, MeaghanJo@pcom.edu

Follow this and additional works at: http://digitalcommons.pcom.edu/pa_systematic_reviews

Part of the Exercise Science Commons, and the Organic Chemicals Commons

Recommended Citation

Does Caffeine Consumption Affect Exercise Performance in Healthy Adults?

Meaghan E. Jones, PA-S

A SELECTIVE EVIDENCE-BASED MEDICINE REVIEW

In Partial Fulfillment of the Requirements For

The Degree of Master of Science

In

Health Sciences – Physician Assistant

Department of Physician Assistant Studies
Philadelphia College of Osteopathic Medicine
Philadelphia, Pennsylvania

December 17, 2010
Abstract

OBJECTIVE: The objective of this systematic review is to determine whether or not caffeine ingestion prior to exercise effects exercise performance in healthy adults.


DATA SOURCES: Randomized, double blind, placebo-controlled trials comparing caffeine to placebo were found using Ovid MEDLINE and Cochrane databases.

OUTCOME MEASURED: Rate of Perceived Exertion of the exercises tested. Quantitative measurements of rate of perceived exertion (RPE) is determined using Borg’s RPE scale from 6-20 (6 being very, very light exertion to 20 maximum effort). The scoring of this was conducted after each individual test conducted in each study.

RESULTS: All three RCT’s included in this review found that caffeine ingested prior to exercise did not significantly affect rate of perceived exertion as compared to the placebo group. All three trials discussed limitations of small subject pool as well as prior rest & exercise.

CONCLUSIONS: The results of the RCT’s reviewed demonstrated that the ingestion of caffeine does not effect the exercise performance of healthy adults as compared to the placebo testing. Further research is needed with larger subject participation to determine if caffeine can be used as an ergogenic aid effecting exercise performance.

KEY WORDS: Caffeine, Ergogenic Aid, Exercise, Exercise Performance, Obesity, Weight loss
INTRODUCTION

Obesity has become a worldwide epidemic within the past 2 decades. The World Health Organization (WHO) has classified obesity in terms of a Body Mass Index (BMI) of greater than 30 and overweight greater than or equal to 25. Diet and exercise is the gold standard in the treatment of obesity but many patients complain that they don’t have the energy to take the time for adequate exercise. Caffeine has been hypothesized to enhance the outcomes of exercise by decreasing the rate of perceived exertion and increasing strength as well as endurance. This paper evaluated three randomized control studies comparing the ingestion of caffeine to a placebo prior to performing various exercise procedures.

Obesity is of great relevance to primary care practitioners. Greater than 60% of Americans are overweight or obese which can lead to a variety of other associated health conditions. The Center for Disease Control and Prevention (CDC) has estimated a cost exceeding 78.5 billion dollars spent can be attributed to both overweight and obese patients. Disorders that can be associated with obesity include diabetes and insulin resistance, hypertension, dyslipidemia, coronary artery disease (CAD), gallbladder disease, cancers, osteoarthritis, stroke, asthma, sleep apnea, pregnancy complications, menstrual irregularities, hirsutism, psychological distress, increased surgical risk and premature death. The pattern of weight distribution also plays a role in development of certain diseases such as CAD and diabetes.5

The physiology of caffeine is known but its effect on exercise performance has not been identified. Caffeine is an adenosine receptor antagonist. Adenosine can cause a transient heart block so with the blocking of the receptors it causes an elevation of cyclic Amp (CAmp). This then causes the heart to beat faster, increase blood pressure and systemic vascular resistance.
Caffeine also increases sympathetic stimulation and the amount of circulating epinephrine, which can increase heart rate and respiratory rate and the force of muscle contraction which all can alter the physiological response to exercise.²

It is recommended that patients exercise at least 60 minutes daily. This exercise is anything that raises a patient's heart rate to their target heart rate (target=220-age).⁴ A person's diet should be decreased in calories and high in whole grains, vegetables and fruits with an effort to avoid fats and starches. When diet and exercise fail medication is the second line in the treatment of obesity. Sibutermine (merida) a nonamphetamine appetite suppressant, Orlistat (Xenical) blocking fat digestion and Phentermine (Adipex-P) an appetite suppressant are all used to aid in weight loss along with continuing diet and exercise.⁴ If medications fail surgical treatments of gastric bypass and banding can be considered.

Many ergogenic aids (any substance which enhances the effects of exercise) have been studied to enhance the effects of exercise in both weight loss programs as well as with elite athletes. Caffeine has been proposed as being an ergogenic aid by influencing the central nervous system (CNS) and increasing a person’s energy level. Caffeine supplementation prior to a variety of aerobic and anaerobic exercises may provide a positive effect.

**OBJECTIVE**

The goal of this review is to determine whether or not caffeine consumption prior to exercise effects exercise performance. It is hypothesized that caffeine ingestion prior to exercise positively effects performance in the aspects of rate of perceived exertion as well as endurance and power.
METHODS

RTC’s were located whose population included adults age 18 and older with exercise experience. The different interventions used were: oral caffeine supplementation and oral placebo supplementation. Ovid Medline and Cochrane Databases were used to gather information. Criteria used for the selection of these studies were: 1) literature published between 2005 – present. 2) Studies chosen all dealt with POEMS. 3) Studies being used for statistical analysis were RCT’s. 4) Studies being analyzed had not been previously used in an SR or MA. Studies not adhering to these criteria were not used. Exclusion criteria included: 1) regular caffeine users and 2) participants unable to perform the specified exercise testing. Choosing English as the language and using keywords: “caffeine,” “exercise,” “exercise performance” and “rate of perceived exertion” in combination with each other, the search was narrowed and studies were eliminated that did not include the POEMS of interest. From these databases 3 studies were found and were used to derive data with statistical analysis to answer the hypothesis. The studies were: 1) Randomized, double blind study comparing placebo, 3mg/kg or 6mg/kg capsules of caffeine. 2) Randomized, double blind, study comparing placebo and 5mg/kg caffeine effect on anaerobic exercise. 3) Randomized, double blind, crossover study comparing placebo and 5mg/kg caffeine effect on anaerobic exercise.

Major characteristics of the trials used in the study are displayed in Table 1. All three studies had similar inclusion criteria of non-caffeine users and the ability to perform the exercise used in each study. The big difference of the studies is the Ahrens 2007 study included only women and the exercise studied was aerobic in nature whereas the Woolf 2008 and Woolf 2009 included only men and the exercise studied was anaerobic in nature. All three studies used the
<table>
<thead>
<tr>
<th>Study</th>
<th>Type</th>
<th># pts</th>
<th>Age (yrs)</th>
<th>Inclusion criteria</th>
<th>Exclusion criteria</th>
<th>W/D</th>
<th>Interventions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ahrens, USA, 2007</td>
<td>RCT</td>
<td>20</td>
<td>19-28 yrs</td>
<td>Ability to follow aerobic step dance class, minimal 1 mo regular attendance, consumed less than 80 mg of caffeine daily</td>
<td>Regular caffeine user, inability to perform aerobic step moves</td>
<td>0</td>
<td>3 or 6 mg of caffeine or a placebo pill given to subjects 60 minutes prior to exercise on 3 separate visits</td>
</tr>
<tr>
<td>Woolf, USA, 2008</td>
<td>Randomized Crossover Study</td>
<td>19</td>
<td>18-40 yrs</td>
<td>Male, participated in &gt;12 hours programmed physical activity &amp; currently participating in a comprehensive training program for 2-4 hours daily</td>
<td>Regular caffeine user, failure to fast 8-12 hours prior to testing, inability to perform tasks</td>
<td>1</td>
<td>Shake with caffeine 5mg/kg or placebo 60 minutes prior to exercise testing</td>
</tr>
<tr>
<td>Woolf, USA, 2009</td>
<td>RCT</td>
<td>18</td>
<td>18-22 yrs</td>
<td>Played collegiate football in the past season, participated in identical training program for 12 weeks</td>
<td>Regular caffeine user, failure to fast 8-12 hour prior to testing</td>
<td>1</td>
<td>Dose of 5mg/kg caffeine or placebo prior to exercise testing</td>
</tr>
</tbody>
</table>
patient oriented measurement of rate of perceived exertion using the Borg’s scale as well as other non patient oriented outcomes such as blood pressure, strength, endurance and ventilation.

**OUTCOMES MEASURED**

Outcomes measured had to be POEMS such as rate of perceived exertion of the exercises performed. Rate of perceived exertion (RPE) was scaled using the Borg’s scale of perceived exertion from 6-20. To help measure these outcomes, tools used were: 1) Wilcoxon’s signed rank test on RPE. 2) Paired T-Test on RPE. 3) Repeated-measures ANOVA on RPE.

**RESULTS**

Table 2 shows the averages of RPE between placebo and two different doses of caffeine seen in the Ahrens 2007 study. Patients were taught an aerobic dance bench stepping (ABDS) routine prior to the initiation of the study. Those who could not perform the steps correctly were excluded from the study. On three occasions subjects were to abstain from caffeine for 12 hours and were given placebo, 3 or 6 mg/kg of caffeine in capsule form 60 minutes prior to testing. During testing patients heart rate and breathing was monitored. At the end of 6, 7, and 8 minutes they were instructed to provide a RPE based on the Borg’s scale of 6-20. These were then averaged. A repeated measured ANOVA was performed on the subjects RPE as well as other measurements. The ANOVA showed no statistically significant differences (p>0.05) of RPE among any of the placebo or caffeine trials.

**Table 2** – Borg’s Rate of Perceived Exertion (RPE) (mean ± SD) during Aerobic Dance Bench Stepping 1 hour after ingestion of placebo or caffeine (n = 20)

<table>
<thead>
<tr>
<th></th>
<th>Placebo</th>
<th>3 mg/kg caffeine</th>
<th>6 mg/kg caffeine</th>
</tr>
</thead>
<tbody>
<tr>
<td>RPE</td>
<td>10.3 ± 2.3</td>
<td>10.2 ± 2.7</td>
<td>9.9 ± 2.4</td>
</tr>
</tbody>
</table>

* Data analyzed using repeated measures ANOVA
Woolf 2009 used caffeine naïve collegiate football players and tested their anaerobic exercise ability by performing the 40-yard dash, 20-yard shuttle and the bench press. Prior to testing subjects fasted for 8-12 hours and abstained from any caffeinated products for 48 hours. Prior to testing HR and BP were monitored. A beverage containing either placebo or 5mg/kg caffeine was consumed and a meal was provided 15 minutes later. The exercise testing was commenced 60 minutes later. Times for the running tests and number of reps were recorded. The BP and HR were also recorded in between each exercise. The RPE was recorded for each exercise and was based on the Borg’s scale of 6-20. The RPE was analyzed by using a paired t-test and a Wilcoxon’s signed rank test was used for the analysis of RPE. (Table 3) No statistically significant difference was observed for RPE between treatments. Table 4 shows the exercise times as well as the reps performed in the bench press. The data was analyzed using paired t-tests. There was no statistical significance between the treatments studied.

Table 3 – Borg’s RPE after exercise tests during caffeine and placebo treatments for study participants (n=17)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Caffeine</th>
<th>Placebo</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-yard dash</td>
<td>13±3</td>
<td>13±2</td>
<td>1.00</td>
</tr>
<tr>
<td>20-yard shuttle</td>
<td>12±3</td>
<td>12±3</td>
<td>0.25</td>
</tr>
<tr>
<td>Bench press</td>
<td>16±2</td>
<td>15±3</td>
<td>0.31</td>
</tr>
</tbody>
</table>

*Data analyzed using paired t-tests; values are mean ± SD

Table 4 – exercise performance during caffeine and placebo treatments for study participants (n=17)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Caffeine</th>
<th>Placebo</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>40-yard dash (seconds)</td>
<td>5.01 ±0.25</td>
<td>5.03 ± 0.26</td>
<td>0.43</td>
</tr>
<tr>
<td>20-yard shuttle (seconds)</td>
<td>4.64 ±0.19</td>
<td>4.66 ±0.24</td>
<td>0.51</td>
</tr>
<tr>
<td>Bench press (repetitions)</td>
<td>17±8</td>
<td>17±8</td>
<td>0.51</td>
</tr>
</tbody>
</table>

*Data analyzed using paired t-tests; values are mean ± SD

**Data transformed using Log10 before statistical analysis; mean ± SD are presented untransformed
In Table 5 the RPE expressed by the participants in Woolf 2008 is shown. The participants were athletes who already performed in more than 12 hours of athletic activity weekly and given either placebo or 5mg/kg of caffeine 60 minute prior to testing on 2 different occasions. They were tested by means of a bench press, leg press as well as a Wingate test (multiple direction sprint test). Measurements of blood hormone and metabolite, blood pressure, performance of the test as well as RPE using Borg’s RPE scale from 6-20 were taken after each exercise. Wilcoxon’s signed rank test was used to evaluate the RPE of each test. There was no significance observed between the treatments. Table 6 evaluates the subject’s performance of the test conducted. Both the chest press and the Wingate tests showed a statistically significant improvement in performance. The leg press did not show any statistically significant improvement.

Table 5 -Borg’s Rate of Perceived Exertion (RPE) (mean ± SD) during exercise tests 1 hour after ingestion of placebo or caffeine (n = 18)

<table>
<thead>
<tr>
<th></th>
<th>Placebo</th>
<th>Caffeine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest Press</td>
<td>20 ± 1</td>
<td>19 ± 1</td>
</tr>
<tr>
<td>Leg Press</td>
<td>19 ± 1</td>
<td>19 ± 1</td>
</tr>
<tr>
<td>Wingate Test</td>
<td>19 ± 1</td>
<td>19 ± 2</td>
</tr>
</tbody>
</table>

Table 6 – Exercise performance of study participants (n = 18) M ± SD

<table>
<thead>
<tr>
<th></th>
<th>Placebo</th>
<th>Caffeine</th>
<th>p- Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest press total weigh lifted (lb x reps)</td>
<td>4,442 ± 1,164</td>
<td>5,254 ± 1,202</td>
<td>0.027*</td>
</tr>
<tr>
<td>Leg press total weigh lifted (lb x reps)</td>
<td>13.884 ± 5.193</td>
<td>15.146 ± 5.590</td>
<td>0.091</td>
</tr>
<tr>
<td>Wingate average power (W/kg body weight)</td>
<td>8.43 ± 0.83</td>
<td>8.88 ± 0.77</td>
<td>0.024*</td>
</tr>
</tbody>
</table>

-Data analyzed using paired t-test
- Data transformed using inverse square root before analysis mean ± SD presented untransformed
*Significantly different between treatments p<0.05

The data used in all 3 studies were continuous data. This type of continuous data was unable to be converted into dichotomous data because portions of the data needed for conversion
were not included within the articles published. Due to the fact that the data was unable to be converted, NNT’s and NNH’s could not be determined.

DISCUSSION

Ahrens 2007 showed that caffeine in any dose compared to a placebo had no effect of the exercise performance in aerobic dance bench stepping exercise. Although the caffeine increased the heart rate of the subjects as well as their blood pressure as compared to the placebo, the subjects did not feel as though they were exerting themselves less or performing the tasks easier. Both Woolf 2008 and Woolf 2009 did not prove a positive effect on the perceived exertion in the subjects of the study with the addition of caffeine. However, the actual performance of the specific exercises was significant for improvement in the caffeine trials compared to the placebo trials in Woolf 2008. Woolf 2009 did not show a statistically significant improvement in the exercises performed however the subjects who ingested the caffeine showed a 59% decrease in time in the running tests and a 47% increase in repetitions during the bench press. The results of the study show that the patient oriented affect of caffeine on exercise does not exist but some non-patient oriented aspects such as strength and endurance are positively affected by the ingestion of caffeine prior to the testing.

Limitations to these studies were the number of subjects used in each study. Only 20 or fewer subjects were used in each study, which makes it difficult to determine if the outcomes would be the same in larger populations. Another limitation is the type of subject used. Since all subjects were athletic in nature one cannot make an assumption that the outcome would be similar in non-athletes or those who have a sedentary lifestyle. Another extreme limitation is the extraneous factors that could not be controlled. Although all of the subjects abstained from
caffeine products for a time period prior to the testing, factors such as rest, prior exercise, and over the counter medications could have affected the results.

CONCLUSION

The studies showed that caffeine ingestion prior to exercise does not positively affect exercise performance or rate of perceived exertion but could possibly affect performance positively in the aspect of power and endurance. Due to this information caffeine should not be used as an ergogenic aid for those trying to enhance their exercise performance. Further research studying caffeine and its effects on specific body systems could help researchers gain further knowledge of any possible effects on exercise. When the exact effects caffeine has on the body during exertion are determined then caffeine can safely be used to increase exercise endurance. Also further research should be done on a population of sedentary patient to determine if the effects are similar. Health care professionals must continue to stress the importance of exercise and promoting a healthy life style to fight the ongoing epidemic of obesity in America.
REFERENCES


