Caffeine's Effect on Athletic Performance

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Abstract

Previous research has suggested that caffeine has somewhat of an effect on certain types of exercise. The purpose of this study was to test the effect of caffeine on male high school athletes performing aerobic and anaerobic exercises. Fifteen high school athletes were given either 60 mg of caffeine or a placebo in a blinded crossover study; they did three series of 35-yard sprints, push-ups, and wall sits till failure. We found that caffeine has a beneficial effect on all three types of exercises. Therefore we can recommend that athletes should consider using caffeine to increase athletic performance.

Introduction

Caffeine has played a huge role in people's day-to-day lives; 80 percent of adult Americans consume caffeine every day (1). Even though this has little to do with caffeine improving a person's athletic performance, it is a substance commonly consumed in most people's day-to-day life, including when they exercise. Research shows that caffeine affects anaerobic and aerobic exercises through a variety of biological mechanisms (2). This is important because if caffeine makes players faster than others, maybe coaches should start using it. In this study, we gave students a caffeine supplement and did a crossover study, and had people run and work out until failure and see if there is a unique difference in their performances.

Anaerobic exercise requires short bursts of energy and is done without the need for oxygen. Caffeine may or may not have an effect (3). Turley et al. tested 24 students, aged 8-10 years old. Athletes were asked to complete a Wingate test on a stationary bike to measure mean power and heart rate. The Wingate test involves a person pedaling an exercise bike for 30 seconds at their fastest output and measuring their power output (3). They also performed a static hand grip test to measure peak power and muscle contractions. The groups were crossed, so each athlete did the test twice, once with caffeine and once without. For the handgrip test, caffeine had no effect, but for the Wingate test, mean power and heart rate were higher for the caffeine group (3). This suggests adolescent boys might benefit from the caffeine in situations where speed is necessary, but not strength. This is important for our study because we also tested athletes' performance and this suggests caffeine may have an effect on exercise with speed but not strength.

Aerobic exercises require people to do exercises for a longer period of time. In these exercises, there's more of a need to consume oxygen. Hoffmen et al. studied 10 college students. The students were asked to do a test on stationary bikes specifically (two different tests: a Wingate test, which measures power, and the 75% VO_2max test which measures how long a person can pedal when using 75% of a person's maximum oxygen capacity) (4). This too was a crossover study where each group did both tests twice; one group was given Java Fit coffee, which is a specific brand of highly caffeinated coffee, and the placebo group had decaffeinated coffee. The finalized results were that for the Wingate test, there wasn't a significant difference in power, however, there was an effect for time to exhaustion in the 75% VO_2max test (4). This is important for our study because we also tested the same variable as the effects of caffeine aerobic performance, but we used sprints.

As discussed in the first two paragraphs, caffeine has effects on aerobic exercises, but however not as many positives on anaerobic exercises. Based on that, there may be a difference in sex with caffeine affecting a male better than a female. Mielgo-Ayuso et al. reviewed numerous studies on caffeine, focusing on sex differences. They found no differences in effect between men and women, when given the same dosage, regardless of sex (5).

In general, caffeine was found to help with the amount of time exercising and feelings of exhaustion. In addition to sex differences, Márquez et al. reviewed caffeine's effect on strength and pain perception. They found that caffeine doesn't have a clear effect on strength but does show an effect on the number of repetitions one can perform (5). The science behind this has to do with caffeine inducing the release of higher levels of calcium and potassium into the bloodstream, which then triggers these electrolytes to pass to the muscle cells and increase endurance (6). However, they found one difference in the sexes regarding the effects of caffeine; when it comes to blocking the perception of pain or fatigue, their final results show in hot environments caffeine supplementation reduced the perception of fatigue in men, but not in women (6).

In addition to electrolytes, there are numerous ways caffeine affects the inside of an athlete's body. According to Green et al. there are many mechanisms that work with an athlete's body that have positive effects. They say caffeine affects catecholamines, lactic acid levels, blood glucose, potassium, calcium, adenosine, pain, and fatigue/perceived exertion. Caffeine increases the energy available to an athlete, by releasing catecholamines, lactic acid, and blood glucose (2). The release of catecholamines triggers an increase in adrenaline, which can increase endurance. This is because adrenaline increases blood glucose which is also a part of the energy your muscles need. Lactic acid is a part of the energy for athletes' muscles, so more lactic acid means more available energy as well (2). In addition to energy, caffeine affects available electrolytes in people's blood, especially potassium, and calcium. Electrolytes help muscles contract and work effectively. Athletes lose electrolytes through sweat, so caffeine makes more of them available (2). The last way caffeine helps is with perceptions of fatigue and pain. Caffeine blocks adenosine receptors in the brain (7). Adenosine collects throughout the day and makes you sleepy. Therefore, caffeine prevents fatigue and perceptions of tiredness. Adenosine can also affect feelings of pain, and caffeine blocks this as well (7).

In our current study, we are focusing on sprinting and exercises that utilize a person's mass. Sprinting is an aerobic exercise where athletes run for a specific distance and stop and repeat, often at a fast speed. Sprinting plays a role in many sports, like football or basketball, where it is required to run quickly, often for long periods. Glaister et al. tested 21 male sport science students doing a series of sprint tests to see if caffeine affects their sprint times, fatigue, heart rate, and blood lactate levels. This was a double-blinded crossed study and what they had the athletes do were first the pre-test. Then the athletes ran 12x30m sprints in 35s intervals with a 30-second break in between. Then they repeated the process but inverted the groups where the other half of the athletes had caffeine and the other half didn’t. They concluded that caffeine has an impact on improving aerobic capacity although it increases fatigue (8). This makes sense because their heart rate is beating faster, but besides that, the results show caffeine makes people run faster. Last, they found an increased blood lactate level. Higher lactate levels increase the numbers of mitochondria, which ends up reducing waste in cells and makes people less fatigued (8). Overall we can conclude that caffeine may have an effect on heart rate, speed, and fatigue allowing athletes to sprint faster.

On the other hand, weightlifting had somewhat opposite effects. Astorino et. al. tested how caffeine affects weightlifting, by measuring muscular endurance and strength. They did this by doing a double-blind crossover study, using 22 resistance-trained men. Two exercises were used, bench press and leg press, and before having them complete trials, researchers found out the max 1-repetition they could lift. Using their max weight, athletes did 60 percent of that in the experiment. Specifically, they measured the total weight lifted by multiplying the reps by the weight. Also, heart rate, blood pressure, and perceived exertion were measured before and after. And from measuring all of these, their results say they found no significant difference in how much you can lift in either exercise, but their limitations were possible because of the small sample size they had (9). Because after all, the caffeine group lifted 11 percent more weight from benching and 12 percent for leg press (9).

Overall, research concludes that caffeine will show some positive effects on athletic performance (2-4,7-9). This study contributes to the understanding of the effect of caffeine on athletic performance, as many sources tested adults or grade school boys. But with our study, we used high school students. We tested a number of high school students doing a blinded crossover study and had them do a series of sprint tests that consist of 35 yards sprints, of 3 trials. We found out the people's weight and had them do push-ups until failure, as well as complete wall sits. After all that, we calculated the amount of weight lifted by multiplying the number of reps by the weight of the person and found out if caffeine will show an effect on both aerobic performance (sprint time) and anaerobic performance (weight lifted).

We hypothesized that the caffeine group will have significantly higher performance than the group with no caffeine. This is consistent with what most sources say; caffeine has some significance on sprint time (aerobic exercises), and weight lifting (anaerobic exercises) (2-4,7-9). We expect that caffeine will (1) decrease sprint time (2) increase push-up weight lifting to failure, and (3) increase wall-sit time held until failure, compared to the placebo baseline measurement.

Methods

We had 15 high school students, specifically athletes, and these athletes ranged from 10th-12 grade. These athletes were people who ran track, made the wrestling team and participated, and were members of the basketball team. All participants were male. The people were recruited from classmates we knew and who we thought would be willing to do the workouts. They returned the parental permission slip given to participate while having to consume caffeine.

The primary researcher used a data sheet with 8 columns, which recorded 3 sprints, which were averaged together, another column with push-ups how many they did and multiplied the person's weight to get an accurate number of how much weight a person could lift, then they had them do a wall sit and calculate their time until failure, which has to do with their leg muscles, in contrast, push-ups involved arms and chest. Participants consumed powder drink mixes, one with caffeine specifically 60 mg which is a little less than a cup of coffee, and a decaf mix which had no other vitamins or sugars, just flavoring and color/dye.

First, 40 minutes before the experiment, the primary author made the drinks and passed them out to the athletes during study hall and had them drink them before the start of the experiment, or about 30 mins prior. Being that this is a crossover blinded study some people received caffeine, and the others got decaf on the first day, and no one knew which one they had then we repeated the process with the drinks flipped. The first exercise we did when getting down to the field house was 3 trials of 35-yard sprints and seeing how fast they were able to run only going down, not going down and back. Next in small groups, the primary author had a number of people do push-ups and recorded their weight before them doing the push-ups. To conclude the experiment they did the wall sits, which was also done with a small group of athletes instead of one at a time.

Results

To determine if caffeine has an impact on athletic performance or not, in our experiment we had volunteered athletes who one was willing to drink a caffeine supplement, run three 35 yd sprints, do push-ups, and had athletes do wall sits. All athletes also completed the same exercises without caffeine in a single-blinded crossover design. And all three of these activities we had the athletes do, we expected that caffeine will be the group that can do that extra rep or run faster.

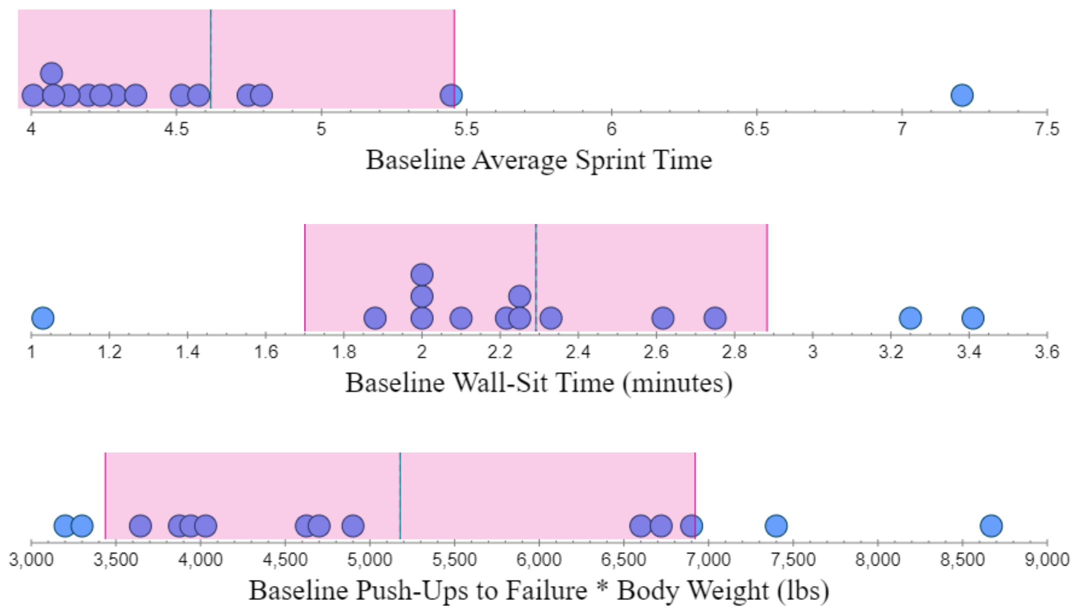

Figure 1. Baseline athletic performance scores. *The picture above shows the baseline of athletes that didn't have caffeine, for push-ups till failure, wall sits, and sprint times. Our graph for push-ups shows we have a mean of 5.179 and a standard deviation of 1741.79. Most people fall in the standard deviation with 4 extreme outliers. Push-ups compared to the graph of wall sit we had a mean of 2.29 with a standard deviation of 0.59 this one had 2 overperformers and 1 underachiever. Last sprint times we had a basic mean of 4.62 seconds of average sprint times with a standard deviation of 0.838 with one outlier running a lot slower.*

Our first hypothesis was that caffeine will affect making people run faster. The same participants ran three sprints with and without caffeine and their times from the three were then averaged. We found a significant effect; caffeine affects sprint time using a two-sample t-test for correlated samples (t(13)= -18.2, p=0.046). The caffeine group averaged 4.2189 seconds compared to the non-caffeinated group had a mean value of 4.4187 seconds.

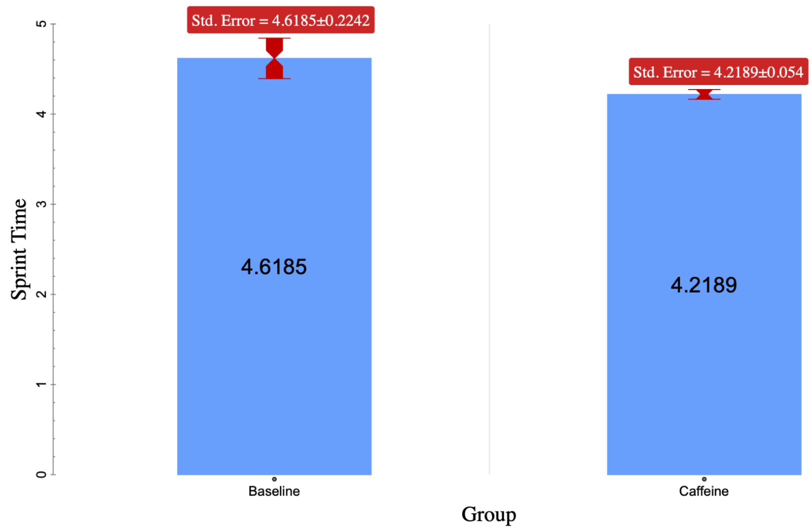

Figure 2. Average sprint time for caffeine and baseline measurements. *In the figure above, the horizontal axis is the group; each athlete did two measurements. The vertical axis is the average sprint time of three splints of 35 yards. The caffeine condition was significantly faster ($p<0.05$).*

Second, we hypothesized that caffeine will have a clear effect on lifting body weight when it comes to push-ups. For this we had the participants do push-ups till failure with caffeine and without it, to measure if caffeine had an effect we had to multiply the weight of the individual, and the number of push-ups the individual did to get the total weight. And we found a significant difference as well using a two-sample t-test ($t(13)=4.6$, $p=0.00025$). The caffeine group averaged 5728.8 pounds compared to our placebo group with a mean of 5179.1 and we found that the caffeine group lifted about 600 more pounds than the placebo.

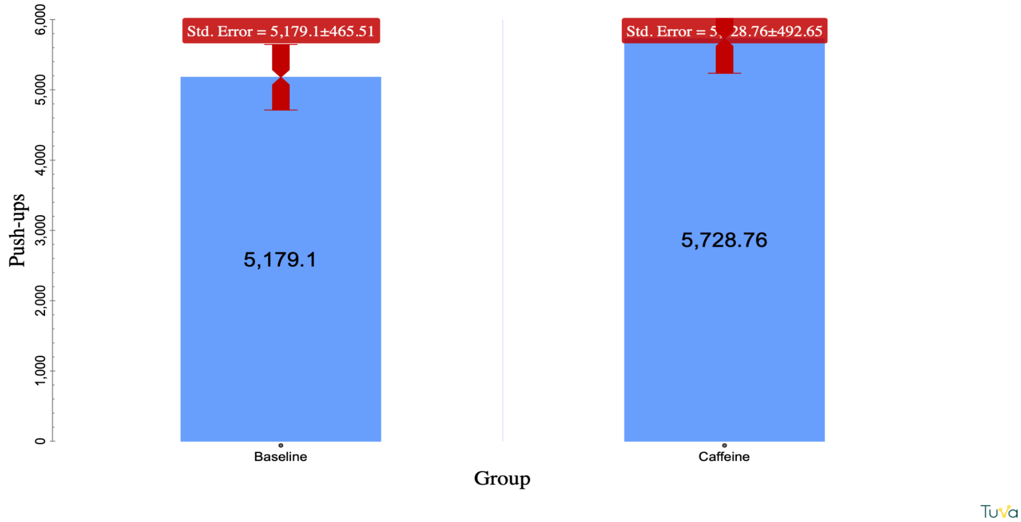

Figure 3. Average weight lifted for caffeine and baseline group. *In the figure above, the horizontal axis is the group; each athlete did two measurements. The vertical axis is the average* amount of weight lifted with caffeine and without caffeine. The caffeine group lifted more because the ($p<0.05$)

Last we hypothesized that caffeine will affect muscle strength when it comes to increasing a person's wall-sit times. We tested them by having participants do wall sits till failure and timed them once with caffeine and next without. We found that the caffeinated group did better in time of wall sits compared to once again our placebo group. The results for the t-test were significant ($t(13)=2.72, p=0.0088$). The caffeine group averaged a mean time of 2.75 or 2 minutes and 45 seconds, compared to our other group which averaged a mean value of 2.52 in other words is 2 minutes and 32 seconds.

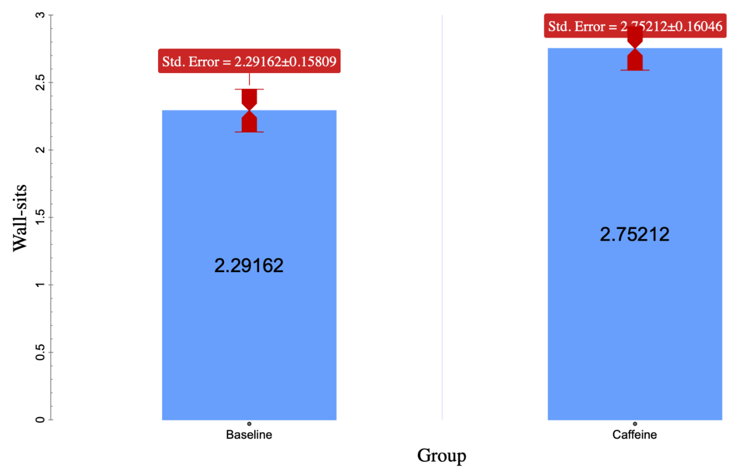

Figure 4. Averaged amount of time for doing wall sits for caffeine and baseline. *In the figure above, the horizontal axis is the group; each athlete did two measurements. The vertical axis is the average amount of time a person was able to last while doing a wall sit. In this graph as well the caffeine group did significantly better with this ($p<0.05$), the caffeine group did last longer when it comes to wall sits.*

Discussion

In this study, we investigated if caffeine will affect athletic performance. Our first hypothesis was that caffeine will affect a person's sprint time, like making them run faster. This study was supported by data in Figure 2, where our caffeinated group ran faster than our placebo group. Next, we hypothesized caffeine affects the number of reps a person can do when lifting their own weight. This study was supported by data in Figure 3, which showed that the caffeinated group lifted more of their weight than our placebo. Our last hypothesis was caffeine will affect muscle strength when it comes to increasing a person's wall-sit times. This was supported by data in Figure 4, where it is shown the caffeine group had a longer time for wall sits compared to our other group.

A prior experiment from Glaister et al. also found that caffeine has an effect; they concluded caffeine has an impact on improving aerobic capacity, which has an effect on making a person run faster but a downfall is getting fatigued faster. And we found the same thing that caffeine does affect making an athlete run faster, but we did not test how fatigued a person is after having them do the sprints. Now we have strong evidence that caffeine does have an effect when it comes to a person running faster. Because they tested a lot of college sports athletes and we tested high school students being that some were athletes and some were not, we can confirm that caffeine is likely to work no matter the grade level.

In the next experiment, Astorino et al. found caffeine has somewhat of an effect when it comes to weight lifting. In their study, the caffeine group did do better but it wasn't a clear difference from the placebo group. But in our study, we found that when it comes to lifting your own weight, which was push-ups, there was a clear difference between our caffeine and placebo groups. The caffeine group was able to lift more of their weight and do more reps than the placebo group. In the other study, they did a bench press, which is more of an anaerobic exercise whereas compared to a push-up it is half aerobic and anaerobic. We know from prior studies that caffeine helps with aerobic exercises, which may be why we found a more clear difference in the groups when it comes to weight lifting.

The last experiment we want to compare our results to was also done by Astorino et al., who in addition to bench presses, did leg presses as well to measure anaerobic exercise. Even though the caffeinated group did better there again wasn't a significant difference when it comes to lifting weights with the leg in their study. On the other hand, we did a wall-sit which again is lifting one's own weight, and in our study, we found a difference, our caffeine group did better when it comes to whether or not caffeine will help with exercises that mainly require legs. The difference between my study and Astorino et al. was the type of leg exercise and how caffeine's effect might be measured differently, leading to different outcomes. For example, caffeine's effect may help with doing 1/10th of a rep when it comes to a leg press but 1/10th of a leg press maybe 4 extra seconds when doing a wall sit. The reason for our data showing better results was because of how we measured our exercises. Our exercises could measure smaller differences. Taken together, these two studies say there might be an impact on anaerobic exercises with one's legs.

In the study above and the study from Turley et al., the results were similar. They found that there isn't a significant effect on anaerobic exercise. But, we did find something in our wall-sit data. We believe that caffeine helps when it comes to large muscle groups, such as push-ups and wall sits which use the core, back, and quadriceps. We believe that caffeine helps with larger muscle groups because of the heart rate beats faster than usual (6). Because those larger muscle groups can hold more blood, the heart pumps more towards the larger muscle groups. Turley's study, in contrast, used a handgrip test; so we can conclude that because Turley's hand grip test doesn't require as much of the larger muscle groups, that's maybe why their results did not look like ours. It might be the size of the muscle group that predicts caffeine's effect.

Even though we believe our project went great, we had a few limitations in our study. One would be to get more people than the number of students we had. We believe that getting a lot more students will get a clearer result, and the more people the less you have to depend on one particular person. Second, we encountered some difficulties that had to do with people not taking the project seriously, for example, a fellow student who participated may not have given it their all, which didn't necessarily affect our data, but we don't know for sure. Lastly, if we were to do it using the actual weights instead of body weight workouts, the study would be more similar to other projects.

According to our research, we can conclude that caffeine likely has an effect on aerobic and anaerobic exercise for teenage athletes. So, therefore, given this knowledge, we would suggest athletes before they do exercises taking some sort of caffeine supplement. It may help them do an extra rep that they weren't able to do before and gain a slight competitive edge. This is important because even with a small amount of caffeine (60mg) people may still see an effect, with that being said, athletes shouldn't be pressured to drink a large amount because just with a little there's still an effect.

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