Energy shot supplements and caffeine: effectual differences on neuronal, muscular, and cardiovascular function

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Abstract: As energy drinks increase in quantity and variety, research studies examining the claims made by the energy drink manufacturers are few and far between. The goal of this experiment was to investigate assertions that the extra ingredients in the energy shot 6-Hour Power provide additional benefits over a pure caffeine supplement, NoDoz. We hypothesized that the extra additives in 6-Hour Power will have no additional physiological effects on neuronal, muscular, and cardiovascular function as compared to NoDoz.

Cardiovascular function was measured by taking the subjects blood pressure and pulse, neuronal function was measured by calculating reaction time, and muscle fatigue time provided information on muscular function. From our classroom, we selected 19 subjects and split these individuals as evenly as possible into two treatment groups based on their daily caffeine consumption and gender. We first determined baseline measurements for both groups. In addition, both groups had measurements taken 30 minutes after receiving 6-Hour Power and NoDoz, with the only difference between the groups being in what week and order they received these supplements.

Results indicated that NoDoz and 6-Hour Power significantly altered the blood pressure, reaction time, and time to muscle fatigue in subjects when compared to baseline measurements. However, NoDoz and 6 Hour Power showed no statistically significant differences in effects when compared to each other. We therefore conclude that caffeine is the major ingredient that affects the aforementioned parameters and the additional supplements in 6-Hour Power provide no additional effects.

Introduction: Brought to the U.S. in 1997, Red Bull was the first of many energy drinks that would appear over the next decade. Twelve years later, with studies just beginning to gather conclusions about Red Bull, the first energy shot, 5-hour Energy, was introduced. With little to no research available, companies that market energy shots can make fantastic and largely unfounded claims about their effectiveness. The goal of our experiment was to investigate claims that the extra ingredients in the energy shot 6-Hour Power provide additional benefits over a pure caffeine supplement, NoDoz. Physiological effects of these products were examined by measuring blood pressure, pulse rate, time to muscle fatigue, and reaction time. Subjects had measurements taken three times over a period of three separate sessions; once with no supplement for a baseline measurement, once after ingesting NoDoz, and once after ingesting 6-Hour Power. We hypothesized that the extra supplements in 6-Hour Power will have no additional physiological effects over NoDoz with regards to the aforementioned criteria.

Prior literature suggests that caffeine has noticeable effects on the cardiovascular, muscular, and nervous systems. Early studies done with caffeine ingestion showed that it significantly quickens reaction time in participants shortly after ingestion [1]. Additionally, studies investigating the effects of pure caffeine on adolescents have shown an increased diastolic blood pressure (DBP) and decreased heart rate (HR) after acute ingestion [2]. A separate study on cardiovascular health showed similar changes in DBP and HR in elderly male test subjects, but younger participants showed no differences from baseline measurements [3]. There is a noticeable disparity between results from these two experiments regarding the effects of caffeine on the cardiovascular system, once again showing how the effects of caffeine are not fully known. Experiments examining the effect of caffeine on muscular function have shown that it can

drastically enhance performance during both endurance and high intensity exercise. However, there is no clear mechanism that can explain the ergogenic effect caffeine has on muscles [4].

Studies on energy drinks provide reasonable insight into the effects of the supplements found in 6-Hour Power. Some of the most common and most researched ingredients include Taurine, Glucoronolactone, and Vitamins B6 and B12. No research to date has shown a direct link between any of these supplements and a significant physiological change in any of the body systems that will be examined [5]. However, one study that measured the effects of an energy drink with ingredient proportions similar to ours (100mg caffeine, 1000mg Taurine, and containing Vitamins B6 & B12) noticed a moderate increase in both SBP and DBP as well as pulse rate [6]. Another study compared the effects of Red Bull energy drink with a similar energy drink without Taurine and found that only Red Bull caused a significant increase in cardiac contractility, suggesting that Taurine might have some effect on cardiac output [7]. Research on these supplements is so far inconclusive, but these preliminary studies help to provide a framework for our hypothesis.

Methods: Subjects were asked to report their daily average caffeine consumption of various caffeinated beverages, age, and gender. Using the information provided, 10 males and 10 females who expressed interest were selected. Participants signed a consent form stating that they were well enough to partake in the study (one female dropped out of the study and all her data was removed).

From the pool of subjects, two people of the same gender with nearly identical caffeine consumption were chosen and split into two different groups. Baseline measurements were collected from all subjects during the first week. During the second week, group one received NoDoz, a 100mg pure caffeine pill. Likewise, group two received 6-Hour Power during the second week, which contains approximately 125mg of caffeine in addition to supplemental additives. Measurements were taken approximately 30-45 minutes after ingestion of the supplements. In the third week, group one was given 6-Hour Power and group two was given NoDoz. Groups were split in this way to remove the bias that taking one supplement before the other could have on our results. Additionally, subjects' blood pressure was always measured first, followed by their reaction time, and finally their muscle fatigability.

Blood pressure and pulse were measured using an automatic blood pressure cuff. In order to standardize measurements, blood pressure was consistently taken on the upper left arm while the subject was in a seated position. Blood pressure was also taken before either the reaction time or force dynamometer tests to prevent blood pressure increase due to these tests. Mean arterial pressure (MAP) was calculated using the formula:

MAP = 1/3 (Systolic – Diastolic) + Diastolic.

A hand dynamometer that generated a force readout on the computer was used to measure the effects of caffeine and energy supplements on the participants' muscle fatigability. As a control, participants faced away from the computer screen and clocks so they couldn't compete with themselves or others on a week-to-week basis. Subjects then squeezed the hand dynamometer with their dominant hand as hard as they could for as long as they could. Participants were told to start grasping the hand dynamometer two seconds after recording began and were stopped once their force generation dropped to half of their original maximum force for longer than four seconds. The period of fatigue was calculated by subtracting the time it took to reach half of their maximum force from their initial force generation time.

Reaction time was calculated using an online reaction time test [8]. The participant would observe a window with a stoplight and a single button in it. The participant was told to click the button as quickly as possible immediately after the light turned green. The stoplight began red, indicating that the participant should click the button to begin the trial. After beginning, the light would change to green after a

random time interval of up to seven seconds. The stoplight would then reset to red and the participant would repeat this four more times for a total of five trials. The program then provided us with the average of their five times. During the process, the participants could not see these times, so as not to affect their subsequent weeks' trials.

Results: When comparing the treatment groups, p-values were obtained using an ANOVA single-factor test. Graphs were made using Microsoft Excel with error bars that measured the standard error of the mean.

Effects on the cardiovascular function

NoDoz caused a statistically significant ($p=0.047$) increase in SBP. 6-Hour Power caused a large, but not statistically significant ($p=0.072$) increase in SBP. While both caused increases in SBP, 6-Hour Power was shown to provide no statistically significant ($p=0.967$) difference in SBP compared to NoDoz (See Table 1 & Graph 1).

Both NoDoz and 6-Hour Power caused statistically significant ($p=0.022$ and $p=0.008$, respectively) increases in DBP. Again, however, 6-Hour Power was shown to provide no statistically significant ($p=0.706$) difference in DBP compared to NoDoz (See Table 1 & Graph 2).

Both NoDoz and 6-Hour Power also caused statistically significant ($p=0.017$ and $p=0.010$) increases in MAP. Like DBP and SBP, 6-Hour Power was shown to provide no statistically significant ($p=0.706$) difference in MAP compared to NoDoz (See Table 1 & Graph 3).

Even though NoDoz and 6-hour power both showed an increase in pulse rate compared to baseline, the differences were not found to be significant ($p=0.080$ and $p=0.296$, respectively). Similarly, 6-Hour Power did not cause a significantly ($p=0.394$) different pulse rate than NoDoz, even though NoDoz had a mean pulse rate that was 4 beats per minute less than 6-Hour Power (See Table 1 & Graph 4).

Effects on muscular function

Both NoDoz and 6-Hour Power caused statistically significant ($p=0.012$ and $p=0.002$) increases in the time it took for a subject to reach half their maximum force generation. As in the cardiovascular system, 6-Hour Power did not cause a statistically significant ($p=0.908$) difference in muscular fatigue time compared to NoDoz (See Table 1 & Graph 5).

Effects on neuronal function

Again, both NoDoz and 6-Hour Power caused significantly ($p=0.047$ and $p=0.039$) quicker reaction times (a decrease in time). However, 6-Hour Power did not cause significantly ($p=0.908$) different reaction times than NoDoz (See Table 1 & Graph 6).

Discussion: Our results are significant for two reasons. First, our data indicates a clear increase in SBP, DBP, MAP, muscle fatigability time, and a quickened reaction time. These results occurred approximately 30 minutes after caffeine ingestion, regardless of whether the caffeine came from NoDoz or 6-Hour Power. After taking 6 Hour Power, the average pulse rate was four beats/min lower than with caffeine alone. While not statistically significant, this difference could have considerable effects over a period of hours. Most importantly, however, the combination of all of our measurements showed that there was no statistically significant difference between the effects of NoDoz and the effects of 6-Hour Power. This evidence provides strong support for our hypothesis that the extra supplements in 6-Hour Power, and energy shots in general, do not provide any additional benefit to the consumer that a caffeine pill, such as NoDoz, does not provide.

That being said, further studies should be done to both re-examine and reinforce these relationships. There were clear limitations during our experiment that might have skewed our results. To begin, our sample size was only 19 subjects, which is quite small to be attempting to draw conclusions about the population as a whole. Furthermore, all subjects that partook in this experiment were from Physiology 435, an upper level class comprised mostly of juniors and seniors. Older persons tend to have a more steady reliance on caffeine in their daily routine and have

built-up a larger tolerance to the drug. While our data still showed significant increases in measured criteria despite this, the effect of caffeine tolerance on the absorption of the additional supplements in 6-Hour Power remains unknown. That said, we did inquire about caffeine consumption on our survey and most responses indicated none to low-caffeine ingestion.

Another confounding factor was the amount of other experiments occurring simultaneously with ours, of which a number of our participants were involved in before, during, and after we took our measurements each day. Although we took blood pressure measurements before the subjects exerted themselves in our own experiment, we could not account for blood pressure changes due to other experiments. Furthermore, their exhaustion from other experiments may have affected their reaction time as well as their muscle fatigability. It has also been suggested that motivational praise during the muscle fatigability test not only affects performance, but that it affects men and women differently. This was very difficult to control for as people were constantly wandering around the room peering in on different experiments.

Additionally, an attention test may have been a better measure of neuronal function than a reaction time test. Due to financial constraints, we could not implement an attention test ourselves, as the resources required to measure attention were not provided for us. Likewise, due to time constraints we were unable to gather our original group of subjects, order more 6 Hour Power, and re-test each subject under each supplement, which would require three separate sessions per additional subject. Furthermore, the original automatic blood pressure cuff was acquired from an outside source and was no longer available. Using a different automatic cuff, or taking blood pressure manually, might alter results. For all these reasons, implementing additional testing would not be reasonably feasible.

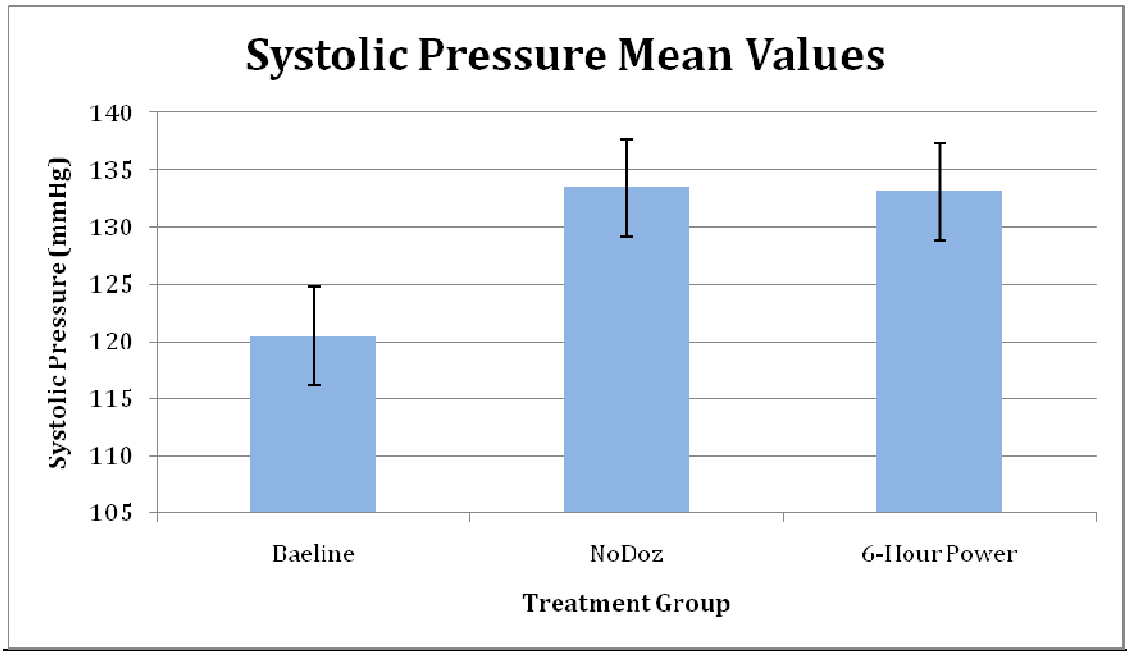
To generate more definitive results, future researchers could improve on a number of our sampling procedures. Future studies should not only use larger, but also more diverse sample sizes to provide more accurate and representative data. Additionally, studies should focus on subjects who do not regularly ingest caffeine and the experiment should attempt to control for caffeine intake outside of the experiment. Researchers should also ensure that their subjects are both isolated while taking measurements and not concurrently involved in other studies.

In addition to these improvements, a number of our methods could be altered for better results. For example, an additional treatment group could be implemented that randomizes the baseline measurements in addition to the NoDoz and 6-Hour Power measurements that we randomized. This would help to eliminate any learning effects for both the reaction time and fatigability tests. Furthermore, future studies may want to use an attention test instead of a reaction time test as a better indicator of neuronal capacity.

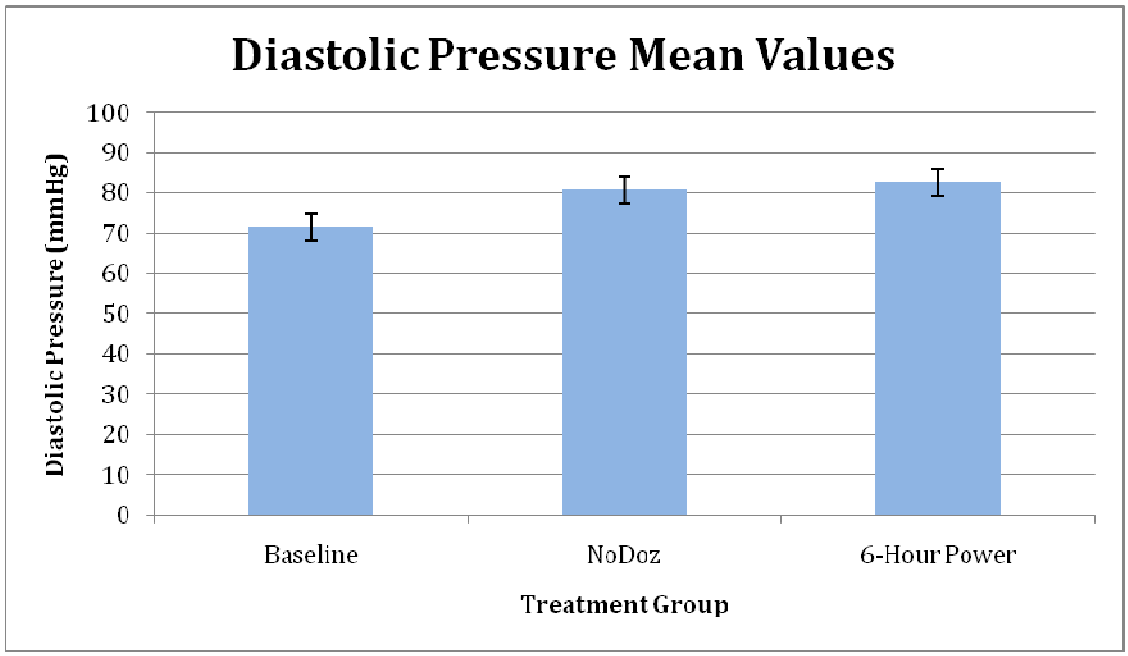
Tables and Figures:

P - values	Baseline & NoDoz	Baseline & 6-Hour Power	NoDoz & 6-Hour Power
Systolic	0.047	0.072	0.967
Diastolic	0.022	0.008	0.706
MAP	0.017	0.01	0.827
Pulse	0.08	0.296	0.394
Fatigue time	0.012	0.002	0.908
Reaction time	0.047	0.039	0.873

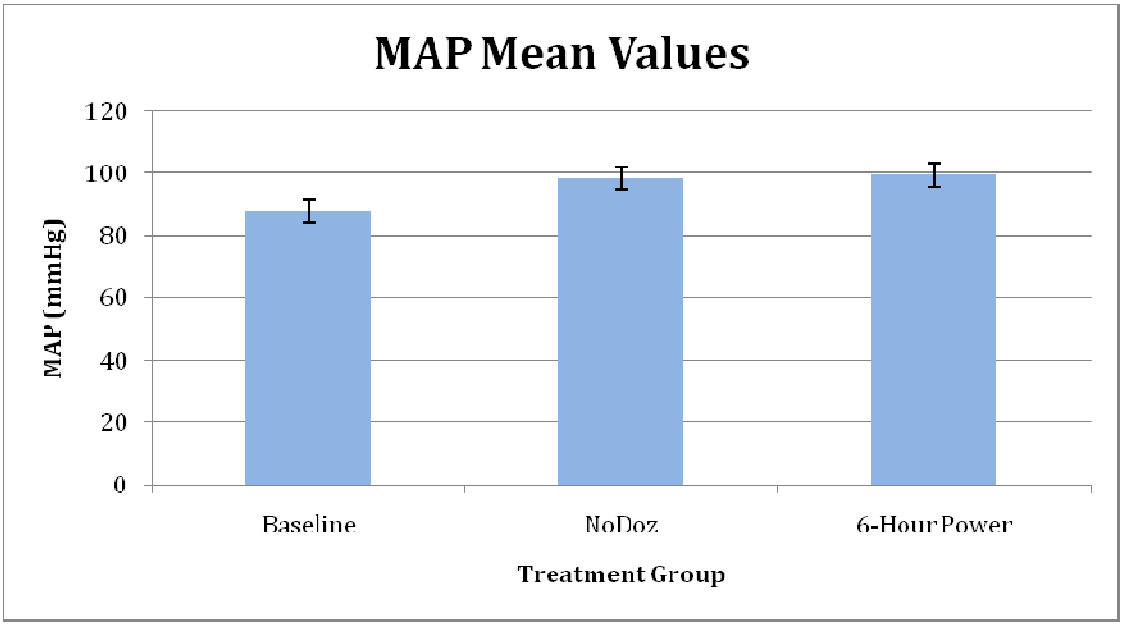
Table 1. Compilation of experimental p-values for systolic pressure, diastolic pressure, mean arterial pressure, pulse, fatigue time, and reaction time.



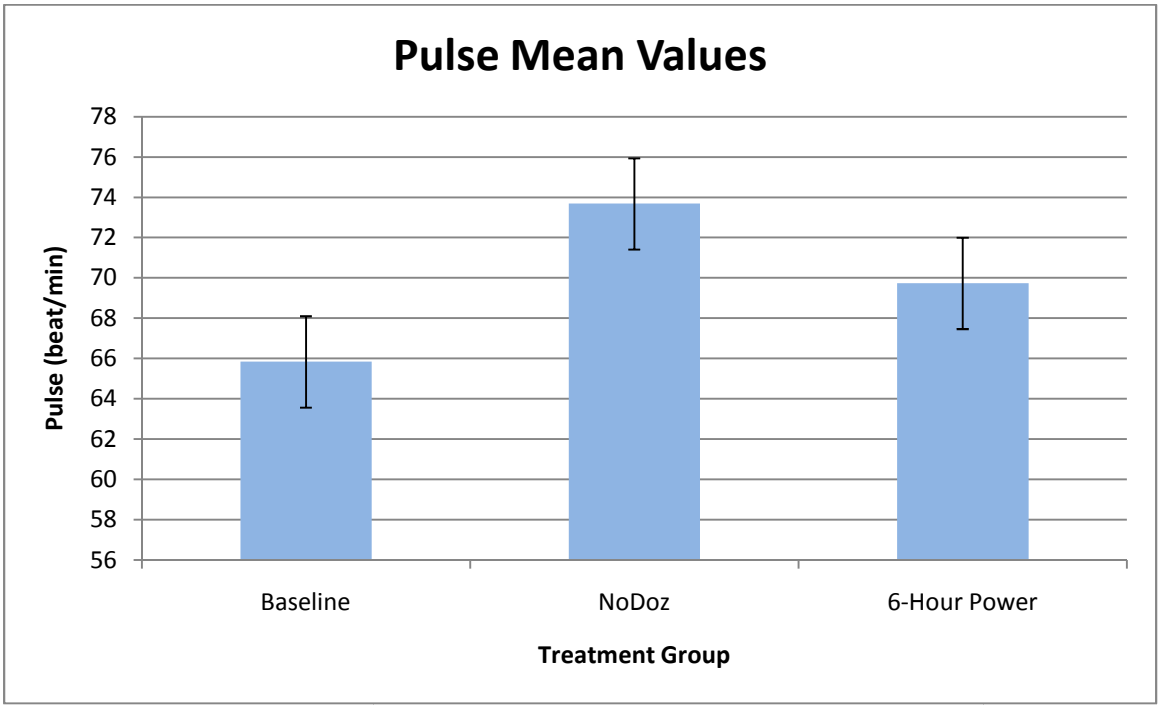
Graph 1. The mean systolic pressure for each of the three treatment groups with standard error bars.



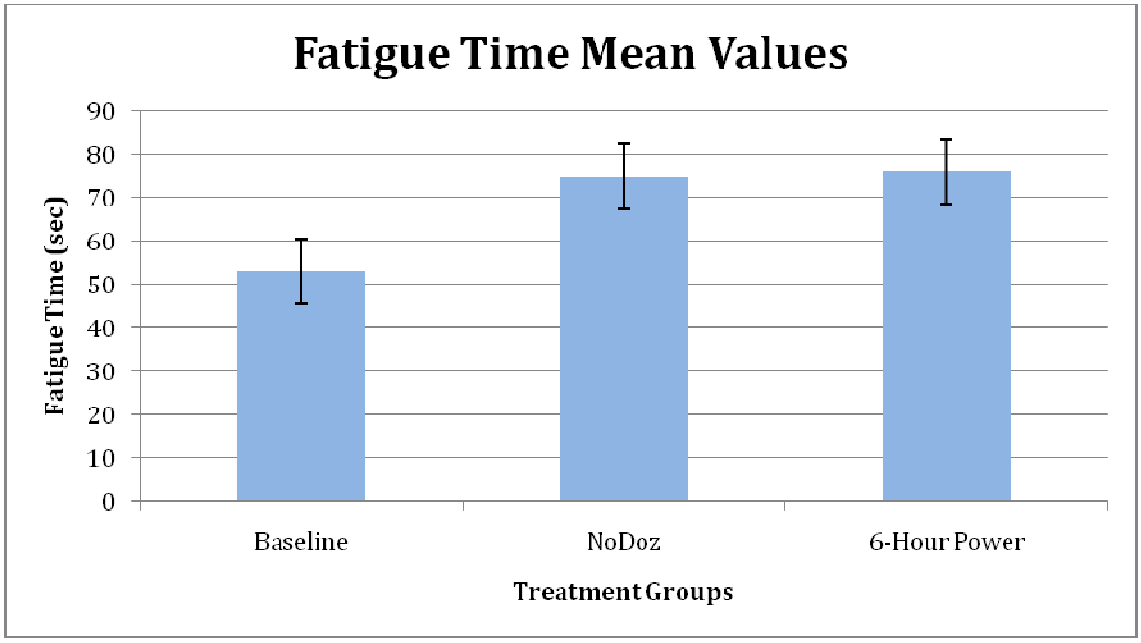
Graph 2. The mean diastolic pressure for each of the three treatment groups with standard error bars.



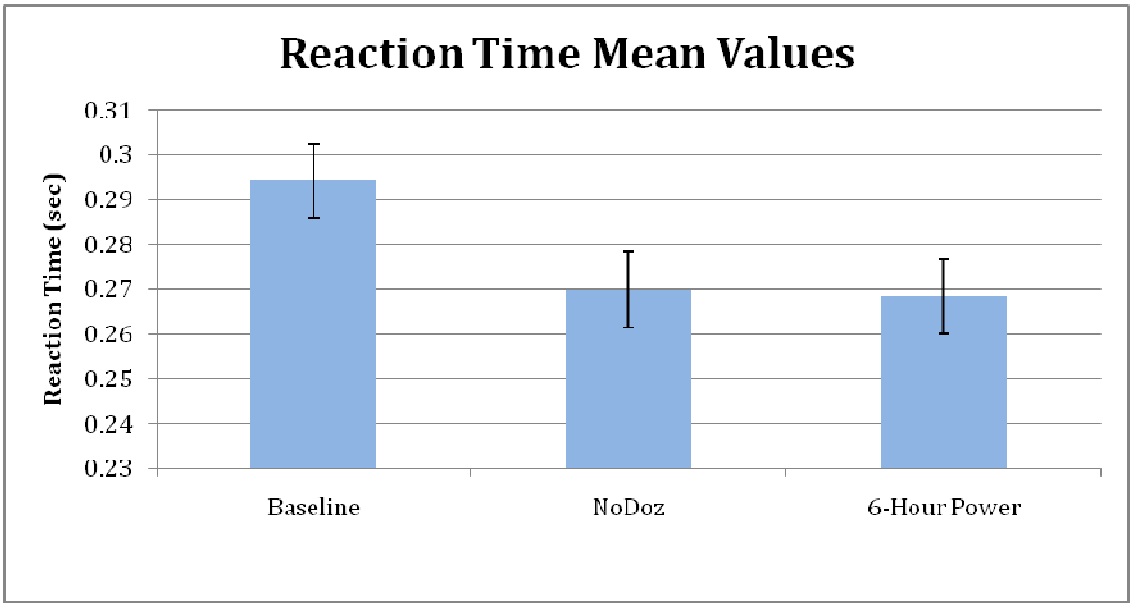
Graph 3. The mean arterial pressure for each of the three treatment groups with standard error bars.



Graph 4. The mean pulse for each of the three treatment groups with standard error bars.



Graph 5. The mean fatigue time for each of the three treatment groups with standard error bars.



Graph 6. The mean reaction time for each of the three treatment groups with standard error bars.

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