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Caffeine's Impact on Heart Rate Variability During Short-Term Exercise in University Students

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Title: Caffeine's Impact on Heart Rate Variability During Short-Term Exercise in University Students

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Abstract: The primary objective is to explore the physiological effects of caffeine on intra-bout exercise-induced blood pressure (BP) and heart rate (HR) deceleration resulting from repeated anaerobic exercise cycling in active university students. Use of caffeinated stimulants has increased in recent years, particularly in the exercise setting. The cardiovascular system (CS) is an essential piece of exercise physiology and is controlled by the autonomic nervous system (ANS). Caffeine has a known effect on the CS during acute exercise. What is not well solidified is the connection between caffeine and exercise-induced markers, such as heart rate recovery (HRR) and BP. Participants underwent a comprehensive informed consent process, baseline physiological measures, including BP and BPM. A double-blind design to assess the effects of caffeine on HRR and BP were measured during two separate appointments. Participants received either 3 mg/kg of caffeine or placebo drink. Following a 15-minute holding period, upon ingesting the drink, participants performed two 30-second maximal-effort cycling bouts on an assault bike, separated by 30 seconds of active recovery. Post-exercise HR measurements were obtained immediately after each bout. Following the exercise session, participants' BP and HR were recorded in 5-minute intervals for a duration of 15 minutes to assess post-exercise recovery dynamics. Independent t-tests were conducted to determine differences between participants. There were no significant differences ($p > 0.05$) between the utilization of caffeine administration on, HR and HR deceleration in the present study. The results demonstrated no statistically significant difference between caffeine and non-caffeinated subjects relative to HRR in an acute anaerobic setting. This aligns with previous findings and warrants further research to aerobic settings. Studying caffeine's impact on HRR in aerobic exercise could provide insight into its broader effects on the ANS and CS.

Key words: heart rate recovery, intra-bout exercise, anaerobic exercise, caffeine, autonomic nervous system, cardiovascular system

Introduction: Increase in usage of pre-workout and other caffeinated stimulants have dramatically increased in the last several years, particularly when it comes to exercise[1]. While caffeine is a known neurostimulant, the complete understanding of the effects of the molecule is still outstanding. Particularly, when it comes to the sympathetic nervous system (SNS). The cardiovascular system is an essential piece of exercise physiology and controlled by the autonomic nervous system (ANS). In previous studies, caffeine has been demonstrated to have an effect on the parasympathetic nervous system (PNS) during submaximal, anaerobic, and acute exercise[2]. Heart rate variability is the variation in the time interval between heartbeats. In a healthy state, the time intervals between heartbeats greatly fluctuate in order to maintain homeostasis despite physical and psychological stimuli. The oscillations of HR are controlled by the ANS, which relays signals from the brain to the heart by electrical signals and hormones such as epinephrine and norepinephrine. The ANS is made up of two divisions, the first being the SNS which signals the heart rate to increase, and the second division being the PNS which signals the heart rate to decrease also known as the rest and digest or the fight or flight systems. What is not as well known is the connection between caffeine's effects versus a placebo effect on individuals during exercise, with a specific emphasis on heart rate and blood pressure being increased or decreased with the use of caffeine or a placebo. The purpose of this research is to explore the physiological effects of caffeine on cardiac recovery, or the return to homeostasis, from an induced increased stimulation on the cardiovascular system. This includes periods of rest in between anaerobic sets, as well as post-workout. Prior research has demonstrated caffeine has a strong sympathicotonia effect[6]. The cardiovascular system is innervated by the parasympathetic and sympathetic fibers from the ANS parasympathetic branch. We hypothesize that individuals upon completing anaerobic exercise with supplemental caffeine will have a heightened, extended time returning to their baseline HR and BP levels than those with a placebo.

Materials and methods: Participants underwent a comprehensive informed consent process, baseline physiological measures, including BP and HR. A double-blind design to assess the effects of caffeine on HRR and BP were measured during two separate appointments a week apart to mitigate fatigue of the experiment. Following a 15-minute holding period, upon ingesting the drink, participants performed two 30-second maximal-effort cycling bouts on an assault bike, separated by 30 seconds of active recovery. Post-exercise HR measurements were obtained immediately after each bout. Following the exercise session, participants' BP and HR were recorded in 5-minute intervals for a duration of 15 minutes to assess post-exercise recovery dynamics. Suggestive participant feedback during both tests was documented. The research used a Polar H7 heart rate monitor strapped to the participants' chests, and the corresponding heart rate app for measuring heart rate all test results. Blood pressure was measured using the Omron IntelliSense digital blood pressure monitor both before supplementation and after exercise. A pure green tea extract was the choice caffeine supplement due to its ready availability and minimal additives. A digital scale was used to measure out the appropriate amount of caffeine unique to each individual. Single-serving, non-caffeinated Crystal Light mixed in 20 ounces of water was used as a flavoring agent to mask the taste of the caffeine. The Rogue Echo Assault bike was used to elevate the individual's heart rate due to the nature of its full-body involvement.

Results:

Figure 1.1:

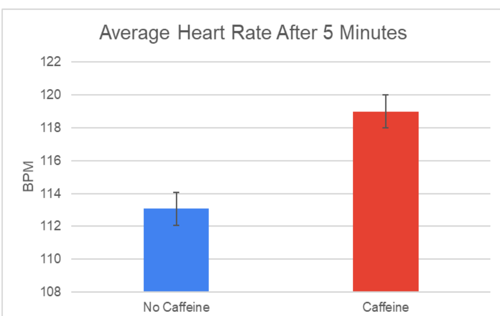

Figure 1.1, the average of n=16 caffeinated subjects (shown in red) and non-caffeinated subjects (shown in blue) of HRR post-anaerobic exercise after 5 minutes.

Figure 1.2:

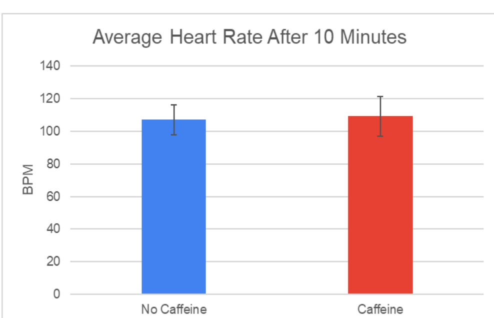

Figure 1.2, the average of n=16 caffeinated subjects (shown in red) and non-caffeinated subjects (shown in blue) of HRR post-anaerobic exercise after 10 minutes.

Figure 1.3:

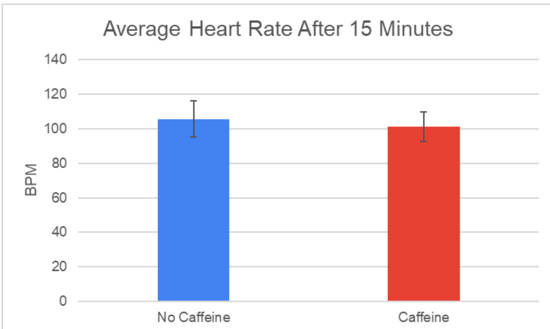

Figure 1.3, the average of n=16 caffeinated subjects (shown in red) and non-caffeinated subjects (shown in blue) of HRR post-anaerobic exercise after 5 minutes.

Discussion: The results did not indicate a statistical significance between HRR of individuals who consumed caffeine before the test versus placebo after 5 minutes (Figure 1.1). Similarly, no change in HRR was observed between the two groups after 10 minutes (Figure 1.2) and 15 minutes (Figure 1.3). The test, correlating HRR in acute anaerobic exercise, yielded the following statistically non-significant results: HRR after 5 minutes ($p = 0.189$), HRR after 10 minutes ($p = 0.455$), and HRR after 15 minutes ($p = 0.190$). All p-values did not meet the threshold for statistical significance ($p < 0.05$), which was the benchmark for this research..

Conclusion: In the context of this study, the expected activation of the SNS by caffeine did not translate into a significant impact on HRR post-anaerobic exercise. One reason could be due to the quantity of participants (n=16). A greater number of participants might have demonstrated more statistically notable results, especially when considering the range of subjective feedback gathered between tests from participants. This lack of significant effect could also be attributed to the specific population examined. The sample consisted of active university students (ages 18-22), who are likely more metabolically resilient and less susceptible to SNS-induced disruptions in homeostasis compared to a sedentary or middle-aged population. Additionally, younger individuals tend to exhibit greater physiological robustness, which might mitigate the impact of caffeine on HRR. Therefore, the expected SNS-triggered responses were not sufficiently pronounced to influence the measured outcomes in this metabolically resilient age group.

Future investigation into the impact of caffeine in an anaerobic setting will likely be more insightful with a greater breadth of population. Moreover, the inclusion of non-active subjects may display clearer conclusions. More research is warranted to experiment how caffeine consumption affects individuals' HRR in aerobic settings as well.

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