The Effects of Low Dose Buccal Administered Caffeine on RPE and Pain during an Upper Body Muscle Endurance Test and Lower Body Anaerobic Test

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Abstract

To date there have been a number of studies that have assessed the effects of caffeine on Rated Perceived Exertion (RPE) and Pain Scale scores during continuous exercise. Presently there is little information about the effects of caffeine on RPE and Pain Scale scores during short term, anaerobic and muscle endurance activity. The purpose of the present investigation was to assess the effects of low-dose caffeine administration on RPE and Pain Scale scores after the one-minute pushup test and the Wingate Anaerobic cycling test. Ten college-aged males were recruited to participate in the investigation. The subjects were given either a piece of caffeinated chewing gum designed to deliver 100 mg of Caffeine in a buccal manner, or a placebo gum with identical shape and flavoring in a double-blind, placebo controlled, repeated measures design. The subjects chewed the gum (caffeine or placebo) for five minutes to allow for caffeine absorption and subsequently performed the one-minute push-up test followed by the Wingate anaerobic test. Subjects responded to the standard Borg RPE scale and the Mosby 10-pt pain scale immediately after each test. The results of the study did not demonstrate any significant difference in performance on either assessment, nor in the responses to the pain scale or RPE scale ($p>0.05$). It appears based upon this data that low-dose buccal caffeine is neither an effective ergogenic aid nor analgesic for muscle endurance or anaerobic efforts.

Keywords: physical exercise, supplementation, ergogenic

Caffeine, the most widely used drug in Western society, is an easily accessible central nervous system stimulant that has minimal negative side effects and high social acceptability (Bellar & Judge, 2011). These factors, combined with the elimination of caffeine from the World Anti-Doping Agency's prohibited substance list on January 1, 2004, have made caffeine quite popular amongst athletes competing in a range of sports (Desbrow & Leveritt, 2007). As a result, numerous investigations have examined caffeine's effect on athletic performance (Doherty & Smith, 2005; Graham, Hibbert, & Sathasivam, 1998; Van Soeren & Graham, 1998). The effects of caffeine have been reported to delay time to exhaustion at 70-85% of VO2 max (Graham, et al.,1998; Van Soeren & Graham, 1998), lower scores of perceived exertion at submaximal aerobic exercise intensities (Doherty & Smith, 2005) and decrease time to complete set distances (Bridge & Jones, 2006). Although there is some debate as to the exact mechanisms responsible for the above cited ergogenic effects of caffeine on athletic performance, the most commonly established is adenosine receptor antagonism, which has been proposed to result in a range of effects both central and peripheral, such as augmented neurotransmission and diminished perceptions of fatigue and pain (Sinclair & Geiger, 2000). Caffeine has been hypothesized to have peripheral analgesic effects post exercise through the antagonism of adenosine receptors (Bellar, Kamimori & Glickman, 2011).

In addition to inherent analgesic properties, caffeine has long been used in conjunction with other analgesics as an adjuvant (Renner et al., 2007; Sawynok, 2011). It has been shown to be an effective adjuvant analgesic with non-steroidal anti-inflammatory drugs (NSAID) but to also have some intrinsic analgesic properties (Sawynok, 2011). Caffeine has also been shown to have ergogenic effects for both endurance sports (Desbrow et al., 2011) and more intermittent and sprint based sports (Davis & Green 2009; Doherty, Smith, Hughes, & Davidson, 2004; Lee, Cheng, Lin, & Huang 2011).

There have been a number of hypotheses offered to explain the possible mechanism behind the reported ergogenic effects of caffeine including increased calcium release from the sacroplasmic reticulum, phosphodiesterase inhibition and increased mobilization of free fatty acids (Davis & Green, 2009; Magkos &Kavouros, 2005). However, the analgesic properties of caffeine frequently have been offered as a possible mechanism for the increases in performance that have been reported with caffeine ingestion (Bellar & Judge, 2011; Doherty et al., 2004).

It has been reported that caffeine may attenuate the effect of perceived delayed onset muscle soreness following eccentric exercise (Maridakis, O'Connor, Dudley, McCully, 2007) suggesting that it is able to target skeletal muscle for analgesia. Caffeine has been shown to attenuate reported pain during cycling (Gilottoni, Meyers, Arngrimsson, Brogilio, & Motl, 2009) and during hand grip to exhaustion tasks (Bellar, et al., 2011).

Doses of caffeine often vary from investigation to investigation. Recent work by Bellar, et al. (2011) demonstrated an analgesic effect in a hand grip to exhaustion task with only a 100mg buccal dose of caffeine administered per participant. This represents a very low dose of caffeine, equivalent to the dose in an average cup of coffee. Few studies to date have examined the effects of caffeine in dosages this low; however, this is an area that warrants investigation as side effects are noted with high doses of caffeine (Bellar & Judge, 2011) and buccal administration does not require long wait-times for absorption into the blood stream.

Interestingly, this effect has been shown to be influenced by the environment as caffeine does not appear to be an effective analgesic under cool conditions (Ganio, et al., 2011), nor are analgesic effects shown with caffeine when ischemia is mechanically induced and moderate aerobic exercise undertaken (Dellerman, Segerdahl, Grass, 2009). Recent work has also demonstrated that caffeine was not an effective analgesic during sets of all out knee extension exercise (Astorino, Terzi, Roberson, & Burnett, 2011). However, in a related study that examined the analgesic properties of caffeine and resistance exercise, a performance increase was noted in the absence of hypoalgesia, suggesting that caffeine may have ergogenic effects beyond those attributable to analgesia. (Hudson, Green, Bishop & Richardson, 2008).

Further studies that assess the effect of caffeine on exercise performance are important as caffeine ingestion may benefit this population by lowering the perception of effort and pain during exercise, possibly resulting in an increased amount of work being performed and more energy being expended during a training session. Of relevance, a reduction in the pain and effort associated with exercise could lead to increased motivation in establishing a regular pattern of more intense training. Given the lack of evidence of the effect of caffeine on muscle fatigue and perception - further investigations are warranted. For the present investigation two performance tests were selected: the Wingate anaerobic test (WaNT) and the one-minute push up test. The research questions were: first to investigate if caffeine had any effect on the performance, and second to examine the effect of caffeine ingestion on changes in perception of pain and rating of perceived exertion immediately following each effort.

Methods

Participants

The present investigation was approved by the institutional review board at Kent State University and all participants gave written informed consent. The participants were a convenience sample of 10 male, apparently healthy college students (Height: 175±5.9cm, Weight: 83.6±9.4kh, BMI: 27.3±3.8). The participants were very active individuals with weight training experience who had recent experience in previous coursework with both the Wingate anaerobic test and the one-minute push-up assessment.

Materials

One-minute push-up test. Participants were required to start in the up position with arms extended approximately shoulder width apart. At the start of the test, participants were required to lower their chest to touch the ground in a controlled fashion while maintaining a flat backed posture, and then return to the starting position. Each successful repetition was counted during the one-minute time-frame. Participants were allowed to rest in the up position if necessary.

Wingate Testing. A Monark Peak Bike (Ergomedic 894E Peak Bike, Monark Sports and Medical, Sweden) with computerized data acquisition was utilized for all WAnT testing. Prior to the initiation of testing, the seat and handlebars were adjusted to the frame of the participant. The subject was allowed to pedal against zero resistance to become accustomed to the bike and to warm up for two minutes prior to the start of the testing. The resistance on the ergometer was adjusted to allow for seven percent of the subjects kilogram weight to be added to the flywheel at the start of the 30-second assessment. The subject was instructed prior to the start of the test not to 'pace' the effort. Following the acceleration of the flywheel to maximum cadence (RPM) the weight basket loaded with the appropriate resistance was released and the subject worked maximally against the load for 30 seconds.

Muscle pain and exertion ratings. Muscle pain was measured using the 0-10 Numeric Pain Rating Scale (©Mosby Inc., Philadelphia, PA.). This scale was originally developed by McCaffery & Pasero (1999). The pain scale has 10 total ratings with verbal descriptors for the following: 0=no pain, 5= moderate pain, 10 = worst possible pain. Muscle ratings of perceived exertion were assessed via the standard Borg RPE scale (Borg, 1998). This numeric scale has 15 total ratings beginning with 6 and ending with 20. Verbal descriptors accompany the following ratings: 6=no exertion at all, 7 = extremely light, 9= very light, 11 = light, 13 = somewhat hard, 15 = hard (heavy), 17 = very hard, 19 = extremely hard, 20 = maximal exertion. Both the Pain Rating Scale and the RPE scale were used to assess pain and exertion immediately after the WaNT and one-minute push-up assessments.

Caffeine. *Stay Alert*™ caffeine gum (Amurol Confectioners, Yorkville, IL.) was chosen as the method of caffeine administration for the present investigation based upon the rapid nature of the delivery mechanism. The gum delivers a dose (100mg) of caffeine after only five minutes of chewing (Kammimori, et al., 2002). The rate of delivery of the gum is due to the caffeine being absorbed via the buccal cavity, which is highly vascularized. The placebo was manufactured by the same company as the caffeinated gum for the specific purpose of serving as a placebo for the purposes of experimentation.

Procedures

The experimental design was double blind within subjects with placebo. All participants completed one day of preliminary testing and one day of experimental testing. Participants were asked to abstain from exercise and ingesting caffeine for 12 hours prior to participating in the study. This period of abstinence was required to allow for clearance of caffeine. Participants were not classified by caffeine use as recent work suggests that the analgesic effects of caffeine are similar for high and low users. (Gilottoni, Meyers, Arngrimsson, Broglio & Motl, 2009).

Preliminary Testing. During the first visit basic anthropometric data were collected including height (cm) and weight (kg) via a beam balance/stadiometer (Health-O-Meter, Bedford Heights, OH.) Participants were also shown the 0-10 Numeric Pain Scale and the Borg RPE scale and became familiar with their use. Finally, participants were given instructions to abstain from caffeine ingestion 12 hours prior to their next visit. These instructions included a list of common beverages and foods that contain caffeine.

Experimental Testing. During the experimental visit participants reported during afternoon hours (12pm-6pm) and were given a piece of chewing gum (placebo or Stay-Alert™) to chew for five minutes. After the five-minute period participants were instructed to discard the gum. Participants then underwent the one-minute push-up test followed by the WaNT after a five-minute rest period. This order was chosen after pilot testing suggested that the WaNT test severely compromised the ability to perform the one-minute push-up test even after rest due to muscle fatigue in the legs affecting the ability to hold the body in a push-up position. Similarly pilot testing suggested that a five-minute recovery from the push-up test was adequate prior to starting the WaNT assessment. After completing the push-up test, participants were allowed ample recovery prior to completing the WaNT. Participants were asked to respond to the Borg RPE scale and the 10-pt analogue pain scale at the conclusion of both the WaNT and the one-minute push-up tests. A minimum of 72 hours passed between visits.

Data Analysis

Prior to analysis all dependant measures were examined for normality via Kolmogorov-Smirnov tests. Performances on the assessments as well as RPE and pain scale responses were analyzed via repeated measures MANOVA. A modern statistical software package was used for all analysis (SPSS version 17.0 for Macintosh) and statistical significance was set a priori at alpha<0.05.

Results

Analysis of normality did not result in any significant Kolmogorov-Smirnov tests ($p>0.05$) suggesting the data were normally distributed. Therefore analysis via repeated measures MANOVA was undertaken.

The performance on the assessments was not statistically different between the caffeine and placebo conditions for either the one minute push up test $F(1,9)=0.844$, $p=0.382$ or the mean power during the WaNT test $F(1,9)=0.133$, $p=0.724$ (Figure 1).

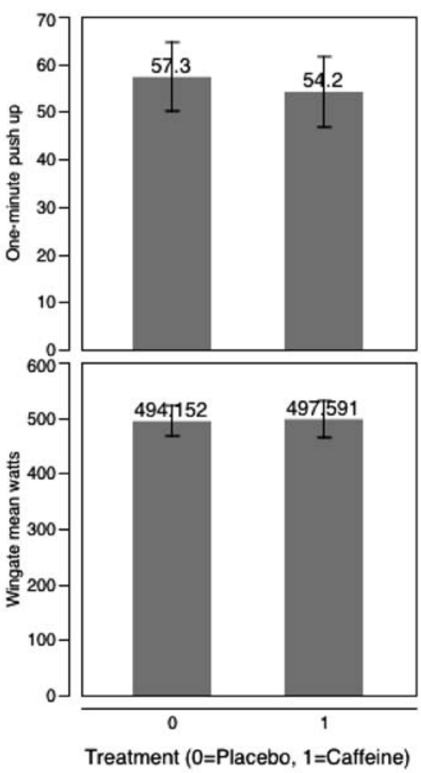

Figure 1: Mean Watts during the Wingate Anaerobic Test and Repetitions for the 1 Minute Push Up test by Treatment (Caffeine or Placebo). Bar inserts represent the mean for that condition.

The reported pain on the 10-pt analogue scale did not differ between treatments for either the one-minute push up assessment $F(1,9) \cong 0.000$, $p \cong 1.00$ or the WaNT assessment $F(1,9)=0.024$, $p=0.879$ (Figure 2).

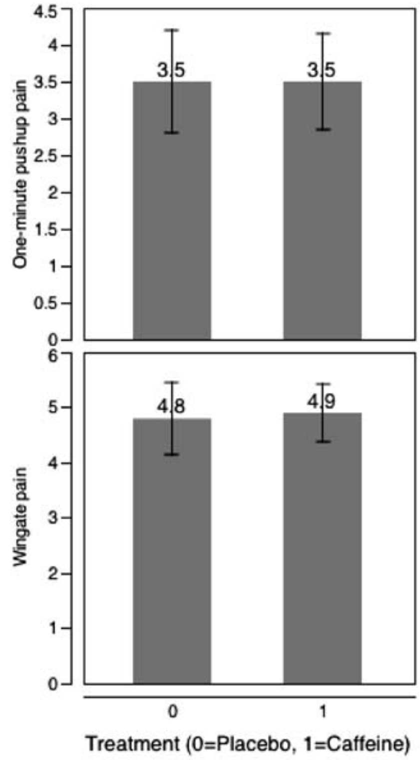

Figure 2: Mean response on the 10 pt analogue pain scale for the Wingate Anaerobic Test and the 1 Minute Push Up test by Treatment (Caffeine or Placebo). Bar inserts represent the mean for that condition.

The reported RPE on the Borg scale did not differ between treatments for either the one-minute push-up assessment $F(1,9)=0.224$, $p=0.647$ or the WaNT assessment $F(1,9)=0.070$, $p=0.798$ (Figure 3).

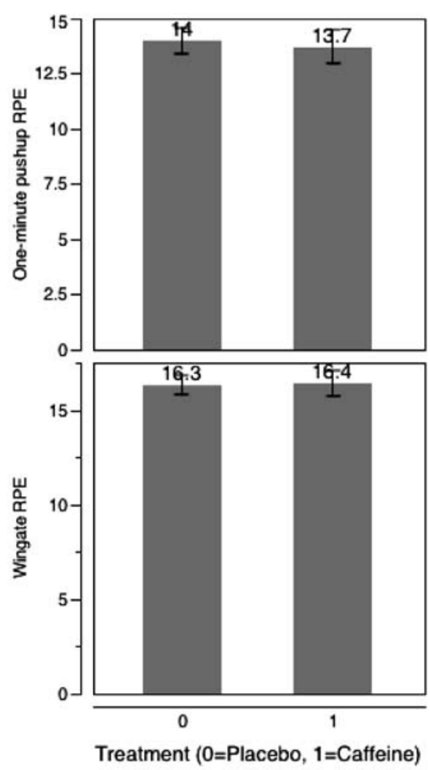

Figure 3: Mean response on Borg RPE 6-20 Scale for the Wingate Anaerobic Test and the 1 Minute Push Up test by Treatment (Caffeine or Placebo). Bar inserts represent the mean for that condition.

Discussion

The results of the present investigation suggest that low-dose buccally administered caffeine is not an effective ergogenic aid for either muscle endurance or anaerobic performance, and is similarly not an analgesic during either type of effort. The buccal administration and low-dose administration utilized in the present study build upon and expand the current literature on the ergogenic and perceptual effects of caffeine during exercise. The present investigation resulted in different conclusions than a previous study that had examined caffeine and WaNT. (Woolf, Bidwell, & Carlson, 2008). In the their study caffeine in moderate doses (5mg/kg bodyweight) was shown to affect the WaNT, however, the only significant effect was increased peak power during the test. Other measures such as mean power, minimum power and power drop were not significantly affected. It should be noted that the dose of caffeine in this study was larger than the 100mg dose administered in the present investigation. Other studies have similarly found that caffeine did not affect WaNT performance (Greer, Morales, Coles, 1998; Greer, Morales, Coles, 2006). Doherty et al. (2004) reported an increase in power production (approximately 44 watts) and a decrease in RPE rating (approximately 1 RPE point) in 11 male cyclists who performed two minutes of exercise at 100% maximum power output followed by a one-minute all-out effort. However, the oral dose of caffeine on average was much larger in the Doherty study (5mg/kg) as compared to the average in the present investigation of 1.2mg/kg of bodyweight and the present investigation made use of buccal administration. This may account for the differences; however; it should be noted that Bellar et al. (2011) demonstrated analgesic effects with buccal caffeine in identical doses (100mg per participant). It is possible that low-dose caffeine is only an effective analgesic for longer duration exercise and this would explain why an effect was found in the Bellar et al. (2011) investigation but not in the present investigation. The hand grip task to exhaustion in the Bellar et al. (2011) study lasted on average around three minutes compared to the tests employed in the present investigation, which were 30 seconds and one-minute in duration, respectively. In comparison to the Doherty et al. (2004) investigation where a performance effect was revealed for peak power increases, the present investigation employed both a lower dose and different form of administration of caffeine that may have reduced and/or attenuated the effectiveness of the supplement.

To date few studies have examined both RPE and Pain during an intense cycling task, such as a Wingate. Jenkins et al. (2008) may represent the most similar report in the current literature to the WaNT portion of the present investigation, where an intense cycling test was paired with caffeine administration and both RPE and pain data collected. Jenkins et al. reported no pain or RPE differences after a 15 min VO_2 peak ride. Though not directly comparable to the Wingate employed by the present study, the results do seem to follow the similar trend that short term intense cycling utilizing the same motion and muscle groups is not affected by caffeine administration.

The findings from the present investigation are also consistent with the literature in regard to muscle endurance. The data from the current investigation does not support buccal caffeine as an ergogenic aid for muscle endurance. Similar findings were reported with muscle endurance using the leg extension and bench press exercise (Beck et al. 2006). The present study does expand the understanding of caffeine as applied to muscle endurance, as the data also suggests that low-dose caffeine in a muscle endurance test is not an effective analgesic and does not reduce the perception of effort.

Though consistent with the literature in many ways, the present investigation is not without limitation. First, although similar doses of caffeine (100mg) have been shown to be effective analgesics (Bellar et al., 2011), the use of low-doses in this investigation may have limited the potential for analgesia. Similarly the low-doses employed may also have limited the affect on the performance outcomes. It is useful, however; to investigate the effects of low-doses of potential analgesics/ergogenics as this can be informative to potential users.

Conclusion

Caffeine can act as an ergogenic aid, but it is important to understand how caffeine may or may not aid in the journey to accomplish athletic goals. Low-dose buccal caffeine is not an effective ergogenic aid or analgesic in either a lower body sprint cycling or upper body muscle endurance test.

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