The Effect of Gender and Age on Muscle Strength

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August 13, 2022

1 Exclusive Summary

The main goal of this report is to analyze the effect of age and gender on mice's muscle strength. We also investigate how the secondary muscle measures affect mice's muscle strength. We build a regression model with only sex effect and age effect. We find out the p-value of sex is 0.0001 and is statistically for max force, and the p-value of the month (age) is 0.0004 for max force/EDL weight. In addition, there is no interaction effect between age and sex due to the large p-value. After adding the max rate of contraction effect and the max rate of relaxation effect into our model, we find out both secondary muscle effects are statistically significant and affect the value of mice's muscle strength. Figures 7 and 8 in the EDA section and the last two tables in the approach section support the frequency effect that does affect the mice's muscle strength.

2 Introduction

2.1 General Background

This report aims to analyze the effect of age and gender on mice's muscle strength. The data is given by Dr. Kim Long, which includes ten females and ten male mice in each sample group. For each mouse, we have ten rows corresponding to 10 different frequencies. Researchers record the maximum muscle force and other response measures at each frequency. Dr. Kim long is mainly interested in the two variables: max force and max force/EDL Weight. Therefore, we will focus on analyzing those two variables in the EDA and approach section.

2.2 Objectives

The first goal of our report is to analyze the effect of gender and age on the specific muscle strength of mice (Max force and Max force/EDL weight). The second goal is to figure out whether there is an interaction effect between gender and age. For solving this goal, we need to consider the frequency as another potential effect in our regression model. Our report's third goal is to determine how the secondary muscle measures (the max rate of contraction and the max rate of relaxation) affect the potential differences between those sample groups.

2.3 Exploratory Data Analysis

We are given two mice data sets samples by Dr. Kim Long. The first data set includes twenty 12 weeks old mice, and the second data set includes twenty 18 weeks old mice. The size of both data sets is 180×8. We want to use box and dot plots to analyze the sex effect of the max force in 12 weeks old mice. From the previous two plots, we find out that the median max force of female mice is lower than that of male mice. Therefore, we are willing to conclude that the female mice would like a lower max force than male mice. For supporting our statement, we would like to plot the same two graphs for 18 weeks old mice. Similarly, for 18-week old mice, the female mice tend to have lower max force than male mice. Then I would like to merge two 180×8 data sets into one 360×9 data set with one extra column called "Month." The previous two graphs show that the median max force of 12 weeks old mice is close to the median max force of 18 weeks old mice. Thus, we conclude that the age effect may not be significant for the max force.

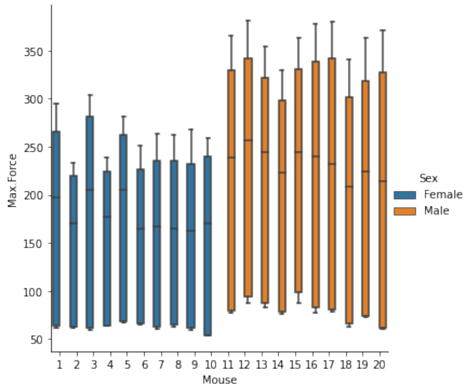

Figure 1: Box Plot of max force in 12 weeks

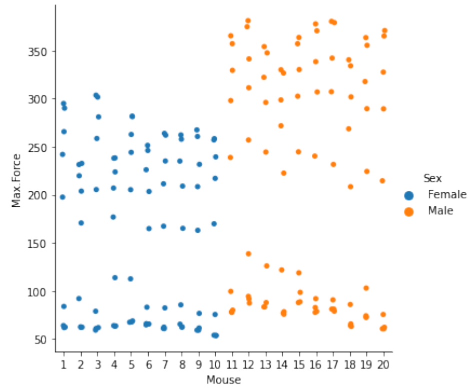

Figure 2: Dot Plot of max force in 12 weeks

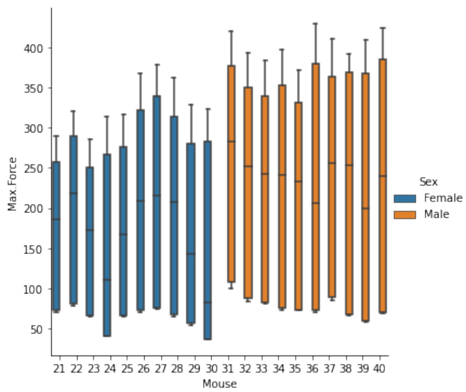

Figure 3: Box Plot of max force in 18 weeks

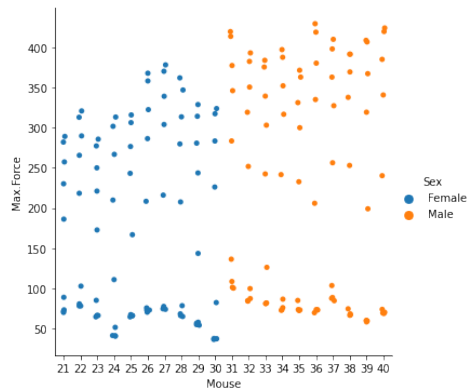

Figure 4: Dot Plot of max force in 18 weeks

From the previous two plots, we find out the Max force/EDL weight increases fast from 50Hz to 150 Hz. It also indicates that the frequency will affect the Max force/EDL weight.

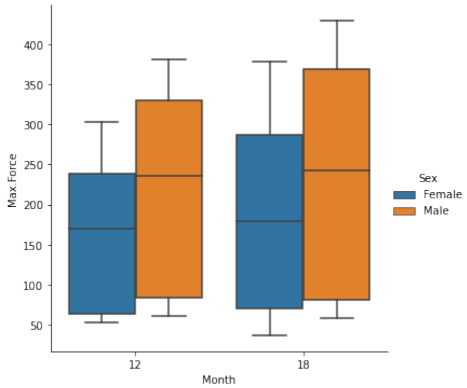

Figure 5: Box Plot of max force for all mice

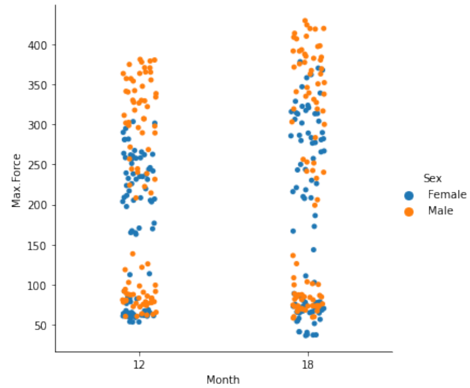

Figure 6: Dot Plot of max force for all mice

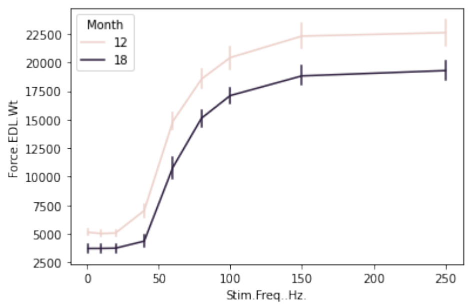

Figure 7: Line Plot of Max force/EDL weight in different age

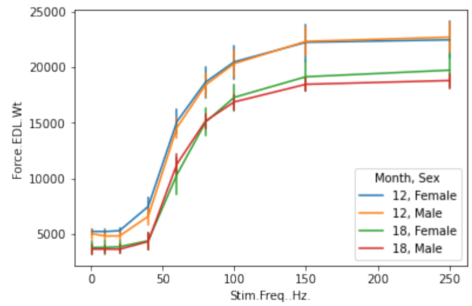

Figure 8: Line Plot of Max force/EDL weight in different age and sex

3 Approach

Our first goal is to analyze the effect of gender and age on the specific muscle strength of mice (Max force and Max force/EDL weight). We can build two linear regression models for max force and max force/EDL weight to solve this problem. We also convert the "Sex" column into a binary integer column with female:0 and male:1.

$$\text{Max force} = Intercept + sex + month$$

$$\text{Max force/EDL weight} = Intercept + sex + month$$

Null hypothesis H(0): $\beta_k = 0$ (k = 1, 2, ..., 3).
Alternative hypothesis H(1): $\beta_k \neq 0$ (k = 1, 2, ..., 3)

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	126.5313	32.1188	3.94	0.0001
Sex1	49.8567	12.3625	4.03	0.0001
Month	2.9090	2.0604	1.41	0.1589

From the previous table, we find out the p-value of sex is 0.0001, which is much smaller than our significant level of 0.05. Therefore, we conclude that the sex is statistically significant for max force.

From the previous table, we find out the p-value of the month (age) is 0.0004, which is much smaller than our significant level of 0.05. Therefore, we conclude that the month (age) is statistically significant for max force/EDL weight.

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	18962.1839	1969.8014	9.63	0.0000
Sex1	-231.7501	758.1769	-0.31	0.7600
Month	-450.3177	126.3628	-3.56	0.0004

Then we would like to add the interaction effect into our regression model. We update our regression model to the following equation and apply the ANOVA test.

$$\text{Max force} = Intercept + sex + month + sex \times month$$

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Sex	1	223711.85	223711.85	16.22	0.0001
Month	1	27417.44	27417.44	1.99	0.1594
Sex:Month	1	372.71	372.71	0.03	0.8695
Residuals	356	4910139.18	13792.53		

$$\text{Max force/EDL weight} = Intercept + sex + month + sex \times month$$

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Sex	1	4833730.14	4833730.14	0.09	0.7604
Month	1	657026803.71	657026803.71	12.66	0.0004
Sex:Month	1	303728.18	303728.18	0.01	0.9391
Residuals	356	18469056479.97	51879372.13		

From the previous two tables, we find out the p-value of $sex \times month$ is 0.1594 for max force, and the p-value of $sex \times month$ is 0.9391 for max force/EDL weight. Those two p-values are much larger than our statistically significant level of 0.05. Thus, we can conclude that there is no interaction effect between gender and age (month).

To determine how the max rate of contraction and the max rate of relaxation affect the outcome variables, we can build the following regression models.

$$\begin{aligned}\text{Max force} &= Intercept + sex + month + sex \times month \\ &+ Max.Rate.of.Contraction + Max.Rate.of.Relaxation\end{aligned}$$

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	123.2191	10.9604	11.24	0.0000
Sex1	-0.4143	15.5221	-0.03	0.9787
Month	-12.1847	0.7459	-16.34	0.0000
Max.Rate.of.Contraction	0.0041	0.0006	6.74	0.0000
Max.Rate.of.Relaxation	-0.0179	0.0005	-35.95	0.0000
Sex1:Month	-0.4671	1.0127	-0.46	0.6449

$$\text{Max force/EDL weight} = Intercept + sex + month + sex \times month + Max.Rate.of.Contraction + Max.Rate.of.Relaxation$$

	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	19233.3635	1127.2220	17.06	0.0000
Sex1	-3974.2739	1596.3620	-2.49	0.0132
Month	-1348.3759	76.7140	-17.58	0.0000
Max.Rate.of.Contraction	0.2004	0.0630	3.18	0.0016
Max.Rate.of.Relaxation	-1.0573	0.0511	-20.69	0.0000
Sex1:Month	30.8611	104.1556	0.30	0.7672

From the previous two tables, if we set our statistically significant to 0.01, we find out the p-value of the month(age), max rate of contraction, and max rate of relaxation is smaller than 0.01. If we add the secondary muscle measures (the max rate of contraction and the max rate of relaxation) into our regression model, age and the secondary muscle measures are statistically significant. Therefore, we conclude that the secondary muscle measures will affect the value of max force and max force/EDL weight.

We already know the frequencies will affect the value of max force and max force/EDL weight from the EDA part. Then we will like to add the frequencies effect into our regression models.

Max force				
	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	85.8602	8.2746	10.38	0.0000
Sex1	20.6656	11.3914	1.81	0.0705
Month	-7.8393	0.5975	-13.12	0.0000
Stim.Freq..Hz.	0.5110	0.0290	17.65	0.0000
Max.Rate.of.Contraction	-0.0026	0.0006	-4.37	0.0000
Max.Rate.of.Relaxation	-0.0171	0.0004	-46.91	0.0000
Sex1:Month	-0.6244	0.7392	-0.84	0.3988

Max force/DML weight				
	Estimate	Std. Error	t value	Pr(>|t|)
(Intercept)	15608.5989	891.3376	17.51	0.0000
Sex1	-1928.9824	1227.0772	-1.57	0.1168
Month	-926.7645	64.3597	-14.40	0.0000
Stim.Freq..Hz.	49.5832	3.1186	15.90	0.0000
Max.Rate.of.Contraction	-0.4494	0.0632	-7.11	0.0000
Max.Rate.of.Relaxation	-0.9858	0.0393	-25.07	0.0000
Sex1:Month	15.5983	79.6260	0.20	0.8448

The previous two tables support our statement that the frequency effect is statistically significant and does affect the value of max force and max force/DML weight.

4 Conclusion

If we only consider age effect and sex effect on the regression model, the p-value of sex is 0.0001 and is statistically for max force, and the p-value of the month (age) is 0.0004 for max force/EDL weight. Moreover, there is no interaction effect between age and sex due to the large p-value. If we add the secondary muscle measures into our regression model, the max rate of contraction effect and the max rate of relaxation effect both are statistically significant for max force and max force/EDL weight. It indicates that the secondary muscle measures will affect the value of max force and max force/EDL weight. If we add the frequencies effect, we find out the frequencies effect does influence the value of max force and max force/DML weight.

5 Appendix