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Correlation Among Different Variables and Life Expectancy

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Correlation Among Different Variables and Life Expectancy

Abstract

The purpose of this project is to show how heart rate, blood pressure, and weight of different species correlate with their life expectancy. We perform graphical analysis and compute Pearson's Product-Moment Correlation Coefficient to show that the heart rate has the highest degree of correlation with life expectancy.

Keywords

Life expectancy, Heart Rate, Blood Pressure, Weight

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PROBLEM STATEMENT

Find variables that strongly correlate with life expectancy.

MOTIVATION

The secret to longevity continues to elude humanity to this day. Despite all the advances in medicine, cardiovascular disease, obesity, and abnormal blood pressure continue to be serious and life-shortening conditions. Finding variables that strongly correlate with life expectancy may help us to understand which aspects of these and other conditions present the highest health risk. This, in turn, may help us to design treatments that would have the most effect in prolonging patient's life span.

Recent studies show that a lower heart rate (known as bradycardia) in otherwise normal heart is beneficial because it prevents the heart from overworking and increases efficiency. Athletes, for example, are known to have a lower resting heart rate (see Table 1).

Human	Heart Rate (per min)	Life Expectancy (years)
Bradycardia (no symptoms)	40	123.5
	50	98.9
Athletes	60	82.4
	68	72.7
Average	70	70.6
	80	61.8
	84	58.9
Tachycardia	90	54.9

Table 1: Life Expectancy estimations based on heart rate (calculated by (CSG)).

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Blood Pressure is the pressure exerted by blood on the blood vessels. Normal blood pressure for humans falls between 90 to 140 mmHg. Blood pressure lower than 90 mmHg (known as hypotension) is considered abnormally low. Abnormally high blood pressure, or hypertension, is a pressure above 140 mmHg. Unlike heart rate, both high and low blood pressure negatively affects health and may results in cardio-vascular disease, stroke, and even death (Franco, Peeters and Bonneux).

Obesity, which runs rampant in the United States, is shown to take years off the affected individual's life unless proper diet and exercise are employed. Studies are based on an individual's body mass index (BMI), which is calculated by dividing a person's weight (in kilograms) by the square of a person's height (in meters). Oxford University researchers found that moderate obesity shortens life expectancy by almost 3 years whereas a severe obesity can shorten the life expectancy by up to 10 years (ScienceDaily).

Instead of concentrating solely on humans, we determine whether weight, heart rate, or blood pressure has strong correlation with life expectancy using the data describing multiple species.

MATHEMATICAL DESCRIPTION AND SOLUTION APPROACH

We use Pearson's Product-Moment Correlation Coefficient (PPMCC) to determine whether specie's weight, heart rate, blood pressure have strong correlation with its lifespan. PPMCC is given by

$$r_{xy} = \frac{\sum x_i y_i - n\bar{x}\bar{y}}{n s_x s_y} = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{\sqrt{n\sum x_i^2 - (\sum x_i)^2}\sqrt{n\sum y_i^2 - (\sum y_i)^2}}$$

where x_i is the ith x score, $\bar{x}$ is the mean of x, and s_x is the standard deviation of x (y_i, $\bar{y}$, and s_y are defined symmetrically).

It turns out that PPMCC is always between -1 and 1. A correlation coefficient of 1 indicates a strong direct linear relationship; a coefficient of -1 indicates a strong inverse linear relationship; and a coefficient of 0 indicates that there is no correlation between the two variables. We compute PPMCC for the heart rate, blood pressure, and weight to understand which of the three has the strongest correlation with the lifespan.

Our calculations of PPMCC are based on the data from Table 3 (see also Figure 1) and summarized in Table 2.

Variable	n	$\sum x$	$\sum y$	$\sum x^2$	$\sum y^2$	$\sum xy$	r_{xy}
Heart rate	20	708	2541	65295	684137	33879	-0.44
Blood pressure	18	707	2231	65295	336721	88491	-0.16
Weight	20	708	129470	65295	14428679504	10750497	0.25

Table 2: PPMCC of heart rate, blood pressure, and weight versus lifespan.

DISCUSSION

Pearson's Product-Moment Correlation Coefficient (PPMCC) can be interpreted as follows (Cohen):

Correlation	Negative	Positive
None	-0.09 to 0.00	0.00 to 0.09
Small	-0.30 to -0.10	0.10 to 0.30
Medium	-0.50 to -0.30	0.30 to 0.50
Large	-1.00 to -0.50	0.50 to 1.00

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According to our calculations, there is a medium correlation (-0.44) between life expectancy and heart rate. According to Figure 1, as life span increases, heart rate decreases. Two extremes are giant tortoises (200 year lifespan, 6 bpm heart rate) and common houseflies (1 month lifespan, 300 bpm heart rate).

There is a small correlation between blood pressure and life expectancy (-0.16). Blood pressure, however, depends on the environment and organism's life style, so more precise correlation estimate could be obtained by factoring these parameters into the analysis.

The correlation between life expectancy and weight (0.25) is also small. Weight and life expectancy are related directly: as the weight of an organism increases, so does its life expectancy. Outliers such as whales and tortoises, however, suggest that there may be no true correlation between these variables.

From the three analyzed variables, the heart rate has the highest correlation with life expectancy.

CONCLUSION AND RECOMMENDATIONS

Based on the analysis presented above, we conclude that heart rate has the highest correlation with life expectancy. It is recommended that individuals who wish to prolong their life should lead active lifestyle. Aerobic exercises are probably the most beneficial. In addition, daily exercise and a healthy life style will decrease the likelihood of obesity and normalize blood pressure.

NOMENCLATURE

Symbol	Description
r_{xy}	Pearson's Product-Moment Correlation Coefficient between variables x and y
$\bar{x}$	the mean of variable x
s_x	the standard deviation of variable$x$

REFERENCES

Cohen, Jacob. Statistical Power Analysis for the Behavioral Sciences. New York: Academic, 1977.

CSG, Computer Support Group, Inc. Life Expectancy Estimator by Heart Rate. n.d. 9 May 2011 <http://www.csgnetwork.com/avglifeexpfromhr.html>.

Franco, Oscar H., et al. "Blood Pressure in Adulthood and Life Expectancy With Cardiovascular Disease in Men and Women." Hypertension (2005): 46:280-286.

ScienceDaily. "Moderate Obesity Takes Years Off Life Expectancy." 19 March 2009. http://www.sciencedaily.com/.<http://www.sciencedaily.com/releases/2009/03/090319224823.htm>.

Watkins, Thayer. "Animal Longevity and Scale." 09 May 2011. San José State University.<http://www.sjsu.edu/faculty/watkins/longevity.htm>.

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APPENDIX-TABLES

Organism	Heart Rate (bpm)	Blood Pressure (mmHg)	Weight (kilograms)	Lifespan (years)
Giant Tortoise	6	150	300	200
Crocodile	24	60	800	45
Human	70	120	90	75
Elephant	30	145	5000	70
Whale	20	26	120000	85
Giraffe	65	300	900	25
Cow	65	157	800	22
Horse	44	120	1200	40
Sheep	75	90	57	10
Medium Dog	90	150	5	13
Cat	150	129	2	15
Snake	45	55	.100	10
Mouse	600	111	.020	2
Rabbit	205	120	1	10
Monkey	192	140	5	20
Guinea Pig	240	60	.1	8
Grizzly Bear	70	170	160	32
Pig	70	128	150	25
Housefly	300	--	.000012	.08
Daphnia	180	--	.000000163	.50

Table 3: Mean heart rate, blood pressure, weight, and lifespan of various organisms (blood pressures of housefly and daphnia were omitted since no data could be found) **(Watkins)**.

APPENDIX-FIGURES

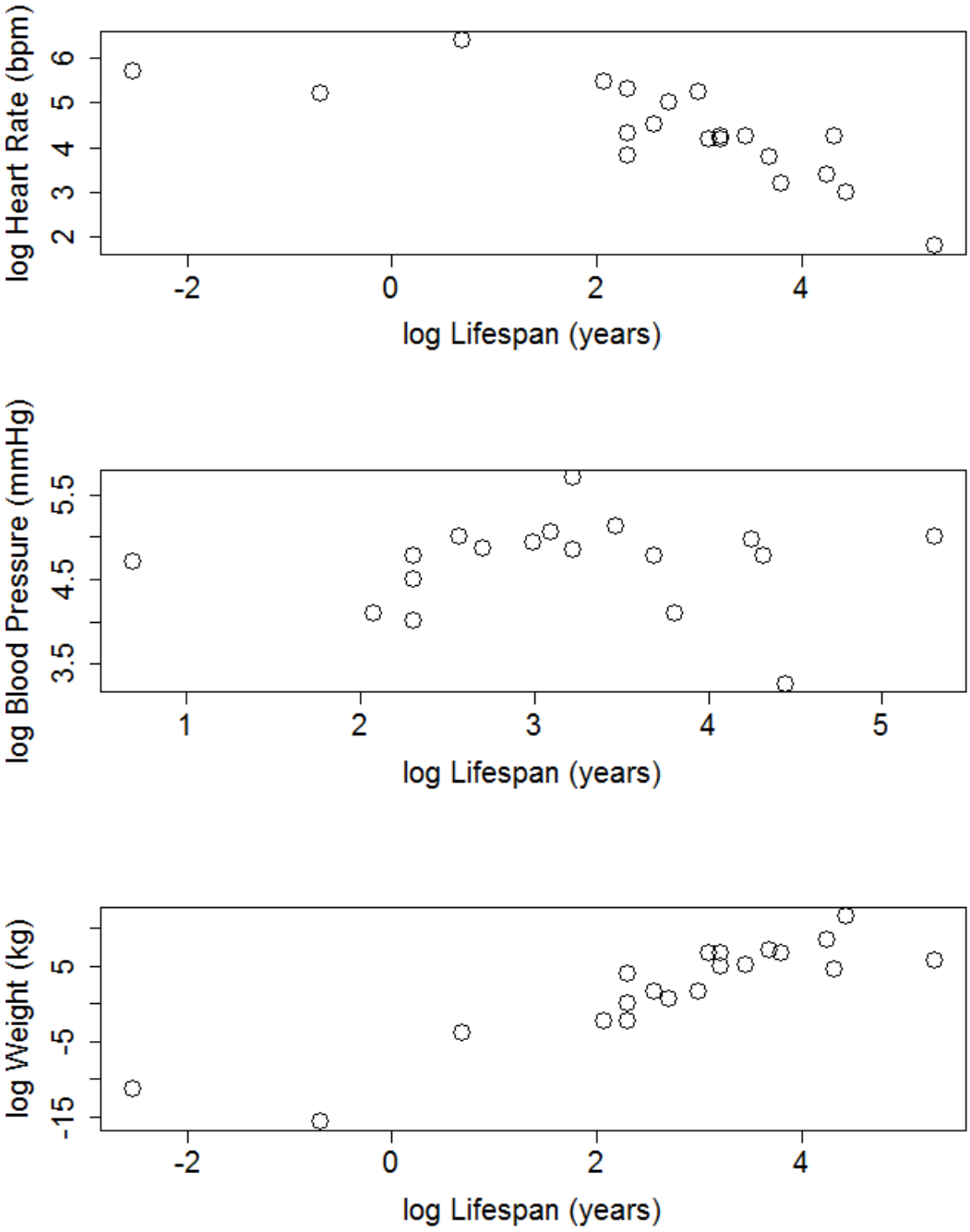

Figure 1: Log-log plot of the data from Table 3.

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