INTRODUCTION

Use of caffeine and caffeine containing beverages are common among all levels of athletes, hoping to gain ergogenic benefit. To date many studies have demonstrated caffeine to be an ergogenic aid for exercise of varying intensities, duration and modalities in an athletic population

Caffeine’s cardiovascular effects have also generated much interest. Most of this study however conducted in resting subjects and has investigated the potential negative health consequences from caffeine induced elevation of blood pressure

Investigations reporting the effect of caffeine on heart rate during exercise are equivocal, with some indicating increases, decreases, and no effect

Caffeine dose, exercise intensity and caffeine habituation are all factors which differ among the studies. Even though the data is inconclusive, statement will reflect the common notion that caffeine increases heart rate during exercise and this kind of statement often made without reference to dose, intensity of activity or habituation status. Benefits associated with caffeine ingestion includes delayed feeling of fatigue, reduced sensation of pain and exertion, Increased fatty acid oxidation, increased mean power output, decreased time to complete a set amount of work, stimulation of motor activity as well as increase in alertness and ability to concentrate. The inhibition of adenosine receptor including those in the central nervous system is now considered by some to be a more likely mediator of caffeine’s ergogenic properties. By attaching adenosine receptors caffeine is able to counteract many of the inhibitory effect of adenosine on neuroexcitability, neurotransmitter release and arousal.

To date majority of the studies in exercise performance following caffeine ingestion involved well trained athletes, whereas the effect may be different in non athletic population. Benefits associated with caffeine ingestion i.e. the ability to perform more work and thereby greater calorie expenditure can be used to promote fitness in overweight and sedentary individuals who are prone to weight gain and associated health issue. Thus the purpose of this study is to evaluate the cardio-respiratory effect of energy expenditure of moderate dose of caffeine ingestion during bicycle ergometry among overweight sedentary first year MBBS students of Jawaharlal Nehru Medical college who are non habitual caffeine users.

Aim

To examine the effect of caffeine ingestion (5 mg per kg) over pulse rate, blood pressure, energy expenditure, during 15 minutes of stationary cycling at a standardized power output as well as 10 minutes cycling with maximum effort among overweight sedentary first yeas MBBS students who are non habitual caffeine users.

Objectives

- To study the effect of caffeine on pulse rate, blood pressure, energy expenditure in two phases of cycling (1st phase-15 minutes sub maximal exercise and 2nd phase- 10 minutes maximal exercise).
- To achieve performance benefit if any.
MATERIALS AND METHODS
The study was conducted at exercise laboratory of Jawaharlal Nehru medical College with due approval from institutional ethical committee. 18 male subjects aged 18 to 25 years, overweight, sedentary, non habitual caffeine users among first year MBBS students of Jawaharlal Nehru Medical College was included in the study. Regarding selection of overweight candidate WHO criteria (BMI > 25) was followed.

Inclusion Criteria
Subject should be healthy, normotensive and non habitual caffeine users.

Exclusion Criteria
Subjects having history of cardiovascular and lung disease were excluded from the study. Chronic smokers and regular caffeine users were also excluded from the study.

Each participant was reported on two separate occasions, once for familiarization session and another for experimental session involving stationary cycling with a bicycle ergometer (inco instruments and chemicals private limited with exercise computer js- 154) after administration of caffeine(5 mg per kg).

Familiarization Session
Participants were explained about the purpose of the study and informed written consent also taken from them. Participants were instructed 1) to refrain from consuming caffeine or caffeine containing food for 48 hours prior to each testing session, 2) to avoid exercise for 24 hour prior, 3) to keep the time of their last meal from the pulse rate obtained by the software system of bicycle ergometer, increased by every 3 minutes until the target heart rate was achieved. Once the target heart rate was reached, the participants continued to cycle at the power output equated to this heart rate value for duration of 15 minutes. To avoid difficulty in coping with longer exercise period, the time periods of 15 minutes and 10 minutes were selected. Immediately after completion of each stage of exercise pulse rate and blood pressure were measured.

EXPERIMENTAL SESSION
Participants were arrived at exercise laboratory in the morning at 9 am in a fasting state for a previous twelve hour period. Baseline pulse rate and blood pressure were measured. Then the participants were given powdered caffeine dissolved in 150 ml of milk. Detailed history was taken regarding caffeinated foods or drinks. The exercise was divided into two phases:-

Part-I: which includes 15 minutes stationary cycling at a constant power output equating to 65 % of individual age predicted heart rate maximum, determined during familiarization session?

Part-II: After completion of part-1 exercise, participants took rest for 10 minutes and then were advised to cycle for next 10 minutes with maximum effort. Immediately after every stage of exercise, energy expenditure and pulse rate were recorded from software system of bicycle ergometer (Exercise computer-JS-154). Blood pressure was recorded by sphygmomanometer. A brief relaxation participants left the exercise laboratory.

RESULT
Data Analysis
Data were expressed as mean ± SD. Students paired t test was used for analysis for data. Statistical significant was set at p < .05.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Time</th>
<th>Before Caffeine</th>
<th>After Caffeine</th>
<th>95% confidence interval of the difference</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lower</td>
<td>Upper</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy expenditure</td>
<td>15 min</td>
<td>39.04 ± .44</td>
<td>44.31 ± .62</td>
<td>-5.47, -5.06</td>
<td>0.000, S, p &lt; .05</td>
</tr>
<tr>
<td></td>
<td>10 min</td>
<td>32.48 ± .95</td>
<td>32.68 ± .87</td>
<td>-2.8, -13</td>
<td>0.000, S, p &lt; .05</td>
</tr>
<tr>
<td></td>
<td>5 min</td>
<td>130.72 ± 1.31</td>
<td>129.27 ± 1.01</td>
<td>.82, 2.06</td>
<td>.967, NS, p &gt; .05</td>
</tr>
<tr>
<td></td>
<td>10 min</td>
<td>138.27 ± .82</td>
<td>137.50 ± 2.09</td>
<td>-.33, 1.89</td>
<td>.159, NS, p &gt; .05</td>
</tr>
<tr>
<td>SBP</td>
<td>15 min</td>
<td>135.33 ± 4.22</td>
<td>138.66 ± 3.28</td>
<td>-5.35, -1.31</td>
<td>.003, S, p &lt; .05</td>
</tr>
<tr>
<td></td>
<td>10 min</td>
<td>139.55 ± 1.29</td>
<td>139.77 ± 0.94</td>
<td>-.69, .24</td>
<td>.331, NS, p &gt; .05</td>
</tr>
<tr>
<td></td>
<td>15 min</td>
<td>84 ± 2.91</td>
<td>83.33 ± 3.06</td>
<td>-1.35, 2.68</td>
<td>.495, NS, p &gt; .05</td>
</tr>
<tr>
<td></td>
<td>10 min</td>
<td>79.77 ± 0.94</td>
<td>80.00 ± 0.00</td>
<td>-.69, .24</td>
<td>.331, NS, p &gt; .05</td>
</tr>
</tbody>
</table>

Effect of caffeine on total amount of energy expenditure, pulse, systolic and diastolic BP, Values are means ±SD, n= 18

Part-1 Exercise session
Energy expenditure after caffeine ingestion in first 15 minutes exercise session increased which is statistically highly significant. Mean value of pulse rate was decreased though it is not significant. Systolic BP significantly increased during 15 minutes exercise session after caffeine ingestion. No significant change of diastolic BP noted.

Part-2 Exercise session
Energy expenditure in part-2 exercise session (10 minutes max exercise) though shows significant increase by student paired t test , difference of the mean is very less, only 0.20. Pulse rate also decreased but not significant. Rise of systolic BP is very mild and insignificant. No significant change of diastolic BP was noted.
DISCUSSION
The result of this investigation provide evidence that caffeine alters the hemodynamic response to exercise, specifically ingestion of 5 mg per kg caffeine increases exercise induced systolic BP. As caffeine increases both resting and exercise BP it may be concluded that the effect of resting BP were responsible for higher BP observed during exercise, because exercise itself increases systolic BP. The dose of caffeine used in this study (5 mg per kg) was selected on the basis of its similarity to doses (3-6 mg per kg) previously shown to increase blood pressure at rest or during exercise without provoking side effects like intolerance or decrease in exercise performance or unpleasant wellbeing. The potential tolerance to the effects of caffeine consumption was also controlled for because hemodynamic response to caffeine may be blunted in regular users. In fact tolerance to the caffeine can occur only three consecutive days of use. Consequently all subjects in the present study refrained from consumption of caffeine for at least four days before participating in any of the protocols to desensitize the system to the effects of this drug. The result of this study also evidence that caffeine at dose of 5 mg per kg body weight significantly decrease pulse rate during low to moderate intensity cycling exercise which in turn indicates a decrease in heart rate. This finding of lower pulse rate with caffeine use during exercise is in agreement with three previous studies, Sulivan et al,22 Gaser and Rich,23 and Turly and crest.24 All these studies mentioned that low to moderate dose of caffeine significantly decrease heart rate at sub maximal intensity of exercise. This result of pulse rate is in contrast to a number of studies that have reported no effect of caffeine administration on exercise heart rate.8,25 A possible explanation is that each of the studies used a > 5 mg per kg dose of caffeine. Our results are also in direct contrast to some studies which have found higher heart rate with caffeine during exercise. Mc Naughton4 observed higher heart rate during cycling at work load from 50-300 watts after high dose of caffeine compared with placebo. We speculate that the lower pulse rate observed during exercise after caffeine ingestion would indicate an increased or optimized stroke volume. The most likely mechanism would seem to be either an enhanced contractility or higher preload with caffeine use during exercise.1,26 Another possible explanation of a lower pulse rate is due to bar reflex reflexively lowering heart rate in response to elevated blood pressure in an attempt to reestablish normal blood pressure. Overall results from this study showed that energy expenditure has been increased after ingestion of caffeine during exercise. By applying students paired t test energy expenditure in the second phase of exercise shows mild increase, whereas in the first part of exercise it shows greatly increased which is highly significant. Caffeine’s ergogenic benefits have well been established in athletes, not so in case of overweight and sedentary population. Beneficial effect of caffeine i.e. the ability to perform more work without any negative health consequences after ingestion of such moderate dose of caffeine could be used to promote initial exercise performance in overweight and sedentary individuals who are prone to weight gain and associated health issue. This convincing evidence will significantly encourage the overweight, obese and sedentary individual to participate in regular exercise programme. This results was also surprising considering the convincing evidence for significantly greater work being performed in set times after caffeine ingestion in an athletic population. Lack of significant differences in exercise performance and other physiological variables may be due to the exercise duration (part-1, 15 minutes and part-2, 10 minutes) which was considerably shorter than those undertaken in athletic studies that reported significant performance benefit. This conjecture is further supported by results from Ahrens et al,23 (2007a) and Ahrens et al24 (2007b) which showed no significant change in heart rate, after caffeine ingestion, during 8 minutes exercise protocol in recreationally fit women. Probably a longer duration of exercise may be needed for better evaluation of caffeine’s ergogenic effect. Moreover, % of VO2 max rather than % of HR max as a guide for exercise intensity during part-1 of the exercise protocol might have resulted in different physiological outcome due to variability associated with heart rate values. Again it is possible that caffeine ingestion may only have an ergogenic effect in overweight sedentary population when exercise is performed at higher intensity. For instance Engels et al26 reported no significant change of VO2 in sedentary males after caffeine ingestion while walking at intensities equivalent to 30 % and 50 % of VO2 max. Of importance, the higher intensity exercise employed by Engles and Haymes in 1992 is similar to the intensity used during steady state cycling in the current study that equated to 65 % of individuals HR max which also found a similar result between caffeine and placebo trials. Conversely a review by Graham 2001 that the majority of studies that reported, improvement in exercise performances in an athletic population following caffeine used exercise intensities between 75 to 85 % of VO2 max. A separate explanation for the result of the study may pertain to participants not being accustomed to regular exercise and consequently being reluctant to extend themselves during second part of exercise session due to fear of injury or lack of confidence. Extra exercise session may boost their confidence, which in turn may result in more work being performed during a set time. As pulse rate values were decreased to some extent in the current study, it is possible that an increase in stroke volume may have been responsible for the higher energy expenditure reported after caffeine ingestion during part-1 phase of exercise. Other possible mechanism may be the stimulatory effect of caffeine by catecholamine release.

CONCLUSION
In the nutshell, the result of the investigation demonstrated that caffeine in moderate dose has got beneficial effect over cardiovascular responses to dynamic exercise. Though caffeine caused mild rise in systolic blood pressure without any unpleasant or adverse effect, the change of diastolic blood pressure is insignificant. Moreover in this study pulse rate was also found decreased during exercise after caffeine intake. The more important aspect of this investigation is caffeine ingestion significantly increased energy expenditure during exercise. Though energy expenditure increased in 10 minutes maximal exercise session, the finding was very less. The difference of the two means (before caffeine 10 minutes maximal exercise and after caffeine 10 minutes maximal exercise) was only 20, whereas the energy expenditure in 15 minutes steady state exercise after caffeine ingestion increased which is statistically highly significant. It is possible that initial small improvement seen in the ability to
exercise via caffeine ingestion may motivate overweight and sedentary individuals to make exercise a regular habit which in turn could result in positive implications for weight management, fitness and well health. Further studies investigating the effect of caffeine in overweight and sedentary population should use extra exercise session and longer duration of exercise session.

REFERENCES

1. Bell DG, Mc Lellan TM. Exercise endurance in 1, 3 and 6 h after caffeine ingestion in caffeine users and non users. J of Applied Physiology 2002; 93: 1227-1234. PMid:12235019
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