

# Science Research Project

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What is the effect of caffeine on post-exercise blood pressure?

## Abstract

Caffeine is a stimulant of the central nervous system, the cardiac muscle and the respiratory system. The effects of caffeine can be felt as soon as 15 minutes after ingestion. When ingested in small amounts, the effects of caffeine include increased heart rate, increased blood pressure and stimulation of the brain. Blood pressure is measured in millimetres of mercury (mmHg) and is recorded as two numbers – systolic and diastolic. Caffeine causes blood pressure to rise. The aim of this experiment was to determine the effect of different sources of caffeine on post-exercise blood pressure. 4 caffeinated drinks were tested – espresso coffee, Red Bull, Diet Coke and Powerade Fuel Plus. 3 test subjects of the same age and sex were used to obtain results. The experiment was repeated 3 times to determine its reliability. Espresso Coffee contained the most caffeine/mL (0.44mg/mL). Results were as predicted in the hypothesis. After 10 minutes of exercise, espresso coffee produced the largest increase in post exercise blood pressure from the control.

## Introduction

My brother is an avid coffee drinker and barista. He is also very focused on being fit and frequently goes to the gym. In addition to drinking coffee, he also drinks pre-workout caffeinated drinks and protein shakes containing caffeine. I became concerned about what the amount of caffeine he was consuming every day was doing to his health. I researched what caffeine is, and the effects it has on the body. From my findings on the internet, many sources agreed that caffeine increases brain stimulation, increases heart rate and increases blood pressure. In seeing this, I thought it would be a good idea for my science experiment to test the effect of caffeine on post-exercise blood pressure. I researched some well known caffeinated drinks and their caffeine content, and decided to use espresso coffee, Red Bull, Diet Coke and Powerade Fuel Plus.

## Aim

To determine the effect of a range of caffeinated drinks on post-exercise blood pressure.

## Hypothesis

The drink that contains the most caffeine will cause the greatest increase in post-exercise blood pressure.

## Method

The experiment was conducted on three male test subjects aged 21 years.

1. The experiment was conducted at 5pm. It was ensured the test subject was wearing suitable clothing for cycling and the exercise bike was adjusted correctly to be used.

2. The test subject was sitting with his feet flat on the ground in preparation for a resting blood pressure reading to be taken.

3. The sphygmomanometer's inflatable pressure cuff was wrapped around the upper arm, in the appropriate place; 2cm above the bend of the elbow of the test subject (see Figure 1).

4. A resting blood pressure reading was taken and recorded.

5. The test subject drank 200mL of water. After 5 minutes, another resting blood pressure was taken.

6. 15 minutes after drinking 200mL of water, another resting blood pressure reading was taken and recorded.

7. Immediately following the blood pressure reading, the test subject rode the exercise bike at intensity level 3 for 10 minutes, at a cadence of 100 revolutions per minute (see Figure 2).

8. At the conclusion of the 10 minute period, a blood pressure reading was taken and recorded.

9. A blood pressure reading was taken after a further 5 minutes.

10. Steps 2-9 were repeated on 2 further occasions on another 2 subjects, at 5pm, on different days.

11. The experiment was repeated using 200mL of Powerade Fuel Plus, 200mL of Diet Coke, 200mL of Red Bull and 200mL of Espresso Coffee, at 5pm on different days (see Figure 3).

12. The results of the experiment were tabulated and graphed.



Figure 1 – Blood Pressure being measured by the sphygmomanometer



Figure 2 - Test subject NS completing experiment



Figure 3 - Drinks used in experiment – Espresso coffee, Diet Coke, Red Bull, Powerade

## Results

### Summary – Subject NS

Systolic Blood Pressure					
Time	Control	Diet Coke	Red Bull	Coffee	Powerade Fuel Plus
0	125	126	128	128	129
5	128	130	128	135	134
15	146	150	158	173	156
20	124	132	136	139	135

Percent Change in Systolic Blood Pressure vs. Control					
Time	Control	Diet Coke	Red Bull	Coffee	Powerade Fuel Plus
0	0.00%	0.53%	2.13%	2.13%	2.93%
5	0.00%	1.56%	0.26%	5.73%	4.95%
15	0.00%	3.20%	8.47%	18.76%	6.86%
20	0.00%	5.90%	9.38%	11.53%	8.58%

Diastolic Blood Pressure					
Time	Control	Diet Coke	Red Bull	Coffee	Powerade Fuel Plus
0	61	63	62	65	60
5	63	63	64	66	65
15	68	69	70	73	70
20	64	64	67	67	63

Percent Change in Diastolic Blood Pressure vs. Control					
Time	Control	Diet Coke	Red Bull	Coffee	Powerade Fuel Plus
0	0.00%	2.73%	1.64%	6.56%	-1.09%
5	0.00%	0.00%	1.59%	5.29%	3.70%
15	0.00%	1.46%	2.44%	6.34%	2.93%
20	0.00%	1.05%	5.76%	5.24%	-0.52%

Summary – Subject HL

Systolic Blood Pressure					
Time	Control	Diet Coke	Red Bull	Coffee	Powerade Fuel Plus
0	131	131	131	131	130
5	130	131	130	135	131
15	147	151	159	175	158
20	134	134	140	139	135

Percent Change in Systolic Blood Pressure vs. Control					
Time	Control	Diet Coke	Red Bull	Coffee	Powerade Fuel Plus
0	0.00%	-0.51%	-0.51%	-0.51%	-0.76%
5	0.00%	1.03%	0.00%	4.11%	1.29%
15	0.00%	2.71%	7.69%	18.55%	7.24%
20	0.00%	0.00%	4.74%	3.99%	1.00%

Diastolic Blood Pressure					
Time	Control	Diet Coke	Red Bull	Coffee	Powerade Fuel Plus
0	70	71	72	70	70
5	72	72	73	71	72
15	78	78	81	82	81
20	71	73	76	75	75

Percent Change in Diastolic Blood Pressure vs. Control					
Time	Control	Diet Coke	Red Bull	Coffee	Powerade Fuel Plus
0	0.00%	0.95%	1.90%	0.00%	0.00%
5	0.00%	0.46%	0.93%	-0.93%	0.46%
15	0.00%	0.00%	3.86%	5.58%	3.86%
20	0.00%	3.30%	8.02%	6.13%	5.66%

Summary – Subject OR

Systolic Blood Pressure					
Time	Control	Diet Coke	Red Bull	Coffee	Powerade Fuel Plus
0	118	121	119	120	120
5	119	121	122	121	122
15	139	144	150	165	148
20	119	125	125	136	125

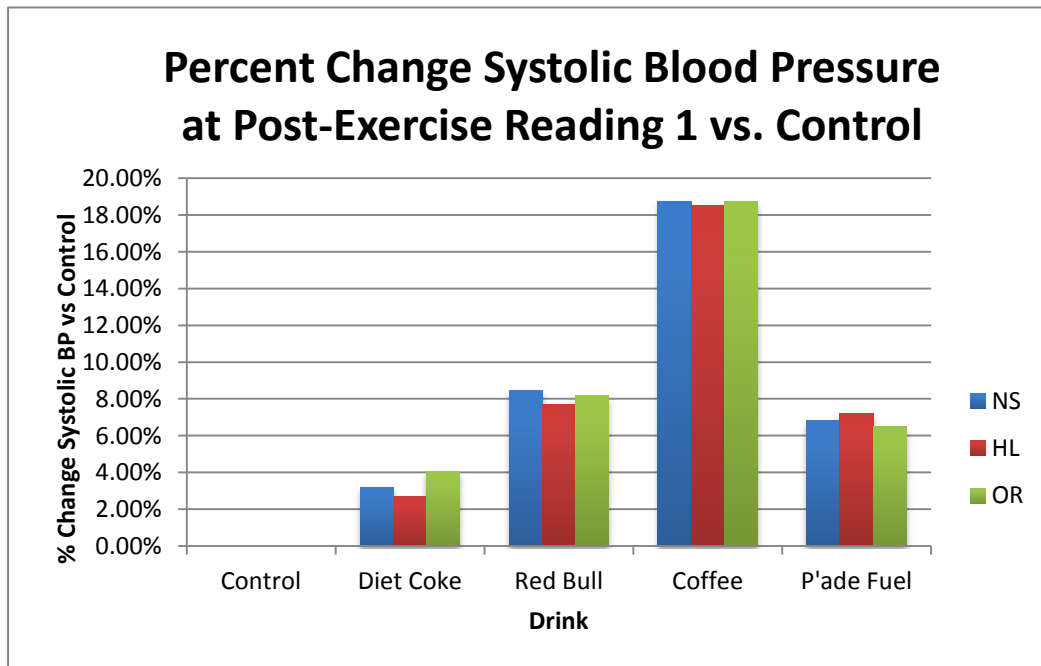
Percent Change in Systolic Blood Pressure vs. Control					
Time	Control	Diet Coke	Red Bull	Coffee	Powerade Fuel Plus
0	0.00%	2.26%	1.13%	1.69%	1.98%
5	0.00%	1.40%	2.51%	1.68%	2.23%
15	0.00%	4.09%	8.17%	18.75%	6.49%
20	0.00%	4.47%	4.75%	14.25%	4.75%

Diastolic Blood Pressure					
Time	Control	Diet Coke	Red Bull	Coffee	Powerade Fuel Plus
0	60	60	60	60	61
5	61	60	61	63	60
15	68	69	71	73	71
20	62	63	66	66	65

Percent Change in Diastolic Blood Pressure vs. Control					
Time	Control	Diet Coke	Red Bull	Coffee	Powerade Fuel Plus
0	0.00%	-0.56%	-0.56%	-0.56%	1.11%
5	0.00%	-0.55%	1.10%	3.30%	-0.55%
15	0.00%	0.98%	4.41%	6.86%	3.92%
20	0.00%	1.61%	5.91%	5.91%	4.84%

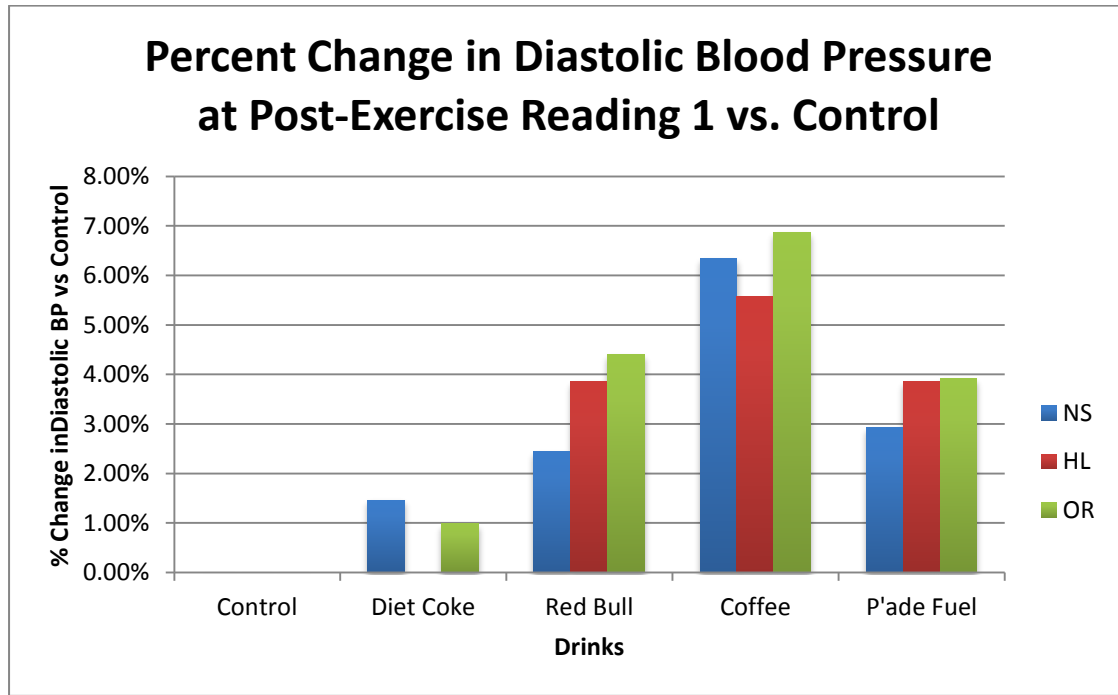
**Percent Change in Systolic Blood Pressure at Post-Exercise Reading 1 vs. Control**

Subject	Control	Diet Coke	Red Bull	Coffee	Powerade Fuel Plus
NS	0.00%	3.20%	8.47%	18.76%	6.86%
HL	0.00%	2.71%	7.69%	18.55%	7.24%
OR	0.00%	4.09%	8.17%	18.75%	6.49%



**Percent Change in Diastolic Blood Pressure at Post-Exercise Reading 1 vs. Control**

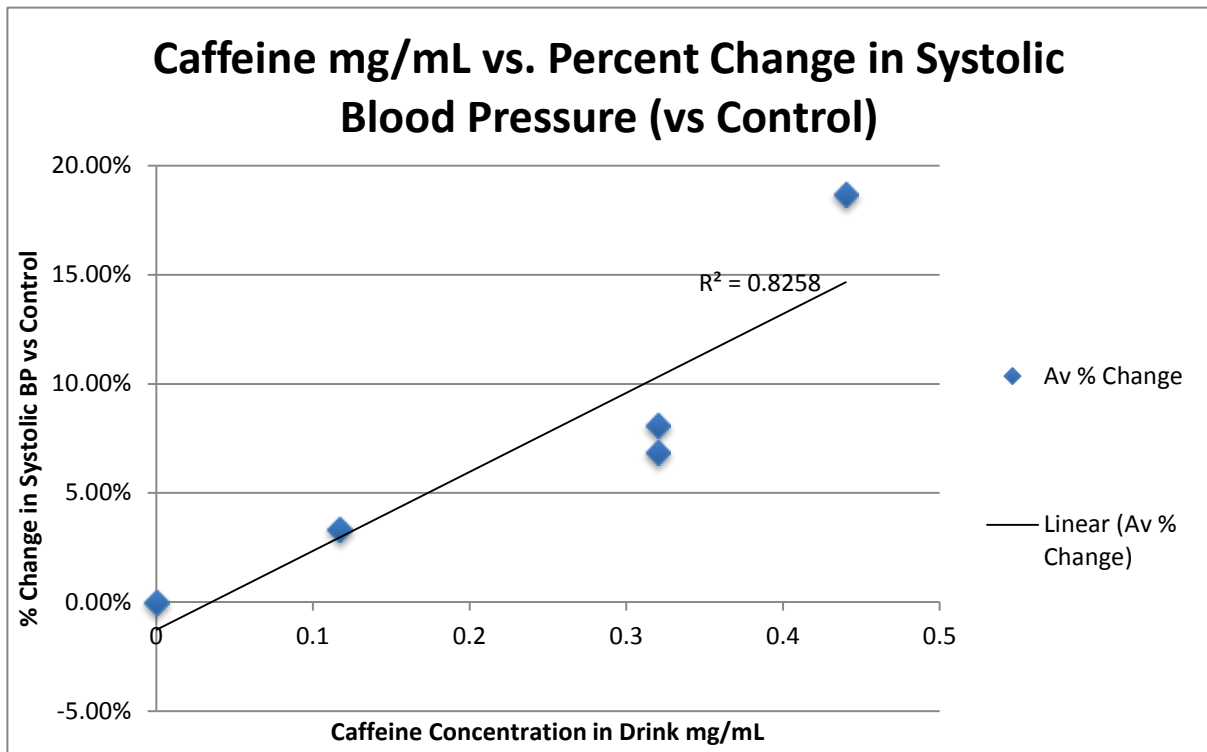
Subject	Control	Diet Coke	Red Bull	Coffee	Powerade Fuel Plus
NS	0.00%	1.46%	2.44%	6.34%	2.93%
HL	0.00%	0.00%	3.86%	5.58%	3.86%
OR	0.00%	0.98%	4.41%	6.86%	3.92%





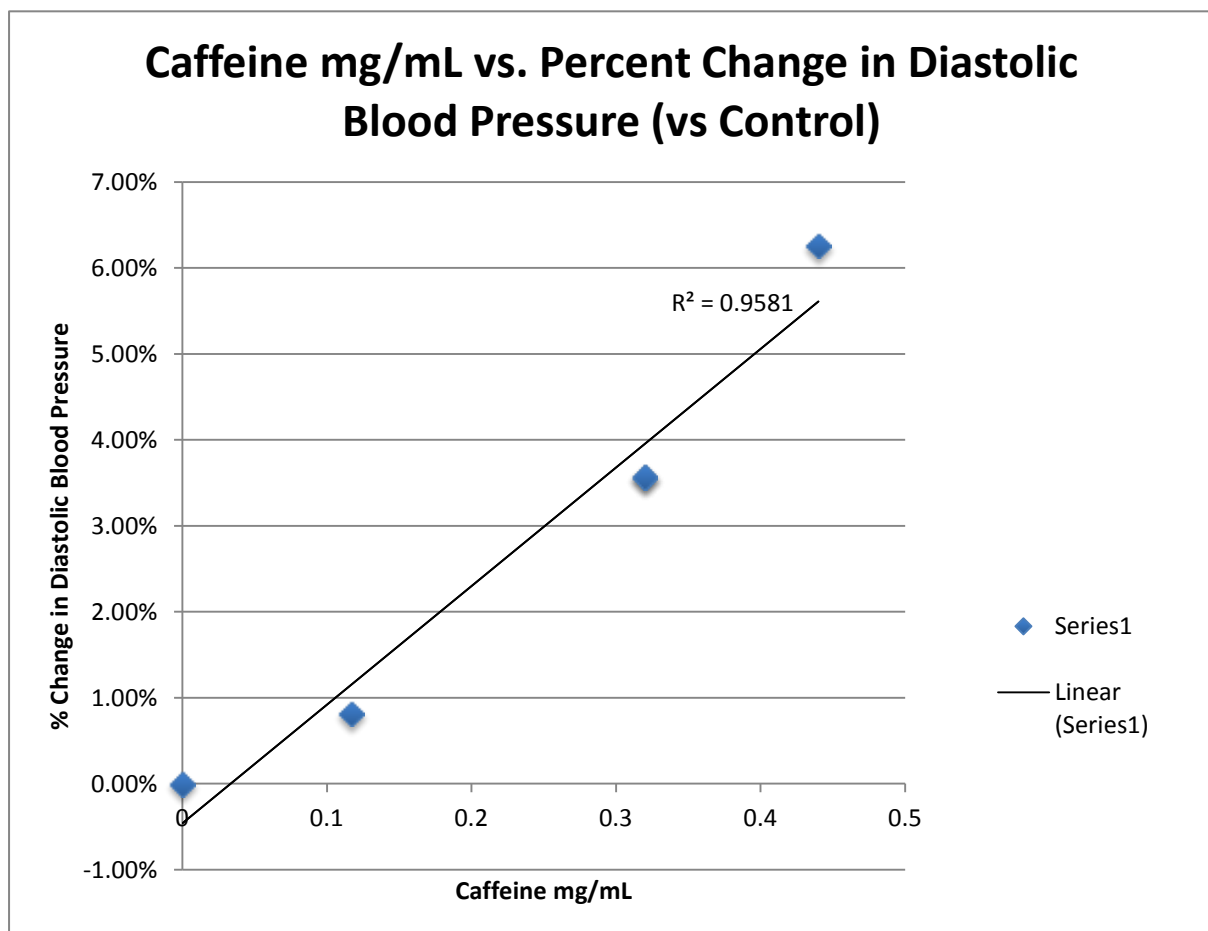
### Caffeine Concentration vs. Maximum Change in Systolic Blood Pressure

Drink	Caffeine Concentration mg/mL	Av % Change
Control	0	0.00%
Diet Coke	0.117	3.34%
Powerade	0.32	6.87%
Red Bull	0.32	8.11%
Coffee	0.44	18.69%



### Caffeine Concentration vs. Maximum Change in Diastolic Blood Pressure

Drink	Caffeine Concentration mg/mL	Av % Change
Control	0	0.00%
Diet Coke	0.117	0.81%
Powerade	0.32	3.57%
Red Bull	0.32	3.57%
Coffee	0.44	6.26%



For raw data, see appendix.

### Discussion

The results support the hypothesis. The table titled 'Percentage Change in Systolic Blood Pressure at Post-Exercise vs. Control' showed that after 10 minutes of exercise, the drink that produced the highest percentage increase over control in systolic blood pressure was espresso coffee (NS – 18.76%, HL – 18.55%, OR – 18.75%). The table titled 'Percentage Change in Diastolic Blood Pressure at Post-

Exercise vs. Control' showed that after 10 minutes of exercise, the drink that produced the highest percentage increase in diastolic blood pressure over control was espresso coffee (NS – 6.34%, HL – 5.58%, OR – 6.86%).

Coffee contained the most caffeine (0.44mg/mL), and, shown in the results tables of subject NS, HL and OR, produced the largest increase of systolic and diastolic blood pressure from the control. On average, blood pressure increased from 144/71 (control) to 171/76 (coffee). The caffeine content of the espresso coffee used was an approximation – it is a difficult quantity to standardise.

Powerade Fuel Plus and Red Bull both contained the same amount of caffeine (0.32mg/mL) and produced a moderate increase of blood pressure from the control. On average, blood pressure increased from 144/71 (control) to 156/74 (Red Bull) and 154/74 (Powerade Fuel Plus).

Diet Coke contained a minimal amount of caffeine (0.117mg/mL) , and only produced a small increase of blood pressure from the control. On average, blood pressure increased from 144/71 (control) to 145/72.

By repeating the experiment three times and averaging out the results, the experiment was fair and allowed for the reliability of the experiment to be determined.

The  $r^2$  value of the trendline was included in the graphs titled 'Caffeine mg/mL vs. Percent Change in Systolic Blood Pressure (vs. Control)' and 'Caffeine mg/mL vs. Percent Change in Diastolic Blood Pressure (vs. Control)' indicates the relationship between the caffeine concentration of drinks and the percentage increase in systolic and diastolic blood pressure.

Accurate equipment (sphygmomanometer) was used to measure blood pressure (mmHg), an experimental variable. A stopwatch was used to measure the time intervals accurately. The variables previously identified were controlled in the experiment, making the experiment valid. The variables controlled were:

- Same age and sex of test subjects used
- Same volume of drink consumed by test subject
- Experiment conducted at same time of day
- Experiment conducted on the same exercise bike
- Experiment conducted with the same cadence (the rate at which the cyclist is pedalling)
- Experiment conducted on same intensity setting on the exercise bike
- Experiment conducted over same time duration
- Blood pressure readings taken at the same time intervals

- Blood pressure readings taken with the cuff correctly fitted at the same place on upper arm

The subjects used were of the same age and sex; however their body masses and blood pressure varied more than 10%. To minimise the variability of the results and to make them comparable, the percentage change in systolic and diastolic blood pressure after 10 minutes of exercise was graphed.

The information this experiment was based on is reliable. All secondary sources that were used in the research report came from reputable sites and were recent documents. The information found in these sources was substantiated in more than one other reliable source used.

Originally, my method stated that I would wait 45 minutes after caffeine ingestion for the subject to start riding the exercise bike. After re-reading my research, however, I decided to reduce the time to 15 minutes after caffeine ingestion for the subject to start riding the exercise bike. Biology Online, 2007, states that “peak plasma caffeine concentration is reached between 15 and 120 minutes after oral ingestion in humans.” Everydiet.org, 2013, suggests that caffeine is absorbed quickly by the body, however the effects of caffeine can be felt as soon as 15 minutes after ingestion. Drug Info, 2011, states that “caffeine takes 5-30 minutes to circulate in the body after it has been consumed.” These secondary sources agree with each other, presenting reliable information.

To improve this experiment, a larger number of caffeinated drinks containing varying amounts of caffeine could be used. Also, a larger sample size of the same age group and sex could be used. Repeating the experiment more times would further determine the reliability of the experiment.

For further investigation, the experiment could be repeated using a different age group of the same sex used in the experiment to test whether the results would be the same among all age groups of the same sex. The experiment could also be repeated using the same age group but of the opposite sex, to test whether there are trends evident related to sex.

### Conclusion

The drink that contained the most caffeine (espresso coffee) caused the greatest increase in post-exercise systolic and diastolic blood pressure.

## References

- Australian Government. 2002. *Australian Institute of Health and Welfare*. [ONLINE] Available at: <http://meteor.aihw.gov.au/content/index.phtml/itemId/270073> [Accessed 03 February 2013].
- Australian Institute of Sport. 2012. *Caffeine Supplement Overview*. [ONLINE] Available at: [http://www.ausport.gov.au/\\_data/assets/pdf\\_file/0003/469650/Caffeine\\_11-website\\_fact\\_sheet.pdf](http://www.ausport.gov.au/_data/assets/pdf_file/0003/469650/Caffeine_11-website_fact_sheet.pdf) [Accessed 02 February 2013].
- Better Health Channel. 2012. *Blood Pressure*. [ONLINE] Available at: [http://www.betterhealth.vic.gov.au/bhcv2/bhcarticles.nsf/pages/Blood\\_pressure\\_explained](http://www.betterhealth.vic.gov.au/bhcv2/bhcarticles.nsf/pages/Blood_pressure_explained) [Accessed 02 February 2013].
- Biology Online. 2007. *Consumption and Metabolism of Caffeine*. [ONLINE] Available at: [http://www.biology-online.org/articles/actions\\_caffeine\\_brain\\_special/consumption\\_metabolism\\_caffeine.html](http://www.biology-online.org/articles/actions_caffeine_brain_special/consumption_metabolism_caffeine.html) [Accessed 02 February 2013].
- Drug Info. 2011. *Caffeine Facts*. [ONLINE]. Available at: <http://www.druginfo.adf.org.au/drug-facts/caffeine> [Accessed 02 February 2013].
- everydiet. 2013. *Effects of Caffeine*. [ONLINE] Available at: <http://www.everydiet.org/994/coffee-caffeine-and-its-effects-in-the-human-body> [Accessed 02 February 13].
- Kidshealth. Teens Health. 2011. *Caffeine*. [ONLINE] Available at: [http://kidshealth.org/teen/food\\_fitness/nutrition/caffeine.html#](http://kidshealth.org/teen/food_fitness/nutrition/caffeine.html#) [Accessed 02 February 13].
- NSW Government Health. 2007. *Caffeine*. [ONLINE] Available at: <http://www0.health.nsw.gov.au/factsheets/drugandalcohol/caffeine.html> [Accessed 02 February 13]
- Providence Health and Services. 2010. *Ask an expert: How does caffeine affect the heart?* [ONLINE] Available at: <http://oregon.providence.org/patients/programs/providence-heart-and-vascular-institute/Pages/askanexpertlanding.aspx?TemplateName=Ask+an+Expert%3A+How+does+caffeine+affect+the+heart%3F&TemplateType=AskAnExpert> [Accessed 02 February 13].

## Appendix

### Control

Subject	NS	Date	13-Feb
	Time	Systolic	Diastolic
	0	126	62
	5	127	63
	15	148	69
	20	124	64

Subject	NS	Date	14-Feb
	Time	Systolic	Diastolic
	0	125	60
	5	129	62
	15	145	68
	20	125	63

Subject	NS	Date	15-Feb
	Time	Systolic	Diastolic
	0	125	61
	5	128	64
	15	144	68
	20	124	64

<b>Average</b>			
Subject	NS	Date	N/A
	Time	Systolic	Diastolic
	0	125	61
	5	128	63
	15	146	68
	20	124	64

Subject	HL	Date	16-Feb
	Time	Systolic	Diastolic
	0	131	71
	5	127	71
	15	147	75
	20	132	71

Subject	HL	Date	17-Feb
	Time	Systolic	Diastolic
	0	133	72
	5	130	72
	15	148	79
	20	136	72

Subject	HL	Date	18-Feb
	Time	Systolic	Diastolic
	0	130	68
	5	132	73
	15	147	79
	20	133	69

<b>Average</b>			
Subject	HL	Date	N/A
	Time	Systolic	Diastolic
	0	131	70
	5	130	72
	15	147	78
	20	134	71

Subject	OR	Date	19-Feb
	Time	Systolic	Diastolic
	0	118	60
	5	119	60
	15	138	68
	20	117	63

Subject	OR	Date	20-Feb
	Time	Systolic	Diastolic
	0	117	61
	5	119	62
	15	137	69
	20	120	61

Subject	OR	Date	21-Feb
	Time	Systolic	Diastolic
	0	119	59
	5	120	60
	15	141	67
	20	121	62

<b>Average</b>			
Subject	OR	Date	N/A
	Time	Systolic	Diastolic
	0	118	60
	5	119	61
	15	139	68
	20	119	62

**Diet Coke**

Subject	NS	Date	22-Feb
	Time	Systolic	Diastolic
	0	127	63
	5	130	63
	15	150	70
	20	134	64

Subject	NS	Date	23-Feb
	Time	Systolic	Diastolic
	0	126	62
	5	130	62
	15	149	69
	20	131	65

Subject	NS	Date	24-Feb
	Time	Systolic	Diastolic
	0	125	63
	5	130	64
	15	152	69
	20	130	64

<b>Average</b>			
Subject	NS	Date	N/A
	Time	Systolic	Diastolic
	0	126	63
	5	130	63
	15	150	69
	20	132	64



Subject	HL	Date	25-Feb
	Time	Systolic	Diastolic
	0	131	71
	5	132	72
	15	152	77
	20	133	74

Subject	HL	Date	26-Feb
	Time	Systolic	Diastolic
	0	129	72
	5	132	73
	15	151	78
	20	135	75

Subject	HL	Date	27-Feb
	Time	Systolic	Diastolic
	0	132	70
	5	129	72
	15	151	78
	20	133	70

<b>Average</b>			
Subject	HL	Date	N/A
	Time	Systolic	Diastolic
	0	131	71
	5	131	72
	15	151	78
	20	134	73

Subject	OR	Date	28-Feb
	Time	Systolic	Diastolic
	0	121	61
	5	120	60
	15	140	69
	20	122	62

Subject	OR	Date	1-Mar
	Time	Systolic	Diastolic
	0	122	60
	5	121	60
	15	145	70
	20	125	63

Subject	OR	Date	2-Mar
	Time	Systolic	Diastolic
	0	119	58
	5	122	61
	15	148	67
	20	127	64

<b>Average</b>			
Subject	OR	Date	N/A
	Time	Systolic	Diastolic
	0	121	60
	5	121	60
	15	144	69
	20	125	63

### Red Bull

Subject	NS	Date	3-Mar
	Time	Systolic	Diastolic
	0	127	60
	5	128	62
	15	157	72
	20	137	67

Subject	NS	Date	4-Mar
	Time	Systolic	Diastolic
	0	129	62
	5	127	69
	15	158	68
	20	136	66

Subject	NS	Date	5-Mar
	Time	Systolic	Diastolic
	0	128	64
	5	130	61
	15	159	70
	20	135	69

<b>Average</b>			
Subject	NS	Date	N/A
	Time	Systolic	Diastolic
	0	128	62
	5	128	64
	15	158	70
	20	136	67

Subject	HL	Date	6-Mar
	Time	Systolic	Diastolic
	0	129	73
	5	129	74
	15	159	80
	20	139	75

Subject	HL	Date	7-Mar
	Time	Systolic	Diastolic
	0	133	72
	5	130	72
	15	160	80
	20	141	75

Subject	HL	Date	8-Mar
	Time	Systolic	Diastolic
	0	130	70
	5	130	72
	15	157	82
	20	140	79

<b>Average</b>			
Subject	HL	Date	N/A
	Time	Systolic	Diastolic
	0	131	72
	5	130	73
	15	159	81
	20	140	76

Subject	OR	Date	9-Mar
	Time	Systolic	Diastolic
	0	119	60
	5	124	62
	15	150	70
	20	125	65

Subject	OR	Date	10-Mar
		Systolic	Diastolic
	0	120	61
	5	121	62
	15	149	71
	20	123	65

Subject	OR	Date	11-Mar
		Systolic	Diastolic
	0	119	58
	5	122	60
	15	151	72
	20	127	67

<b>Average</b>			
Subject	OR	Date	N/A
	Time	Systolic	Diastolic
	0	119	60
	5	122	61
	15	150	71
	20	125	66

### Coffee

Subject	NS	Date	12-Mar
	Time	Systolic	Diastolic
	0	129	62
	5	135	64
	15	174	73
	20	138	66

Subject	NS	Date	13-Mar
	Time	Systolic	Diastolic
	0	128	68
	5	137	66
	15	172	72
	20	140	68

Subject	NS	Date	14-Mar
	Time	Systolic	Diastolic
	0	127	65
	5	134	69
	15	173	73
	20	138	67

<b>Average</b>			
Subject	NS	Date	N/A
	Time	Systolic	Diastolic
	0	128	65
	5	135	66
	15	173	73
	20	139	67

Subject	HL	Date	15-Mar
	Time	Systolic	Diastolic
	0	130	70
	5	135	71
	15	173	81
	20	139	75

Subject	HL	Date	16-Mar
	Time	Systolic	Diastolic
	0	129	69
	5	137	74
	15	175	82
	20	140	75

Subject	HL	Date	17-Mar
	Time	Systolic	Diastolic
	0	133	72
	5	133	69
	15	176	83
	20	138	75

<b>Average</b>			
Subject	HL	Date	N/A
	Time	Systolic	Diastolic
	0	131	70
	5	135	71
	15	175	82
	20	139	75

Subject	OR	Date	18-Mar
	Time	Systolic	Diastolic
	0	125	56
	5	125	60
	15	165	72
	20	139	68

Subject	OR	Date	19-Mar
	Time	Systolic	Diastolic
	0	118	62
	5	119	66
	15	164	73
	20	135	65

Subject	OR	Date	20-Mar
		Systolic	Diastolic
	0	117	61
	5	120	62
	15	165	73
	20	135	64

<b>Average</b>			
Subject	OR	Date	N/A
	Time	Systolic	Diastolic
	0	120	60
	5	121	63
	15	165	73
	20	136	66

Powerade Fuel Plus

Subject	NS	Date	21-Mar
	Time	Systolic	Diastolic
	0	127	60
	5	135	70
	15	158	70
	20	136	63

Subject	NS	Date	22-Mar
	Time	Systolic	Diastolic
	0	131	60
	5	134	64
	15	154	69
	20	134	63

Subject	NS	Date	23-Mar
	Time	Systolic	Diastolic
	0	129	61
	5	134	62
	15	155	72
	20	135	64

<b>Average</b>			
Subject	NS	Date	N/A
	Time	Systolic	Diastolic
	0	129	60
	5	134	65
	15	156	70
	20	135	63

Subject	HL	Date	24-Mar
	Time	Systolic	Diastolic
	0	131	70
	5	133	75
	15	156	80
	20	138	75

Subject	HL	Date	25-Mar
	Time	Systolic	Diastolic
	0	131	72
	5	131	72
	15	160	80
	20	133	75

Subject	HL	Date	26-Mar
	Time	Systolic	Diastolic
	0	129	69
	5	130	70
	15	158	82
	20	134	74

<b>Average</b>			
Subject	HL	Date	N/A
	Time	Systolic	Diastolic
	0	130	70
	5	131	72
	15	158	81
	20	135	75

Subject	OR	Date	27-Mar
	Time	Systolic	Diastolic
	0	120	65
	5	124	66
	15	145	72
	20	125	70

Subject	OR	Date	28-Mar
	Time	Systolic	Diastolic
	0	118	57
	5	120	57
	15	148	71
	20	123	60

Subject	OR	Date	29-Mar
	Time	Systolic	Diastolic
	0	123	60
	5	122	58
	15	150	69
	20	127	65



<b>Average</b>			
Subject	OR	Date	N/A
	Time	Systolic	Diastolic
	0	120	61
	5	122	60
	15	148	71
	20	125	65