

Does Name Brand Make a Difference in OTC Pain Medications?



Introduction:

People everywhere rely on over-the-counter pain medications to relieve their pain from headaches, injuries, chronic aches, and so many other ailments. When going to buy these medications, many people end up asking themselves if it's really worth it to spend more money on the name brand medications rather than the generic off brands. There are several different active ingredients that can be put in pain medications, including acetaminophen, ibuprofen, and aspirin. For each of these active ingredients, there are a few very common brands for each drug and several alternative brands for each drug. In this experiment, I will be testing Tylenol as the name brand against Equate as the alternative brand for pain relievers with acetaminophen as the active ingredient. Equate brand acetaminophen runs for \$3.84 per bottle of 200 caplets with 500 mg of acetaminophen per caplet, which is equivalent to \$0.0192 per caplet. Tylenol brand acetaminophen runs for \$14.97 per bottle of 225 caplets with 500 mg of acetaminophen per caplet, which is equivalent to \$0.0665. The Tylenol brand acetaminophen is over three times more expensive than the Equate brand acetaminophen, despite both brands having the same dosage per caplet.

Statistical Question:

Do name brand over-the-counter pain medications (Tylenol) have a significantly lower mean disintegration time in seconds than their generic brand equivalents (Equate)?

$$H_o: \mu_T = \mu_E$$

$$H_a: \mu_T < \mu_E$$

$$\alpha = 0.05$$

Where... μ_T = the true mean time (in seconds) it takes for one 500 mg caplet of Tylenol Extra Strength Acetaminophen to fully disintegrate into a powder in simulated stomach acid

μ_E = the true mean time (in seconds) it takes for one 500 mg caplet of Equate Extra Strength Acetaminophen to fully disintegrate into a powder in simulated stomach acid

Data Collection:

For my samples, I bought one bottle (containing 200 caplets) of Equate Extra Strength 500 mg Acetaminophen and one bottle (containing 225 caplets) of Tylenol Extra Strength 500 mg Acetaminophen. It was important to obtain both medications with the same dosage (500 mg) and as many similar qualities as possible to reduce variability. The two medications are very similar in size and shape, and neither caplet has an outer coating (see enlarged image below). In order to satisfy the condition of randomization, I shook up each bottle, removed one pill from the middle of the top layer, put the lid back on, and repeated these steps until I had five pills of each medication. For this process, I also used gloves and sterile surfaces to try to minimize getting any residue on the pills that might alter their ability to dissolve. Next, I mixed together 3,000 ml of distilled water and 26 ml of 9.47 M hydrochloric acid (Muriatic acid) to replicate the environment of a human stomach as best as I could with the resources available to me (this ratio was determined by researching the Molarity of HCl in a human stomach, which is roughly .08M). This dilution resulted in a pH within the range 1-3, which corresponds with that of a

human stomach. The dilution was done in a larger container first before being evenly distributed to each of ten glasses. This ensures that the concentration of hydrochloric acid in each glass is nearly identical. Once everything was set up, I, with the help of two assistants, dropped the five Tylenol pills into five glasses, started a timer, and stirred constantly. Watching the pills closely, I waited until there were no noticeably large pieces of the pill left in the glass to record each of their times in seconds. In other words, I waited until there seemed to be only powder left in the solution to record the time. I only did five pills at once so that I could watch more closely. Since each of the glasses was filled from the same original mixture and each pill is independent of the others, there was no need for random assignment of the order in which I tested the medications. After completing the tests with Tylenol, I repeated the process with Equate.



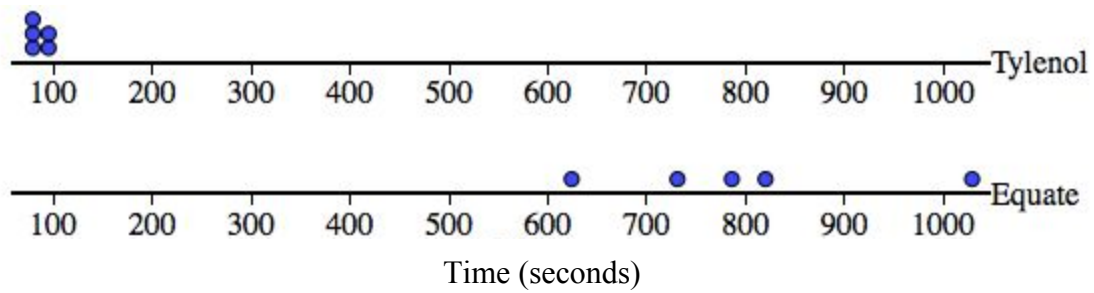
Data Display:

Disintegration Times (sec)	
Tylenol	Equate
99	1,029
82	731
76	786
79	624
91	820

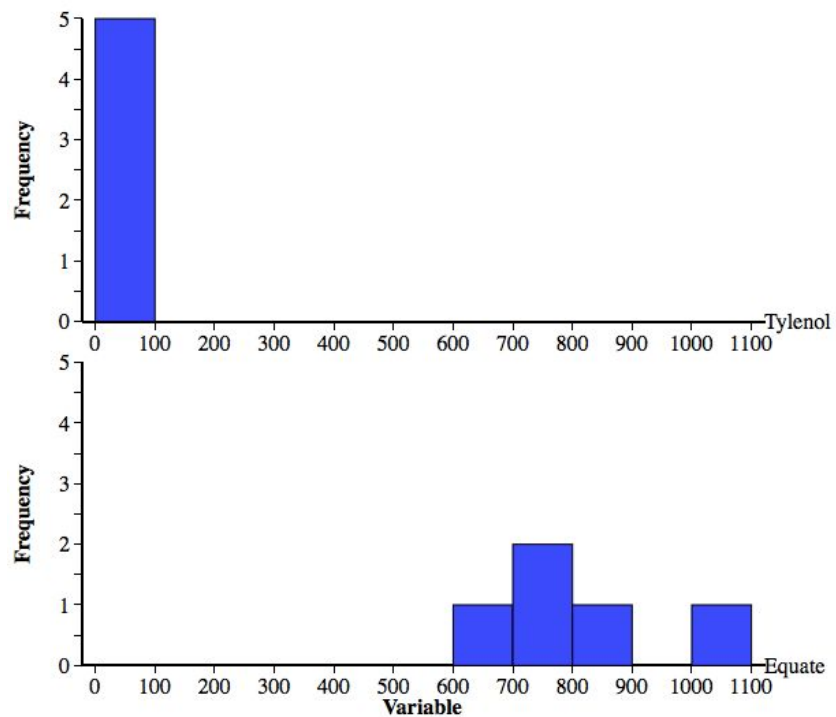
Summary Statistics

Group Name	n	mean	SD	min	Q ₁	med	Q ₃	max
1: Tylenol	5	85.4	9.45	76	77.5	82	95	99
2: Equate	5	798	148.958	624	677.5	786	924.5	1029

Dotplots

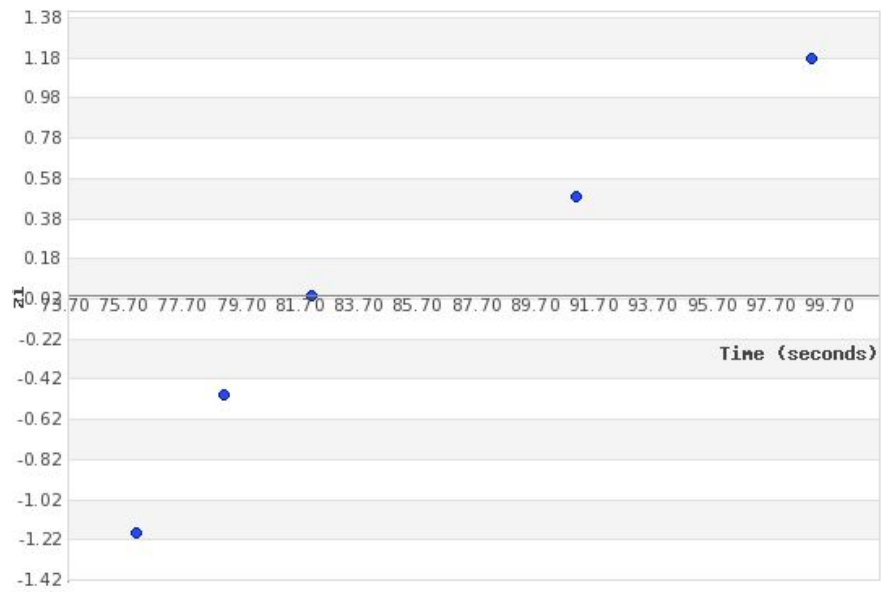


Histograms



Normal Probability Plots

Tylenol



Equate



The two distributions have very clear differences. The distribution for Tylenol disintegration times has a center of $\bar{x} = 85.4$ seconds, and the spread is 23. There are no major outliers. The distribution for Equate disintegration times has a center of $\bar{x} = 798$ seconds, and the spread is 405. Both of these values are much much larger than those of the Tylenol distribution. In the Equate distribution, there are also no major outliers. For both of these distributions, the NPP is approximately linear, so we can conclude that they are both approximately Normal, although we should proceed with caution due to the small n values and slight curvature of the NPPs.

Data Analysis:

10% condition:

- First sample: there are more than 50 caplets of 500 mg Tylenol Extra Strength Acetaminophen in the bottle that I sampled from
- Second sample: there are more than 50 caplets of 500 mg Equate Extra Strength Acetaminophen in the bottle that I sampled from

*other conditions checked in previous sections

*parameters and hypotheses defined in previous sections

Use a Two-Sample t Test

Test Statistic:

$$t = (\bar{x}_T - \bar{x}_E) - (\mu_T - \mu_E) / \sqrt{(S_T^2/n_T) + (S_E^2/n_E)}$$
$$t = (85.4 - 798) - (0) / \sqrt{(89.30/5) + (22189.08/5)}$$
$$t = -10.676$$

P-Value:

$$p = P(t < -10.676)$$

$$p = 0.000209$$

Conclusion:

Since $p = 0.00021 < \alpha = 0.05$, we reject the null hypothesis and accept the alternative hypothesis. There is convincing evidence that the true mean time in seconds that it takes for one 500 mg Tylenol Extra Strength Acetaminophen caplet to fully disintegrate is less than the true mean time in seconds that it takes for one 500 mg Equate Extra Strength Acetaminophen caplet to fully disintegrate.

These results mean that the name brand OTC pain reliever, Tylenol, is in fact of higher quality, in regards to how long it takes to start absorbing into one's body, than its generic brand competitor, Equate. While Tylenol is over three times as expensive as Equate, the sample average disintegration time of Tylenol was over nine times shorter than the sample average

disintegration time of Equate. Given this data, it is up to the individual whether or not nine times as fast of an absorbing time is worth three times as much money.

Reflection:

In this experiment, my goal was to replicate the environment of a stomach in order to test how long it takes for pain relieving medications to disintegrate and start being absorbed into the body. Overall, I feel pretty positively about my project executions and findings, although there are a few places for potential error that could be improved upon in further research.

One thing that could have been better was my replication of the environment of a stomach. I used the same kind of acid that is found in the human stomach with the same concentration and pH, however, the solutions I used were at room temperature as opposed to the natural stomach temperature of roughly 98.7°F. I also neglected to add any chemicals that would mock the behaviors of enzymes present in the stomach, such as potassium chloride or sodium chloride. Another inconsistency is that in my experiment, the solutions were being stirred constantly, whereas in the actual digestive process, the stomach would be contracting and moving more vigorously. Another way to improve my experiment would be to increase my sample sizes for both brands of medication. This would reduce variability in my data.

Additionally, in an expanded experiment, I could replicate the same process with more medications. One example would be testing Advil brand pain relievers against another generic brand of pain relievers, both with the active ingredient of ibuprofen. I could also test to see if there is a difference between coated caplets, uncoated caplets, liquid gels, and other forms of these medications.