What is the True Human Body Temperature?

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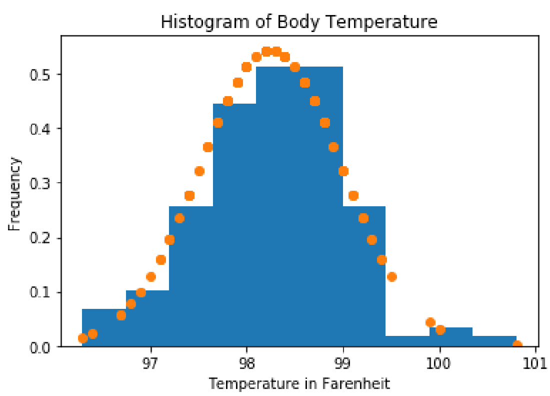
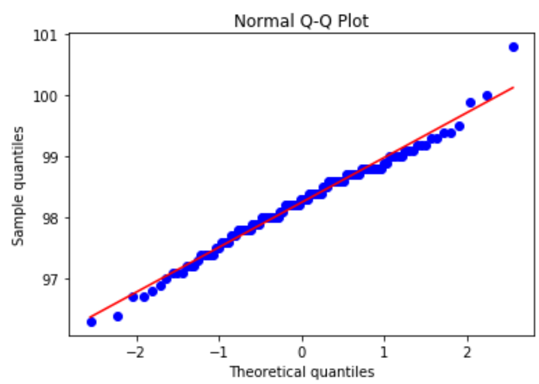
BACKGROUND

The mean normal body temperature was held to be 98.6 oF for more than 120 years since it was first conceptualized and reported by Carl Wunderlich in a famous 1868 book. But is this value statistically correct?

NORMALITY TEST

The data in this exercise is body temperature of 130 people composed of 65 male and 65 female participants. The mean temperature of 130 people is 98.25 °F. The distribution of body temperatures was tested for normality using Q-Q plot and by comparing theoretical normal distribution to the histogram of body temperature of the sample.





Inspecting graphically, the sample set follows a Normal Distribution.

Sample size of 130 is sufficiently large to apply the central limit theorem in the data analysis(CLT) which requires a sample size of greater than 30. All samples are also independent on each other since it was taken from different people.

IS 98.6 °F the TRUE POPULATION MEAN?

Z-statistic will be used since sample size is greater than 30. Two hypotheses were tested to answer if 98. 6 °F is the true population mean.

Ho: True population mean is 98.6 °F

H1: True population mean is not 98.6 °F

One sample test was used to test these two hypotheses using the formula below.

$z = \frac{sample\ mean - 98.6}{sample\ standard\ deviation/\sqrt[2]{sample\ size}}$ = -5.45

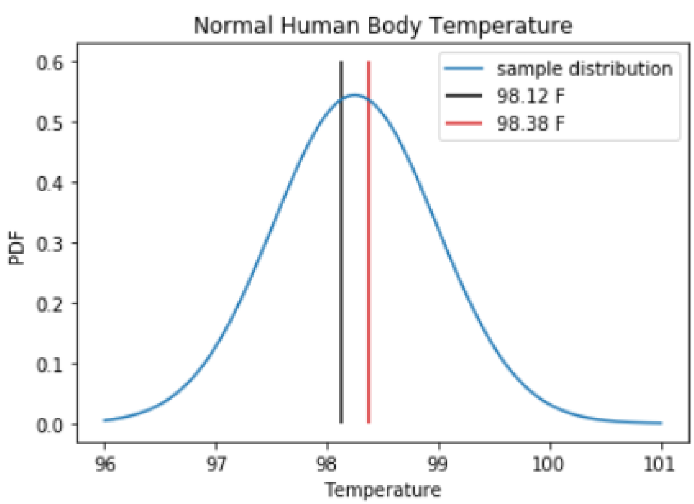
This calculated z-value of -5.45 mean that the sample mean of 98.25 ^oF is 5.45 standard error units below the assumed population mean of 98.6 ^oF. The probability of getting a population mean that is within 5.45 standard error units from 98.25 ^oF is calculated using the p_value. The p_value is calculated the calculated z above and using 2 tails using the following formula

p_value=stats.norm.cdf(z) x 2= 4.9 x 10^{-8}

Calculated p_ value < 0.05 assumed significance level so the null hypothesis Ho: True population mean is 98.6 ^oF is **rejected** and **H1: True population mean is not 98.6 ^oF** is **accepted.**

NORMAL TEMPERATURES

Both z-statistics and t-statistics using 95% confidence level yielded the same margin of error (0.13 ^oF) and range of normal temperature. The calculated t_value of 1.98 is very similar to the calculated z_value of 1.96 When sample size are greater than 30, t statistics and z statistics will give same results. The graph below shows the range of "Normal Human Body Temperature" which range from 98.12 ^oF to 98.38 ^oF. Any temperature outside this range is considered "ABNORMAL". The mean body temperature of "98.6 ^oF" by Carl Wunderlich is out of this range and is considered ABNORMAL.



DIFFERENCE BETWEEN MALE & FEMALE TEMPERATURES

Two hypotheses were used to test if male and female temperatures are significantly different.

Ho: Female mean temperature is equal to male mean temperature

H1: Female mean temperature is NOT equal to male mean temperature

Two sample t- test with significance level of 0.05 was used to test these two hypotheses using the following formula.

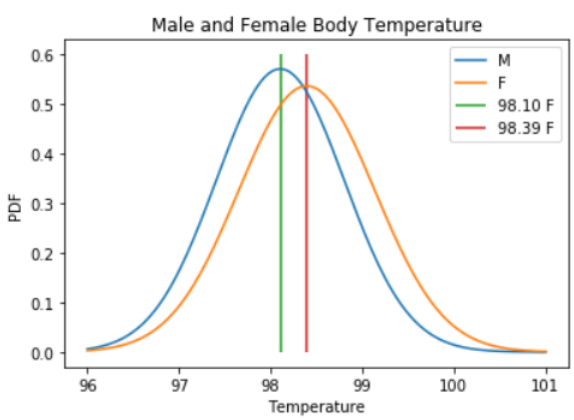
$$t_{x1-x2} = \frac{(Tmean_{female} - Tmean_{male}) - d}{SE}$$ where d is difference of mean, d=0 for Ho

$$SE = \sqrt[2]{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$$ where SE is standard error, s_1 is female temperature standard deviation, s_2 is male temperature standard deviation and n_1 and n_2 are their respective sample sizes.

$$DF = \frac{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)^2}{\frac{\left(\frac{s_1^2}{n_1}\right)^2}{n_1 - 1} + \frac{\left(\frac{s_2^2}{n_2}\right)^2}{n_2 - 1}}$$ where DF is degrees of freedom.

The calculated t_{x1-x2} and DF are used to calculate p value using t distribution table. Two tail distribution was used in solving p value.

P value = Probability (Mean temperature difference of male and female > 2.29)



$Tmean_{female} - Tmean_{male}$	0.29 °F
Assumed significance level	0.05
SE	0.13
t_{x1-x2}	2.29
DF	128
p value	0.024

Below is the summary of results.

The calculated p value < 0.05 which means the null hypothesis ***Ho: Female mean temperature is equal to male mean temperature*** will be rejected and H1 is accepted. So yes, there is a significant difference in temperature of male and female temperatures.

IPython NOTEBOOK SOLUTIONS

All solutions can be viewed in IPython Notebook in my github below.

https://github.com/DrAugustine1981/Springboard/blob/master/human_body_temp.ipynb