Estimation and Comparison of an Individual's Mean Resting Heart Rate to an Average of 92,457 Adults' Resting Heart Rates

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Introduction

The first purpose of this project is to estimate the author's mean resting heart rate (RHR) just before bedtime. The second purpose is to compare this average to a reasonable adult average.

According to Edward R. Laskowski, M.D., a normal RHR should fall somewhere between 60 and 100 beats per minute (Laskowski). To understand if our RHR generally falls within this normal range, we decided to collect heart-rate data.

We also compared the sample mean of the author's individual RHR data to the average of 92,457 adults' RHR, 65.5 beats per minute (Quer et. al.), to understand if there is any evidence of a significant difference between the author's true mean heart rate and the value 65.5 BPM. The reader should note that we are treating the value 65.5 BPM as if it were a population parameter.

Data Collection

Over the course of 74 evenings, an OMRON heart rate monitor was used to measure the author's heart rate to the nearest beat per minute. Laskowski notes that heart rate can be sensitive to various factors including air temperature, emotions, and body position (Laskowski). Thus, to ensure similar conditions, each measurement was taken sitting in a upright position just before bedtime in a calm and relaxed state. Also, as heart rate can be somewhat variable from minute to minute, three measurements were taken each evening with a two-minute interval between each measurement.

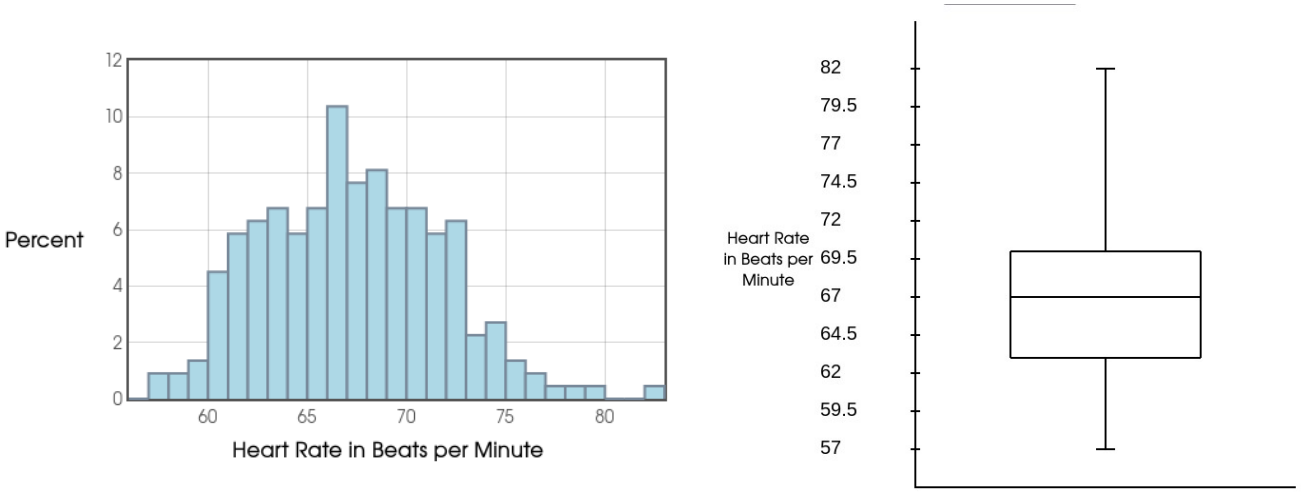
The Data

The complete data set of 222 entries can be found in the appendix.

The the summary statistics for the data are given below.

Number of Data Points:	$n = 222$
Mean:	$\bar{x} = 66.7523$
Standard Deviation:	$s = 4.5011$
Minimum:	Min$= 57$
1st Quartile:	$Q_1 = 63$
Median:	$M = 67$
3rd Quartile:	$Q_3 = 70$
Maximum:	Max$= 82$

A histogram and box plot of these data is also given below



The histogram and the boxplot suggest the possibility of high outliers. According to the 1.5 IQR rule, the lower bound for low outliers is

$$Q_1\text{-}1.5\cdot IQR=63\text{-}1.5\cdot(70\text{-}63)=52.5$$

and the upper bound for high outliers is

$$Q_3+1.5\cdot IQR=70+1.5\cdot(70\text{-}63)=80.5$$

From the above, we see that the data point of 82 BPM (beats per minute) is a high outlier. In our analysis we shall take this into consideration by running the analysis with the outlier and without.

We note that in the absence of the outlier, the distribution of heart rates appears to be roughly symmetric.

Results and Analysis

Since the standard deviation of the author's heart rate is unknown, we used a one-sample *t* confidence interval to estimate the mean heart rate. We also decided on a confidence level of 99%.

With the outlier, the 99% one-sample *t* confidence interval is

(65.9673, 67.5372)

That is, we are 99% confident that the true mean heart rate is between 65.9673 BPM and 67.5372 BPM.

Without the outlier, the 99% one-sample *t* confidence interval is

(65.9156, 67.4509)

Thus, if excluding the outlier is justified, we are 99% confident that the true mean heart rate is between 65.9156 BPM and 67.4509 BPM.

Since we cannot justifiably exclude the outlier, we will take the first interval as our best estimate. We note that that both intervals are quite similar and the outlier makes little difference.

The margin of error of the first interval is 0.78495, which means that we are 99% sure that our parameter estimate of 66.7523 BPM is within 0.78495 BPM of the true mean heart rate.

Although it may be somewhat crude, rounding the above values to the nearest whole beat per minute might make the analysis a bit more comprehensible to a reader with little or no statistical training. Rounding, we are ***about*** 99% confident that the author's mean heart rate is within ±1 BPM of the parameter estimate of 67 BPM.

We compared the author's sample mean 66.7523 to the the reference average by using a two-sided one-sample *t*-test for a difference from a known mean.

The null and alternative hypotheses are:

H_0: The author's true mean RHR is NOT different from 65.5.
H_a: The author's true mean RHR IS different from 65.5.

Again, we must point out that we are treating the value 65.5 as if it were a population parameter.

For the above hypotheses, the test statistic, p-value, and other values are given below.

Sample Size:	n =222
Degrees of Freedom:	$df = n - 1$ =221
Square Root of Sample Size:	$\sqrt{n}$ =14.8997
Sample Mean:	$\overline{x}$ =66.7523
Sample Standard Deviation:	s =4.5011
Critical t Value:	t^* =1.97076
t statistic:	t =4.1453
p-value:	p-value =0

Running the same analysis without the high outlier, we have the following.

Sample Size:	n =221
Degrees of Freedom:	$df = n - 1$ =220
Square Root of Sample Size:	$\sqrt{n}$ =14.8661
Sample Mean:	$\overline{x}$ =66.6833
Sample Standard Deviation:	s =4.3921
Critical t Value:	t^* =1.97081
t statistic:	t =4.0051
p-value:	p-value =0.0001

Conclusions

For every observation, the author's heart rate fell within the range of values considered to be a normal, healthy resting heart rate: 60 BPM to 100 BPM (Laskowski). Moreover, we are very confident that the average heart rate falls in the lower end of the normal spectrum at 67 BPM within plus or minus 1 BPM. From this, we conclude that the author presently exhibits a healthy resting heart rate.

Since the p-value of the above test of significance both with and without the outlier is very close to 0, we conclude that the author's true mean RHR is significantly different from the value of 65.5 BPM observed by Quer, et. al. Although the author's RHR is healthy as established above, we still have evidence that the author's true mean RHR is above 65.5 BPM. We also note that the effect size is quite small. That is, there is little practical difference between the two means. (Again, for the sake of full disclosurewe emphasize that we are treating the value 65.5 BPM as if it were a population parameter.)

Acknowledgments

We note that the graphs, figures, confidence intervals, and other computations were calculated using a free statistical software package (Holt) at the following URL:
https://holt.blue/MTH_243/Resources/stats_suite.html ("The Holt.Blue Statistical Software Suite").

As a reference text for statistical procedure, we used "Introductory Statistics" by OpenStax.

References

Illowski, B., Dean, S., et. al. "Introductory Statistics." *OpenStax*, 2017, https://openstax.org/details/books/introductory-statistics

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Laskowski, Edward R., "What's a normal resting heart rate?" *Mayo Clinic*, 2022, https://www.mayoclinic.org/healthy-lifestyle/fitness/expert-answers/heart-rate/faq-20057979.

Quer G., Gouda P., Galarnyk M., Topol E.J., Steinhubl S.R., "Inter- and intraindividual variability in daily resting heart rate and its associations with age, sex, sleep, BMI, and time of year: Retrospective, longitudinal cohort study of 92,457 adults." *PLOS ONE 15(2): e0227709*, 2020. **Inter- and intraindividual variability in daily resting heart rate and its associations with age, sex, sleep, BMI, and time of year: Retrospective, longitudinal cohort study of 92,457 adults** https://doi.org/10.1371/journal.pone.0227709

Appendix

The complete heart-rate data set is on the following page.

1st Measurement	2nd Measurement	3rd Measurement
73	70	69
61	62	60
65	63	61
66	64	68
65	66	66
70	72	71
63	60	60
60	62	63
61	60	58
69	67	66
74	68	73
68	71	67
72	75	77
67	66	66
70	67	64
59	62	62
71	70	70
69	68	70
64	65	66
66	68	64
65	63	63
72	71	68
66	66	64
70	72	68
70	71	74
63	63	62
60	61	61
70	64	68
71	68	76
74	72	69
72	73	71
61	62	63
68	66	66
69	69	66
70	66	66
65	65	67
72	70	72
63	64	71
63	61	62
65	65	65
66	66	66
73	72	73
67	70	69
61	62	61
65	66	63
69	68	66
62	62	65
64	59	62
64	64	62
60	63	61
60	58	60
68	67	67
69	69	70
60	61	61
63	62	62
66	67	67
59	57	57
68	67	70
72	68	71
72	71	71
64	67	69
67	67	67
69	68	68
69	67	64
72	69	70
66	65	65
82	76	79
61	63	63
68	69	66
65	64	65
74	75	74
71	67	68
72	71	72
75	74	78