One Sample T Test: 3 Example Problems (Humans)?

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In the realm of hypothesis testing, the One Sample T-Test is a fundamental statistical procedure. It is employed when we need to determine whether the unknown population mean (μ) of a continuous variable is statistically different from a specific, hypothesized value. This test is crucial when the population standard deviation is unknown, which is a common scenario in real-world data analysis.

Understanding how to properly execute and interpret the T-Test is vital for drawing valid conclusions from sample data. The structure of the test--specifically how the alternative hypothesis is defined--determines the type of test we perform.

The Three Essential Types of One Sample T-Tests

The application of the One Sample T-Test can be categorized into three distinct types, each targeting a slightly different research question about the population mean compared to the null value:

Two-tailed one sample t-test: Used to check if the population mean is simply **not equal** to the hypothesized value.
Right-tailed one sample t-test: Used to check if the population mean is **greater than** the hypothesized value.
Left-tailed one sample t-test: Used to check if the population mean is **less than** the hypothesized value.

We will now explore detailed step-by-step examples for each scenario, demonstrating the necessary calculations and interpretations required for robust statistical reporting.

Example 1: Two-Tailed One Sample T-Test (Testing for Difference)

Consider a scenario where conservation biologists are tracking the physical attributes of a rare species of turtle. Historically, the known average weight for this species has been 310 pounds. The research team suspects that recent ecological changes might have impacted the turtles' weight, leading to a shift--either higher or lower--from this established benchmark. They want to know if the current mean weight is significantly different from 310 pounds.

To address this question, we employ a two-tailed T-Test. This approach tests for a difference in either direction. For this analysis, we set the significance level (α) at 0.05, meaning we are willing to accept a 5% chance of incorrectly rejecting the null hypothesis. The process requires a systematic approach involving data collection, hypothesis formulation, calculation of the test statistic, and determination of the associated p-value.

Step 1: Gather the Sample Data

The conservation team randomly samples 40 turtles and records their weights. This sample provides the necessary parameters for the calculation of the test statistic.

Sample size n = 40
Sample mean weight x = 300 pounds
Sample standard deviation s = 18.5 pounds

The sample mean of 300 pounds already suggests a difference from the hypothesized population mean of 310 pounds, but the T-Test will determine if this observed difference is statistically significant or merely due to random sampling variation.

Step 2: Define the Hypotheses

In a two-tailed test, the null hypothesis (H0) posits that there is no change, while the alternative hypothesis (H1) covers any deviation from the null value.

H0: μ = 310 (The current population mean weight is equal to 310 pounds.)
H1: μ ? 310 (The current population mean weight is not equal to 310 pounds.)

Step 3: Calculate the Test Statistic t

The T-statistic measures the difference between the sample mean and the hypothesized population mean, scaled by the standard error of the mean. This standardized score allows us to determine how extreme our sample result is under the assumption that the null hypothesis is true.

The formula used is: **t** = $(x - \mu) / (s/\sqrt{n})$

Plugging in the observed values: $(300 - 310) / (18.5/\sqrt{40}) = -10 / (18.5 / 6.3246) = -10 / 2.9249 =$ **-3.4187**.

Step 4: Calculate the P-value and Draw a Conclusion

The next critical step involves calculating the p-value. This value represents the probability of observing a test statistic as extreme as -3.4187 (or more extreme in either tail) if the null hypothesis were true. To find this, we must reference the T-distribution with the appropriate degrees of freedom (df).

The degrees of freedom are calculated as n - 1, which is 40 - 1 = 39. Using a T-distribution table or statistical software, the p-value associated with t = -3.4187 and df = 39 is determined to be **0.00149**.

Since this p-value (0.00149) is significantly less than our chosen significance level $\alpha = 0.05$, we confidently reject the null hypothesis. This provides strong statistical evidence to conclude that the mean weight of this species of turtle is, in fact, not equal to 310 pounds. Given the sample mean of 300 pounds, it appears the population mean has decreased.

Example 2: Right-Tailed One Sample T-Test (Testing for Increase)

Educational researchers are examining the efficacy of a new preparatory course for a standardized college entrance exam. The historically established mean score for all test takers is 82. The researchers hypothesize that students who take their new course will perform better, thus raising the average score above 82. This requires a right-tailed, or upper-tail, T-Test, as we are only concerned with detecting an increase.

We will again use a significance level of $\alpha = 0.05$ for this one-directional test. The rejection region lies entirely in the upper tail of the T-distribution, corresponding to positive and significantly large T-statistics.

Step 1: Gather the Sample Data

A random sample of 60 students who completed the new preparatory course yields the following performance data:

Sample size $n = 60$
Sample mean $x = 84$
Sample standard deviation $s = 8.1$

Step 2: Define the Hypotheses

For a right-tailed test, the null hypothesis must contain the equality component, suggesting the course did not improve scores (or that scores remained the same or decreased). The alternative hypothesis asserts the desired outcome: an increase in the mean score.

H0: $\mu \leq 82$ (The population mean score is 82 or less.)
H1: $\mu > 82$ (The population mean score is greater than 82.)

Step 3: Calculate the Test Statistic t

Using the standard T-test formula, we substitute the values:

t = (84 - 82) / (8.1/√60) = 2 / (8.1 / 7.7460) = 2 / 1.0456 = **1.9125**

Step 4: Calculate the P-value and Draw a Conclusion

With a sample size of 60, the degrees of freedom (df) is 59. We look up the probability in the upper tail corresponding to t = 1.9125. The associated p-value for this one-tailed test is calculated as **0.0303**.

Comparing the p-value (0.0303) to our significance level ($\alpha = 0.05$), we find that 0.0303 is less than 0.05. Therefore, we reject the null hypothesis. There is sufficient statistical evidence to conclude that the mean exam score for students taking the new preparatory course is statistically greater than the historical mean score of 82. The new course appears to be effective.

Example 3: Left-Tailed One Sample T-Test (Testing for Decrease)

Agricultural scientists are monitoring a species of plant that typically reaches a mean height of 10 inches under controlled conditions. They introduce a new pesticide treatment and suspect that it might inhibit growth, resulting in a mean height significantly less than 10 inches. To test this specific hypothesis, a left-tailed, or lower-tail, One Sample T-Test is required. The test will focus solely on whether the population mean has decreased.

As with the previous examples, we conduct the test using a significance level of $\alpha = 0.05$. The rejection region for this test will be located in the extreme left tail of the T-distribution, where negative T-values indicate significantly low sample means.

Step 1: Gather the Sample Data

The scientists collect a random sample of 25 plants that received the new pesticide treatment:

Sample size n = 25
Sample mean x = 9.5 inches
Sample standard deviation s = 3.5 inches

Step 2: Define the Hypotheses

In this left-tailed test, the null hypothesis assumes the treatment had no negative effect (or possibly a positive one). The alternative hypothesis supports the scientists' suspicion that the mean height has decreased.

H0: $\mu \geq 10$ (The population mean height is 10 inches or more.)
H1: $\mu < 10$ (The population mean height is less than 10 inches.)

Step 3: Calculate the Test Statistic t

We calculate the T-statistic using the sample mean (9.5) and the hypothesized population mean (10):

t = (9.5 - 10) / (3.5/√25) = -0.5 / (3.5 / 5) = -0.5 / 0.7 = **-0.7143**

Step 4: Calculate the P-value and Draw a Conclusion

With a sample size n = 25, the degrees of freedom (df) is 24. We reference the T-distribution to find the p-value associated with t = -0.7143. For this left-tailed test, the probability of observing a T-statistic this low is **0.24097**.

When we compare this p-value (0.24097) to the significance level (α = 0.05), we observe that 0.24097 is much greater than 0.05. Because the p-value exceeds the threshold, we fail to reject the null hypothesis. We must conclude that there is insufficient statistical evidence to support the claim that the pesticide treatment has caused the mean height for this plant species to drop below 10 inches. The observed difference of 0.5 inches is likely attributable to random sampling error rather than a true population effect.

Summary of One Sample T-Test Applications

These three examples illustrate the flexibility and critical importance of defining the alternative hypothesis correctly in any statistical investigation. Whether seeking a difference, an increase, or a decrease, the One Sample T-Test provides a structured methodology for comparing a sample mean against a hypothesized population standard. Crucially, the outcome hinges on comparing the calculated p-value against the chosen significance level, ensuring that conclusions are based on rigorous probability assessment.

For those interested in delving deeper into inferential statistics, especially concerning sample comparisons and distributional properties, the following resources offer valuable insights into related hypothesis testing procedures: