Final Project Paper - STAT 155 - Fall 2022

Section 04

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Introduction:

Many people across the world powerlift, regardless of gender. However, we observe a pattern that men typically lift more than women. We wanted to compare the amount of weight in kilograms that men and women of the same weight categories can lift in order to observe whether there is an actual difference between the amount they can lift, or if gender stereotypes are only reinforcing this pattern. The research question we explored throughout our project was: Does the sex of a powerlifter affect the amount of kilograms they are able to squat?

Dataset and Exploratory Data Analysis:

The samples were obtained from a public archive of results from past powerlifting competitions. This archive would be classified as an observational study and not an experiment since there was no intervention from the archivists. We accessed this dataset through Kaggle, recommended to us by Professor Normington. The dataset can be accessed here.

The units in this dataset are the powerlifters that participated in the observed powerlifting competitions. In this dataset there are a total of 412,000 lifters. Our primary outcome of interest was the Best3SquatKg variable, which is the heaviest squat that the powerlifter succeeded in lifting in the competition. This variable is quantitative, and there is a 5 number summary of it in Table 1. Our primary predictor of interest is the powerlifter's sex, which is a categorical variable. We found that 29% of those powerlifters were female and the other 71% were male, showing that there were more male athletes than female athletes.

A potential confounder that we have identified is the bodyweight (in kg) of the participants. This is a potential confounder since a higher bodyweight could be associated with an increase in the squat max of the lifters, as seen in Figure 1. We also observed in Figure 2 that female lifters tend to have a lower bodyweight than male competitors. Two potential effect modifiers that we have also identified are the equipment used by the powerlifters and their age. These variables are effect modifiers since both equipment and age can affect the amount that they are able to lift. Therefore, a competitor's equipment and age have an effect on the relationship between sex and maximum squat.

Methods:

We fit a multiple linear regression model, and decided to include all of the potential confounders and effect modifiers in our model in order to explain as much of the variation in squat maxes as possible. Our population parameter is the difference in the maximum amount of kilograms that a powerlifter can squat for men and women, which we will estimate using the β_1 from our model.

<u>The model statement we have constructed is as follows:</u>

$E[bestsquat3kg \mid sex,\ bodyweight,\ age,\ equipment] = \beta_0 + \beta_1 SexM + \beta_2 BodyweightKg + \beta_3 Age$ $+ \beta_4 EquipmentRaw + \beta_5 EquipmentSingleply + \beta_6 EquipmentWraps$

The chosen model includes the sex, bodyweight, age, and equipment variables because this model had the highest R^2. We considered using a model with an interaction between sex and bodyweight, but that model had an R^2 that was only 0.002 higher than the one without an interaction. It was therefore easier to use a model without this interaction. Some variables that could have been helpful in our investigation but were not included in the dataset are the amount of hours that the competitors spent training for their respective competitions along with the amount of experience in years they have had with powerlifting.

We fit the model above in RStudio, which also outputs the p-values and test statistics along with it, and calculates them using the Central Limit Theorem. Specifically we are discussing the following hypotheses:

<u>Null Hypothesis:</u> $H_0 : \beta_1 = 0$

<u>Alternative Hypothesis:</u> $H_A : \beta_1 \neq 0$

Our null hypothesis is that there *is no* relationship between the maximum squat in kg of a competitor and their sex, holding all other predictors constant. Our alternate hypothesis is that there *is* a relationship between the maximum squat in kg of a competitor and their sex, holding all other predictors constant. We are utilizing the default significance threshold of 0.05, because we do not see a reason as to why we should alter this value.

Results:

The results of our multiple linear regression model in RStudio are in Table 2. Within the powerlifters in our sample, we found that $\widehat{\beta_1} = 52.04$, meaning that the male sex is associated with a 54.02kg heavier squat max than females when maintaining all other predictors constant. The 95% confidence interval that we calculated using the formula above was (53.112, 54.928), which means that we are 95% confident that the difference in maximum weight that powerlifters can squat given their sex lies between 53.112kg and 54.928kg, holding all other variables constant. The 95% confidence signifies that we are confident that 95% of similarly constructed intervals will contain the true mean difference in weight in kg that powerlifters of different sexes can squat, holding all other predictors constant.

The p-value on our SexM coefficient is $p<0.0001$. Since our p-value is smaller than the standard significance threshold of 0.05, we can reject the null hypothesis and conclude that there is likely a relationship between sex and a competitor's max squat in kg, holding their age, bodyweight, and equipment used constant.

Discussion:

Based on the data, gender does seem to have some influence in the max amount of kg that men and women can squat, holding other variables constant. However, since we rejected the null hypothesis there is a chance we made a Type 1 error, which there is a 5% chance of with the significance threshold that we used. Although the p-value we attained is low, we can not be 100% sure that we made the correct inference. We can not eliminate the possibility that the null hypothesis is actually true. Additionally, since this is an observational study and not an experiment, we cannot make any causal conclusions.

Some limitations of our dataset include how we would like to consider some other variables that were not recorded, including the lifter's years of experience and the age at which they started powerlifting, in order to see if accounting for this affects the perceived relationship between sex and squat max. Also, we would like to be able to collect data from a more general group of powerlifters, as this dataset typically includes only information from upper-level competitions.

Given our results, we could suggest that the fairest option for powerlifting competitions is to separate competitors into divisions based on biological sex. However, it is important to consider the ethical implications of forcing transgender athletes to compete based on biological sex instead of their gender. Therefore, we do suggest that powerlifting competitions remain split by gender, but that they also allow for flexibility in transgender athletes competing in the divisions that they identify with.

Tables and Figures

Minimum	7.5
Q1 (25th percentile)	132.5
Q2 (50th percentile/median)	182.5
Q3 (75th percentile)	235.0
Maximum	575.0

Table 1. 5 Number Summaries for Best3SquatKg

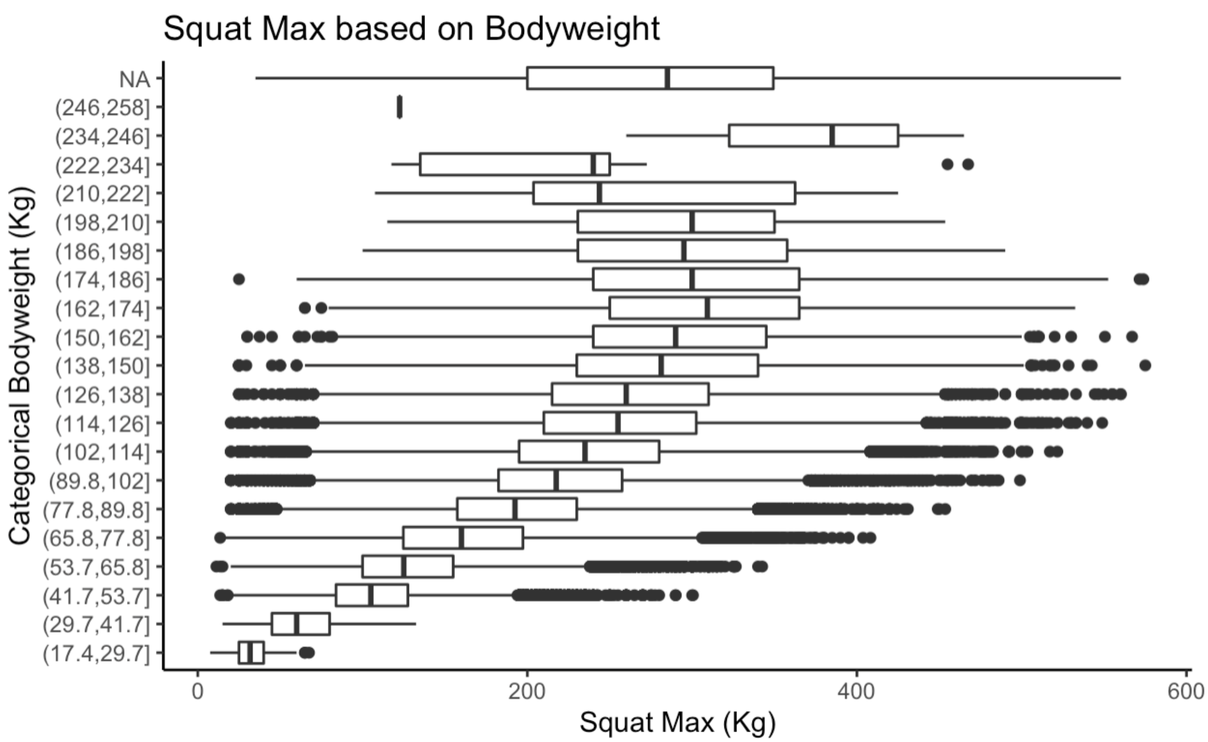

Figure 1. Multiple boxplots demonstrating the relationship between bodyweight and squat max.

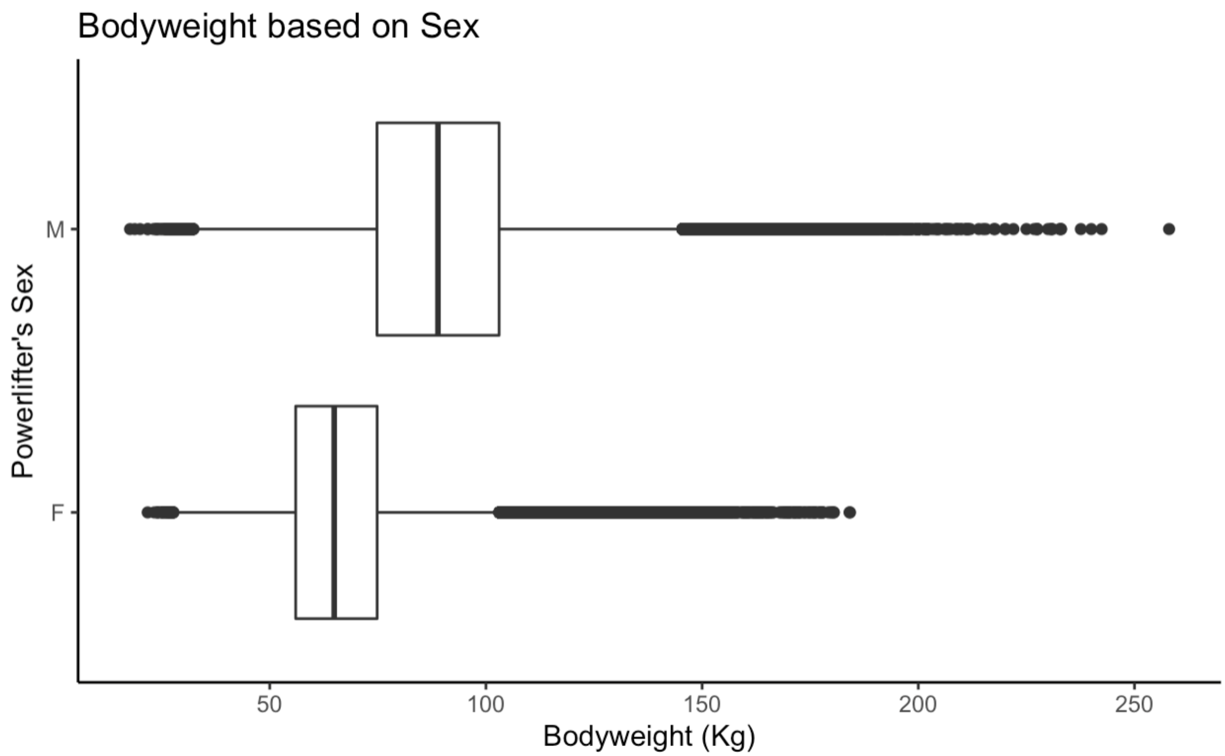

Figure 2. Two boxplots showing how men typically have a higher body weight than women.

	Estimate	Std. Error	t-value	p-value
(Intercept)	91.382	0.454	201.19	<0.0001
SexM	54.024	0.164	329.02	<0.0001
BodyweightKg	1.522	0.003	458.56	<0.0001
Age	-0.316	0.005	-58.29	<0.0001
EquipmentRaw	-81.124	0.345	-253.13	<0.0001
EquipmentSingle-Ply	-41.188	0.349	-118.11	<0.0001
Equipment Wraps	-64.865	0.368	-176.09	<0.0001
R-Squared = 0.6027				

Table 2. The RStudio outputs for a linear model predicting the squat max based on Sex, Bodyweight, Age, and Equipment used.