Shift Times, Exercise, and Weight Gain

Examining the Effects of Metabolic Activity and Shift Times on Weight Gain with a Zero-Inflated Poisson Model

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October 5, 2021

Research Questions

Q1: What is the effect of exercise time on weight gain?

- Overall effect is negative
- Negative effect is weaker with later shifts

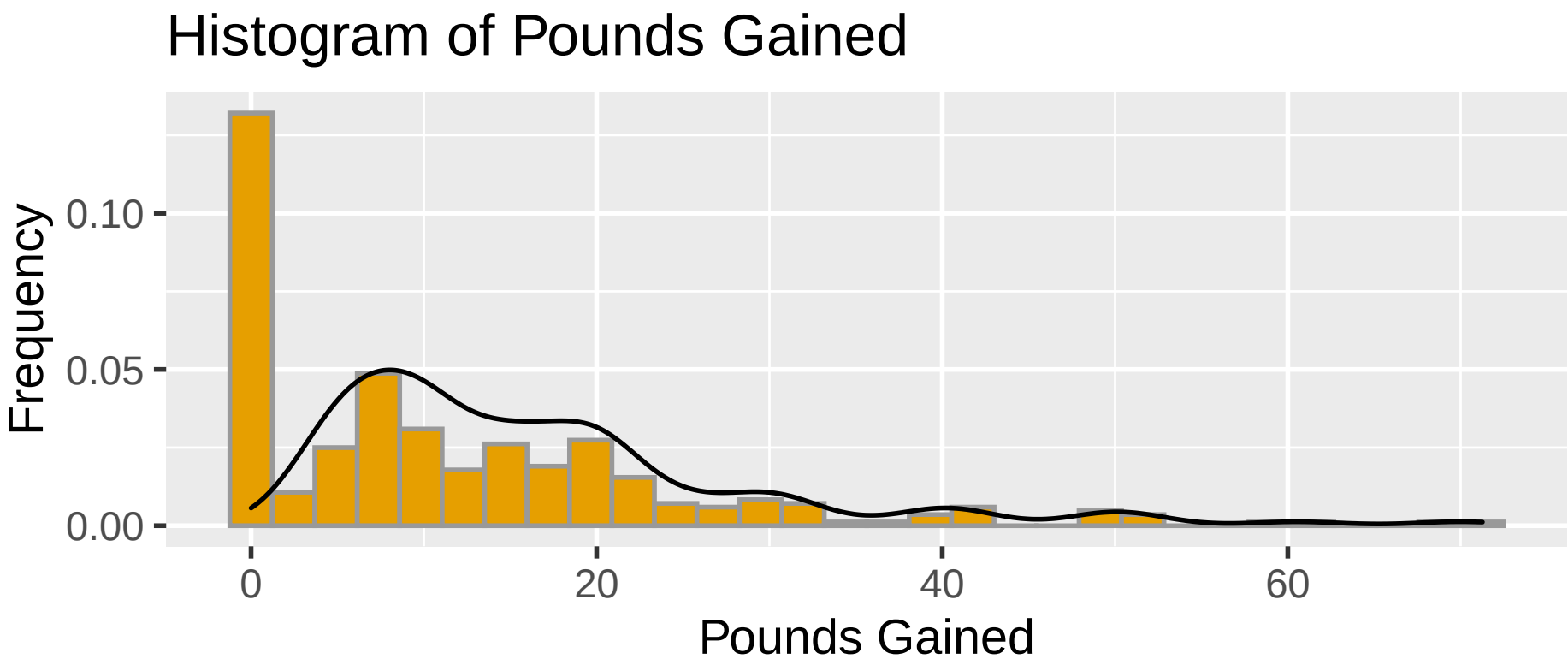
Q2: What is the effect of shift times (earlier to later) on weight gain?

- Overall effect is negative
- Negative effect is stronger in men

Data

Response: Weight Gained

- Treat as a count of pounds gained over an 8 month period
- Distinguish between those who gained weight and those who did not



We can model the number of pounds gained as a Poisson random variable with an inflated zero count.

Predictor Variables

Key Predictor 1: Total Metabolic Minutes

- A measure of weekly exercise time
- A weighted sum of walk, moderate, and vigorous exercise

Key Predictor 2: Shift Time

- The time when the respondent's shift begins
- Treated as ordinal

Additional Control Variables

- Beginning Weight (in lbs.)
- Gender (Male/Female)
- Age (in years)

Missing Data and Outliers

Missing Observations

- 392 responses from a population of 1,100 employees
- 44 missing weight gain
- 238 remaining after imputing TMM

Outliers

- 8 observations of weight gain outside of 1.5*IQR range
- Model fit improved with omission of these 8 observations
  1. Log-likelihood rises from -1115 to -767.7
  2. Diagnostic plots are improved

Model Building

Causal Elicitation

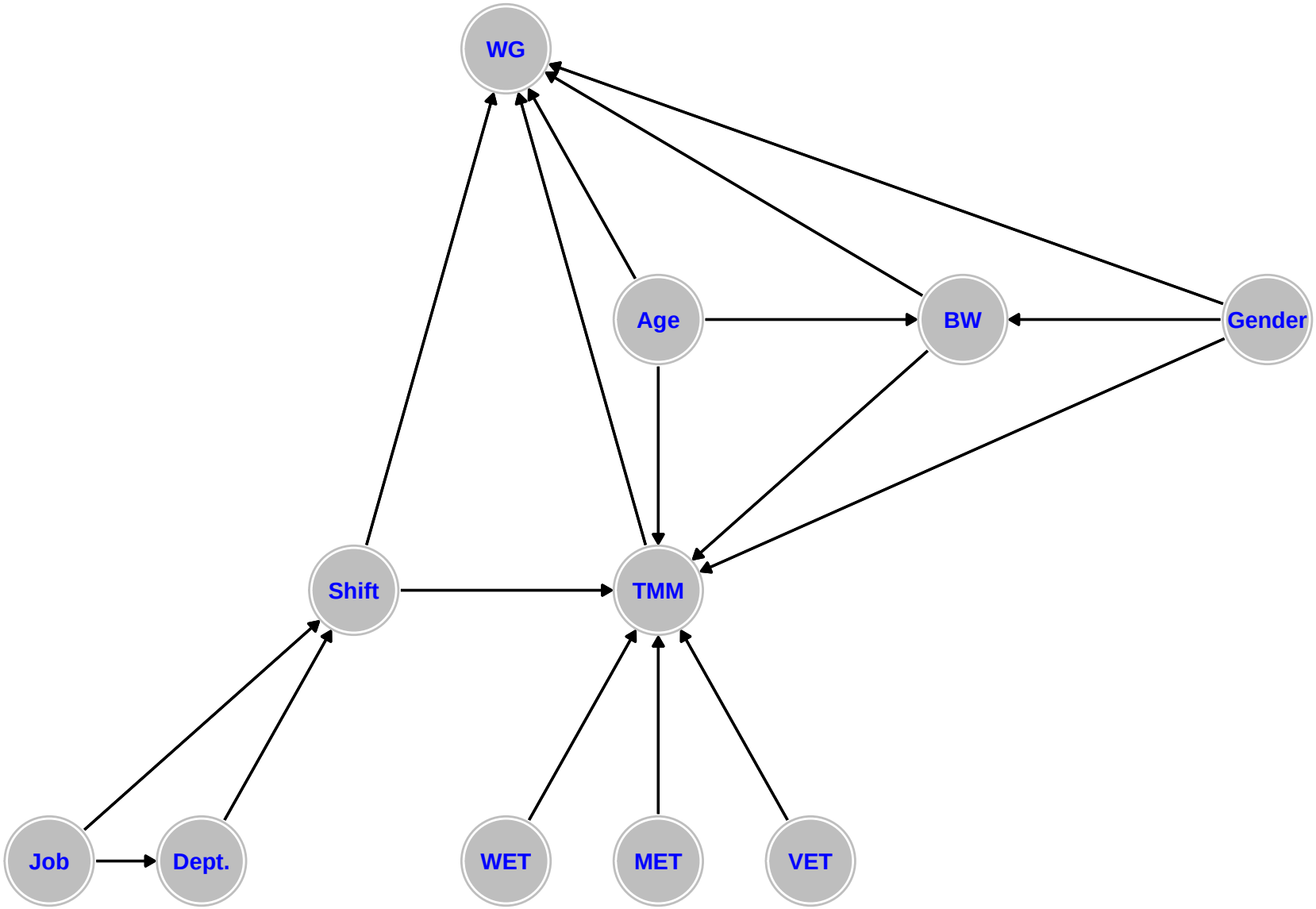
- Causal questions require explicit modeling of causation
- Use caution in interpretation (this was not a RCT)

Interactions

- No a priori theoretical expectation for interaction effects
- Checked all predictors for interactions with gender and shift
- Included only if different factor levels had divergent slopes

Our Model

DAG of Causal Model



Interactions

We found 6 interactions worth including:

with Shift

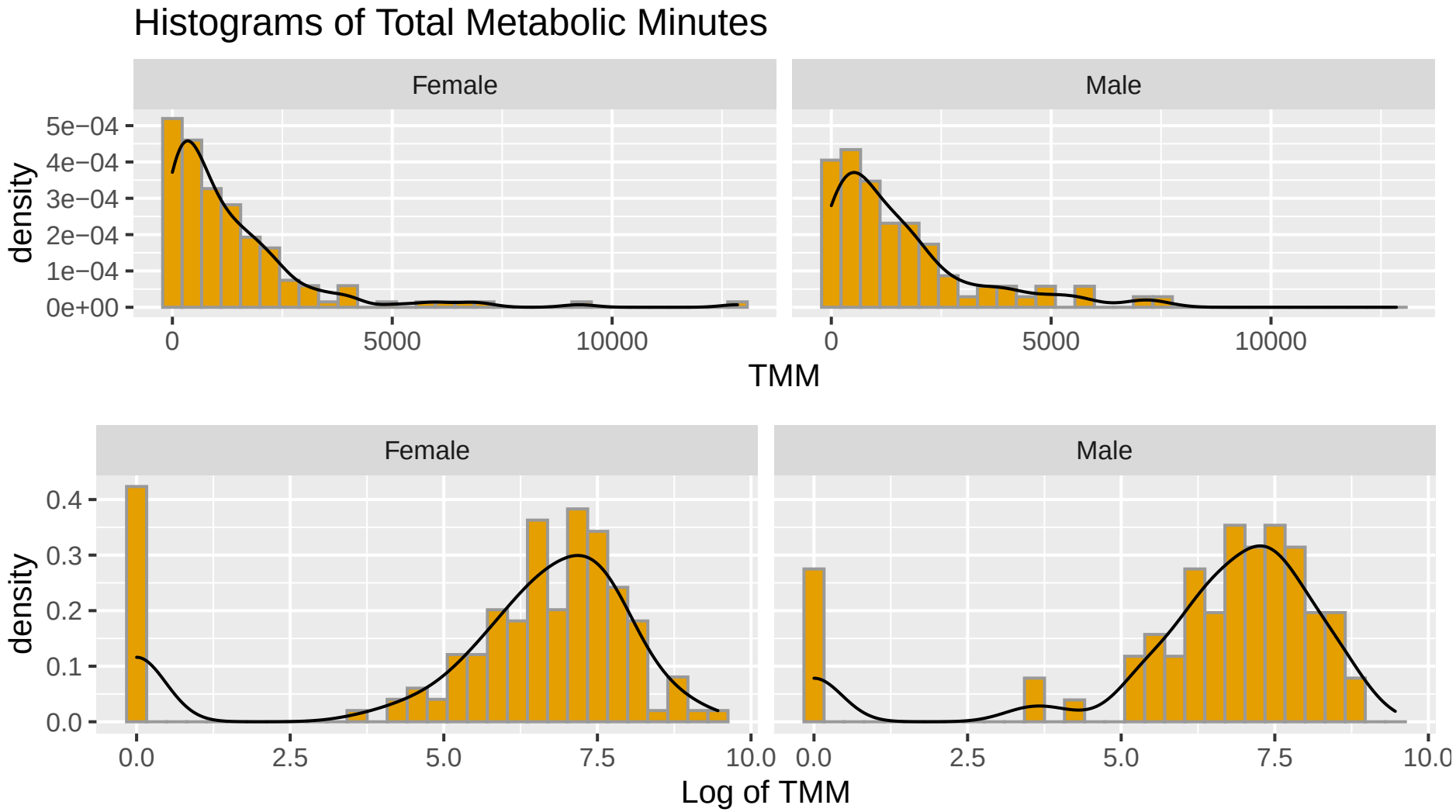
- Total Metabolic Minutes
- Age
- Beginning Weight
- Gender

with Gender

- Beginning Weight
- Shift

Transformations

Only TMM required a transformation (natural log) to reduce the skewdness.



Final Regression Results

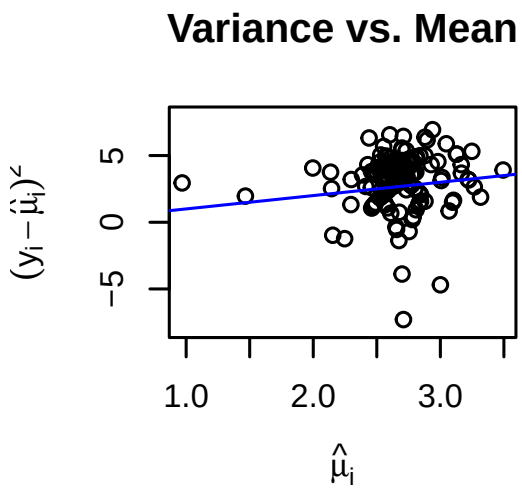
Zero-Inflated Poisson Model

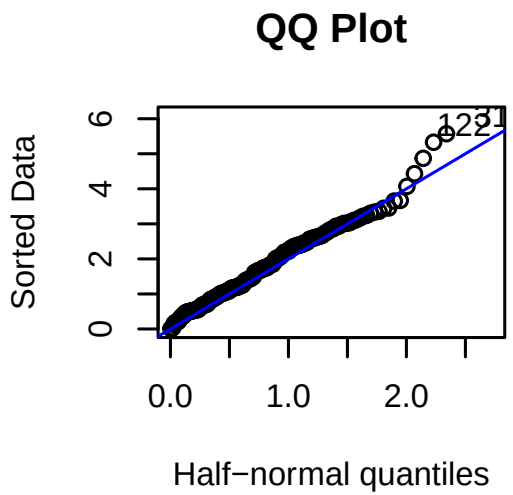
- Binomial model for gaining weight or not:
  - Coefficients represent the change in log-odds of gaining weight
  - No significant predictors found in this part of the model
- Poisson Model for number of pounds gained:
  - Coefficients represent change in log-mean pounds gained
  - 6 significant predictors found in this part of the model

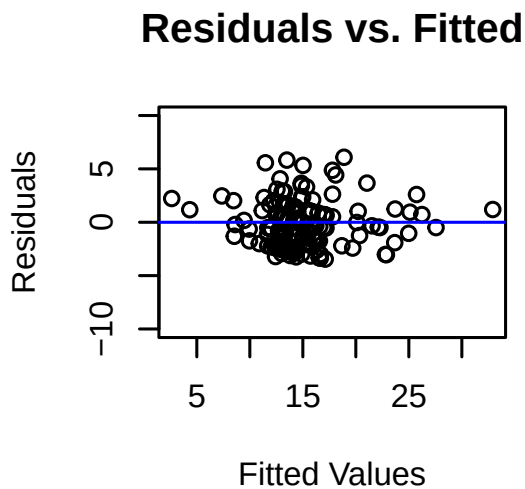
Variable	Coefficient	p-value
Shift	-0.356	$<$0.001
Log of Total Met Min	-0.145	$<$0.001
Beginning weight	0.004	0.036
Shift:log of Total Met Min	0.055	$<$0.001
Shift:Male	-0.133	$<$0.001
Beginning Weight:Male	0.004	0.007

Poisson Diagnostic Plots

- Variance = Mean
- Half-Normal Quantiles
- Null Residuals







Discussion

Main Effects on Weight Gain

- TMM has a negative effect
- Later shifts have a negative effect
- Beginning weight has a small positive effect

Interactions

- Effect of TMM is weaker with later shifts
- Effect of shift is stronger in men
- Higher beginning weight is associated with greater weight gain in men

Caveats and Future Research

- Need more research (preferably RCT) on who gains weight
- Causal inference based on strong assumptions
- Study does not distinguish between healthy and unhealthy weight gain

Appendicies

Supplemental Tables and Figures.

Poisson Results with Outliers

	Estimate	Std. Error	Pr(>|z|)
(Intercept)	3.675	0.298	0.000
oshift	-0.304	0.056	0.000
genderMale	-0.373	0.292	0.202
log(Total_Met_Min + 1)	-0.096	0.018	0.000
beg_weight	0.000	0.002	0.799
Age	-0.005	0.002	0.023
oshift:log(Total_Met_Min + 1)	0.035	0.005	0.000
oshift:beg_weight	0.000	0.000	0.072
oshift:genderMale	-0.113	0.024	0.000
log(Total_Met_Min + 1):genderMale	-0.038	0.017	0.026
beg_weight:genderMale	0.005	0.001	0.000

Zero-Inflated Estimates with Outliers

	Estimate	Std. Error	Pr(>|z|)
(Intercept)	-0.570	1.951	0.770
oshift	-0.051	0.442	0.909
genderMale	-0.197	1.713	0.909
log(Total_Met_Min + 1)	0.005	0.117	0.967
beg_weight	0.001	0.012	0.963
Age	-0.007	0.015	0.654
oshift:log(Total_Met_Min + 1)	-0.028	0.029	0.334
oshift:beg_weight	0.001	0.003	0.783
oshift:genderMale	-0.047	0.176	0.789
genderMale:log(Total_Met_Min + 1)	0.096	0.120	0.425
genderMale:beg_weight	0.002	0.008	0.846

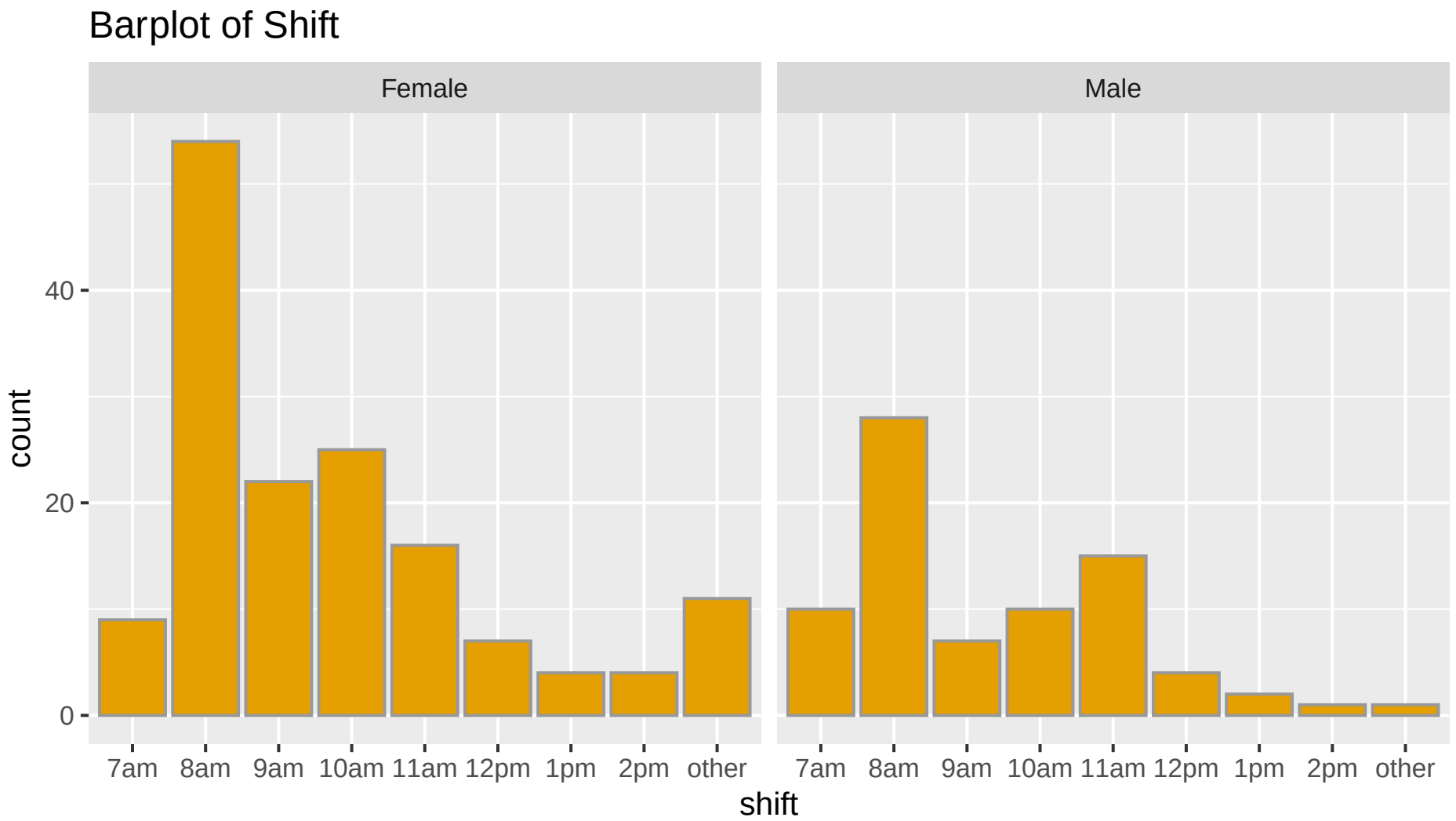
Poisson Estimates without Outliers

	Estimate	Std. Error	Pr(>|z|)
(Intercept)	2.697	0.318	0.000
oshift	-0.208	0.064	0.001
genderMale	-0.124	0.309	0.687
log(Total_Met_Min + 1)	-0.097	0.023	0.000
beg_weight	0.004	0.002	0.008
Age	-0.001	0.002	0.469
oshift:log(Total_Met_Min + 1)	0.038	0.006	0.000
oshift:beg_weight	0.000	0.000	0.112
oshift:genderMale	-0.086	0.025	0.001
log(Total_Met_Min + 1):genderMale	-0.003	0.021	0.901
beg_weight:genderMale	0.002	0.001	0.086

Zero-Inflated Estimates without Outliers

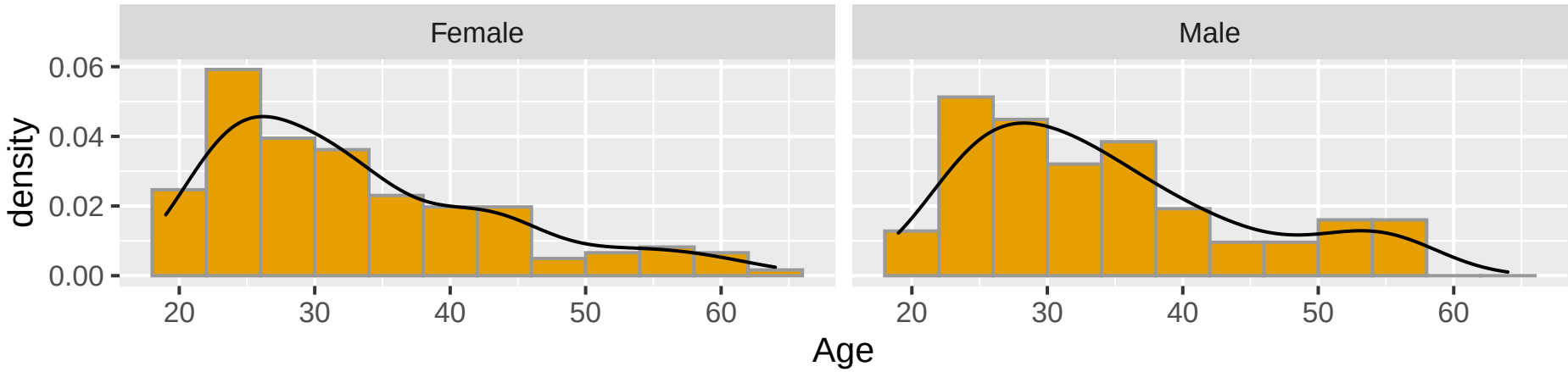
	Estimate	Std. Error	Pr(>|z|)
(Intercept)	-0.039	2.077	0.985
oshift	-0.109	0.468	0.815
genderMale	-0.137	1.729	0.937
log(Total_Met_Min + 1)	-0.031	0.121	0.799
beg_weight	0.000	0.013	0.984
Age	-0.014	0.015	0.363
oshift:log(Total_Met_Min + 1)	-0.022	0.030	0.459
oshift:beg_weight	0.001	0.003	0.766
oshift:genderMale	-0.064	0.181	0.725
genderMale:log(Total_Met_Min + 1)	0.076	0.124	0.540
genderMale:beg_weight	0.002	0.008	0.770

Shift by Gender

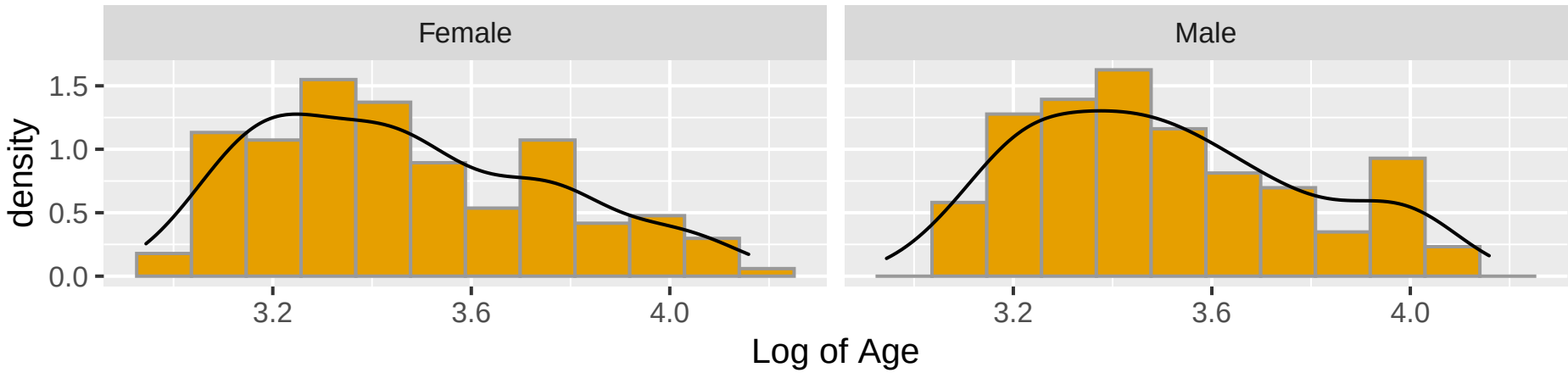


Age and Log-transformation

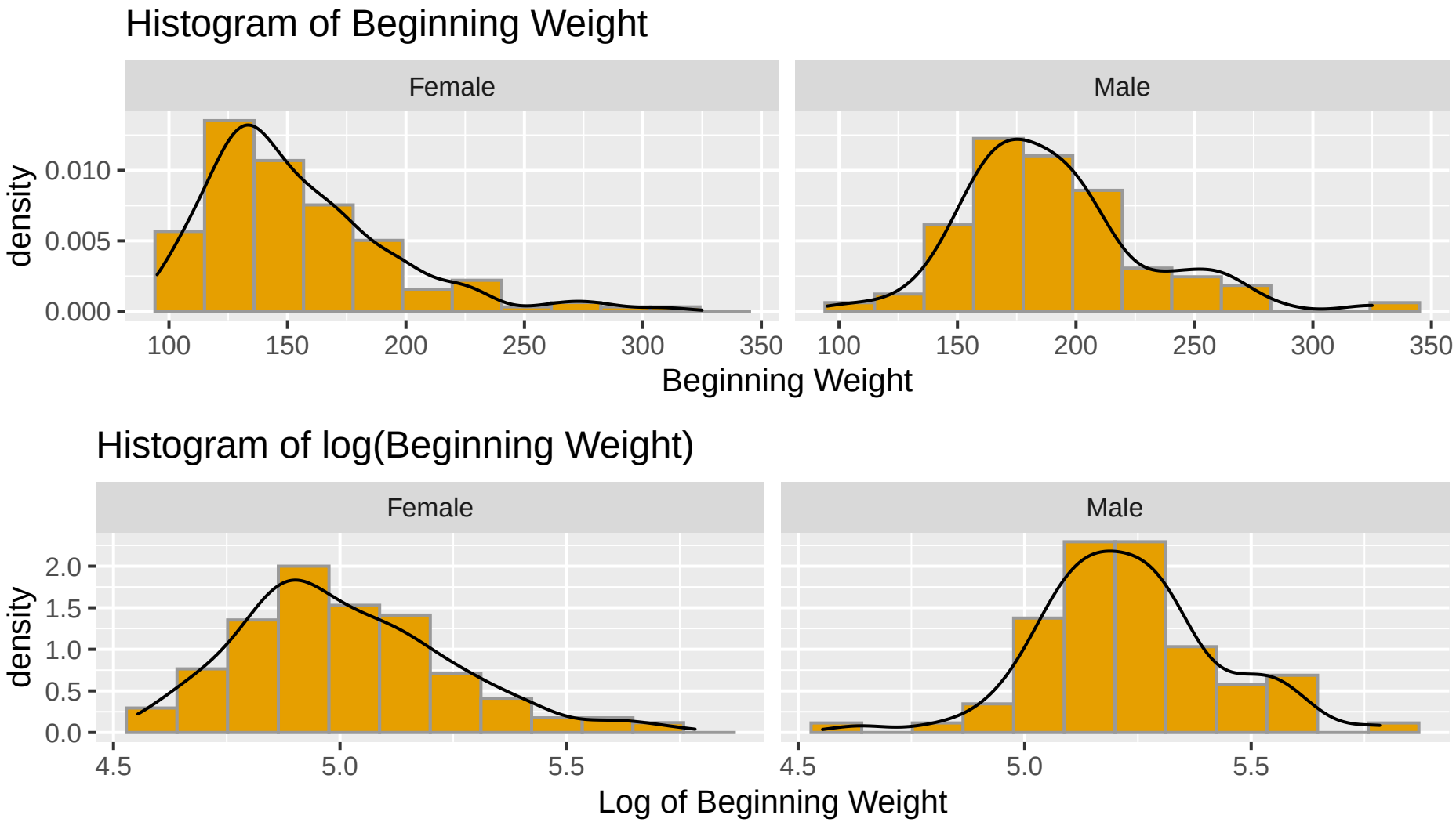
a. Histogram of Age



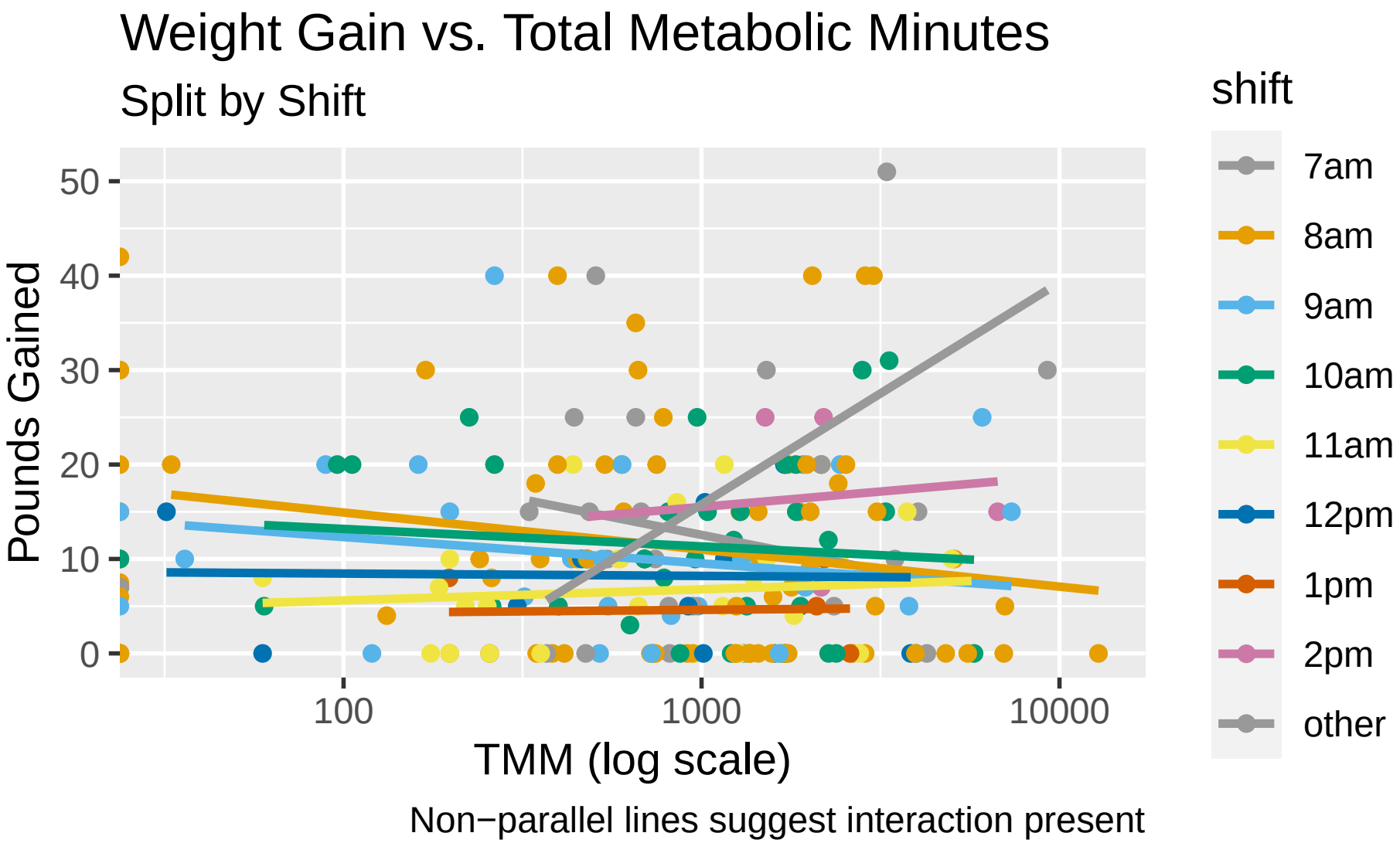
b. Histogram of log(Age)



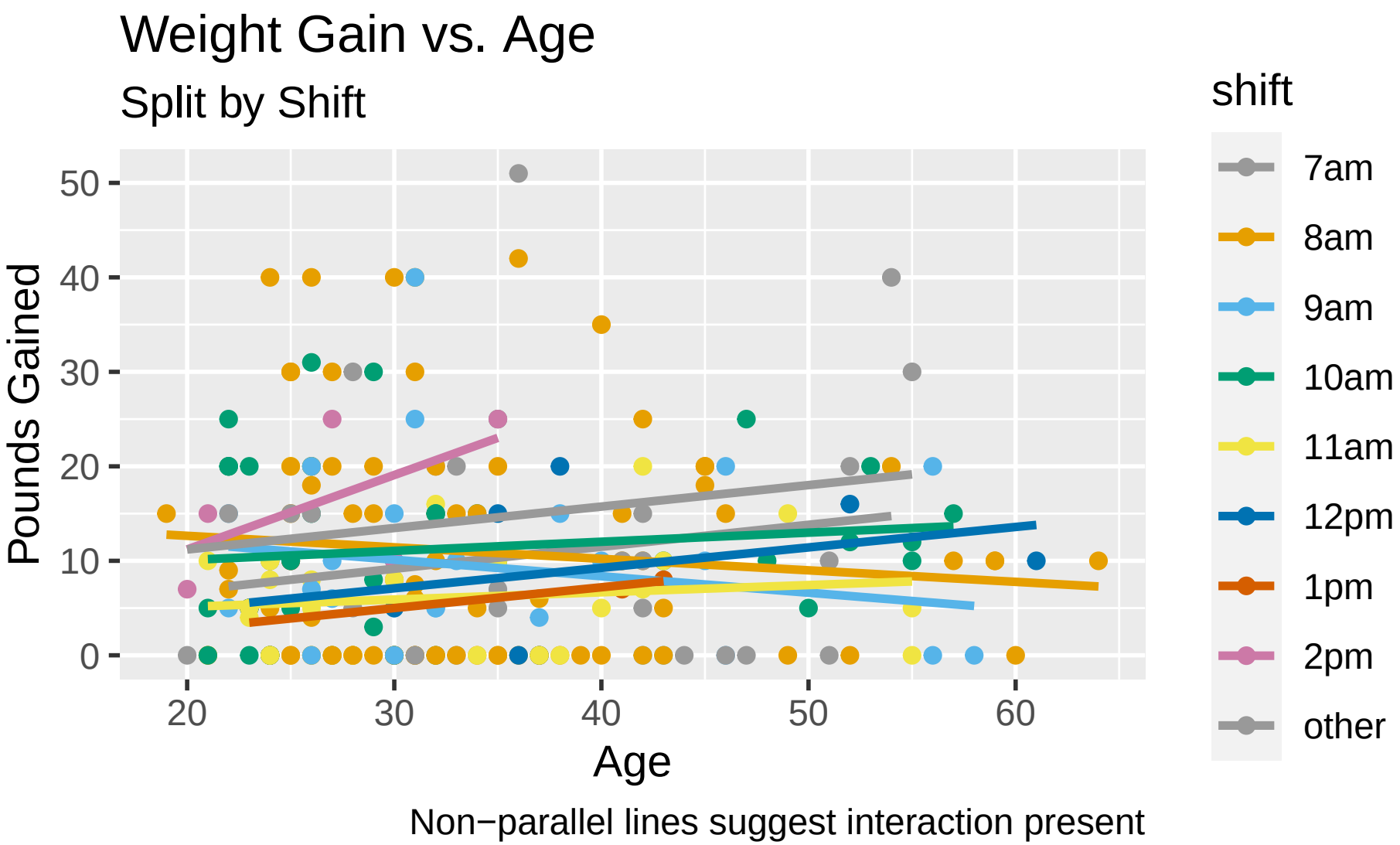
Weight and Log-Transformation



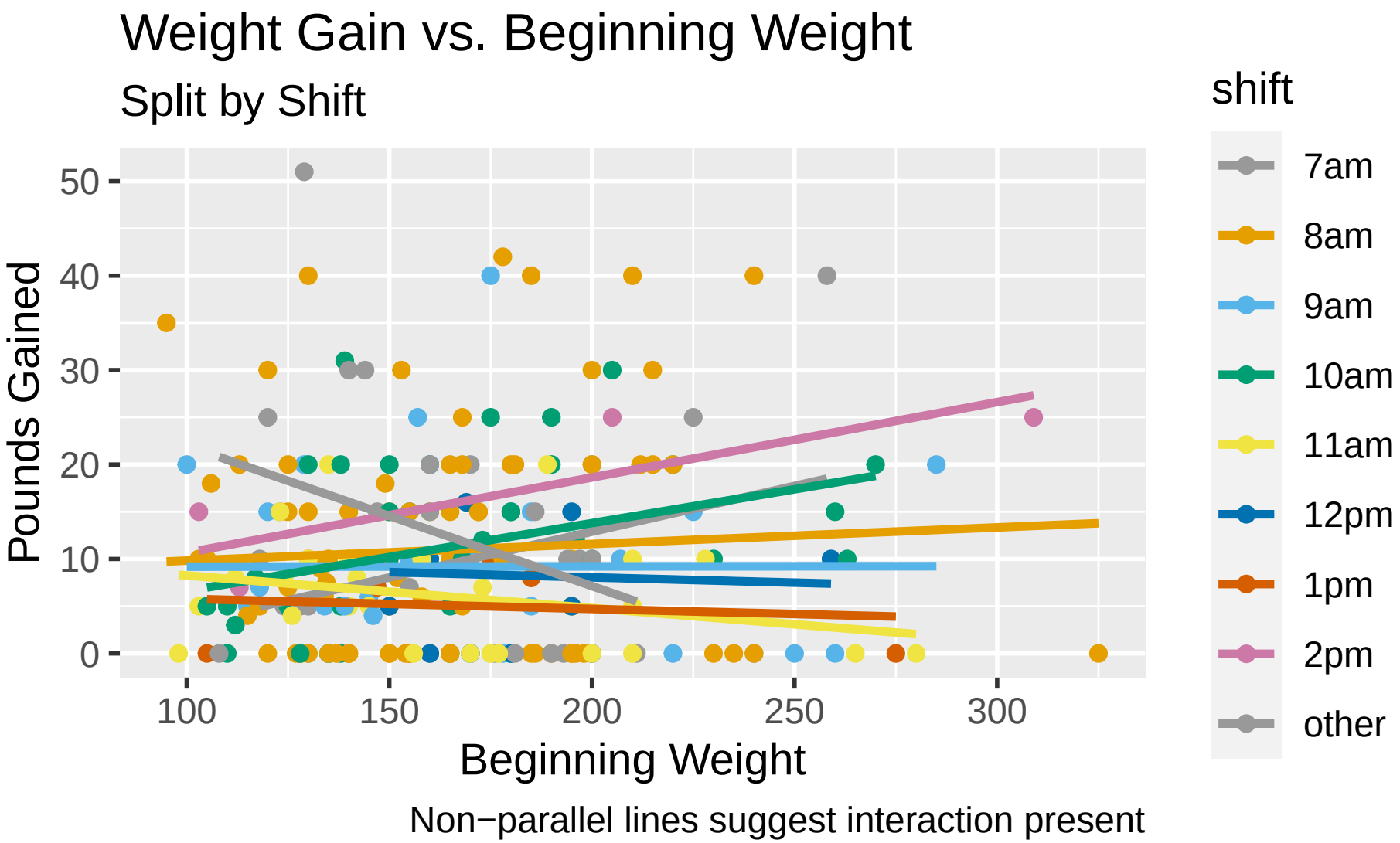
TMM and Shift Interaction



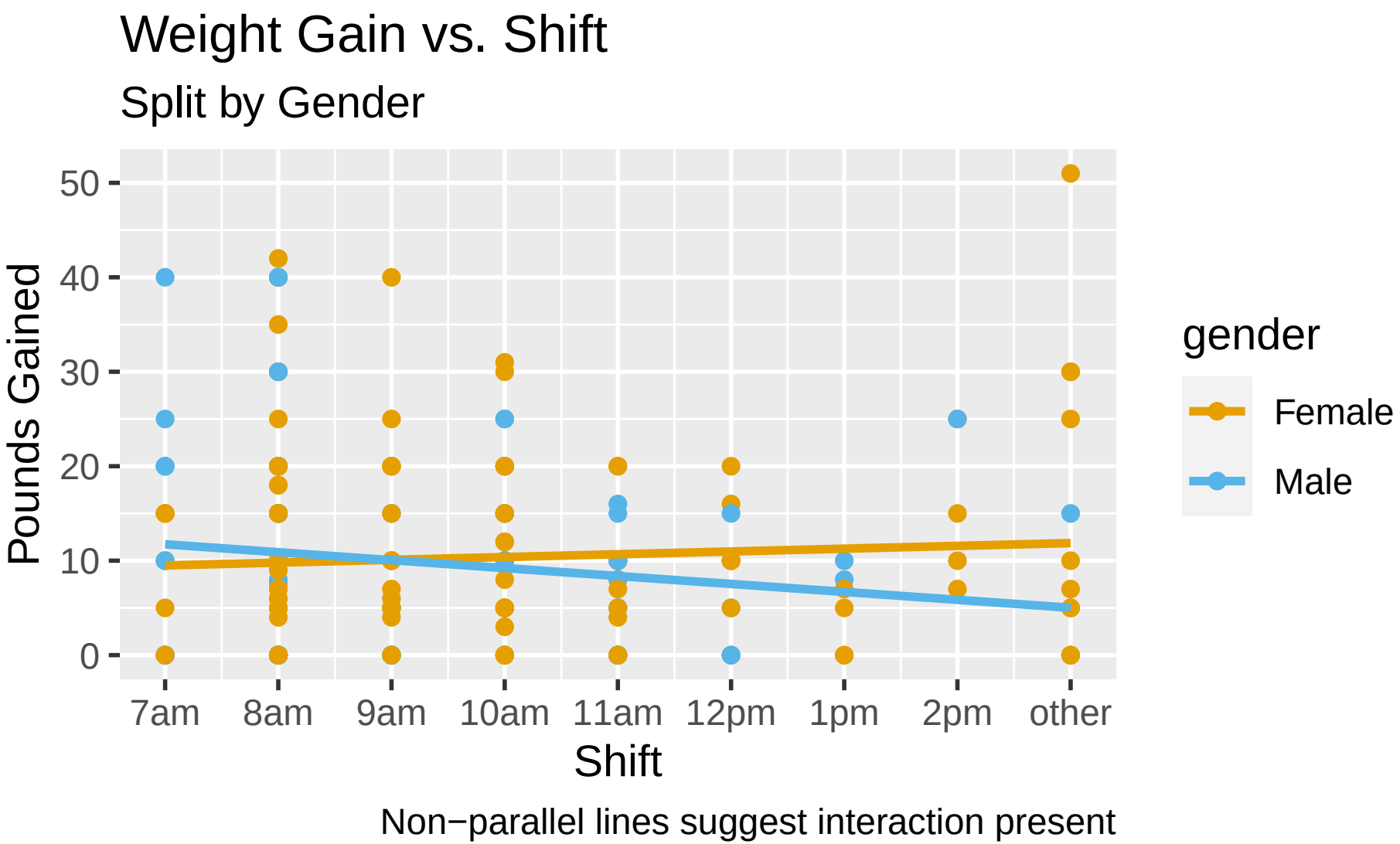
Age and Shift Interaction



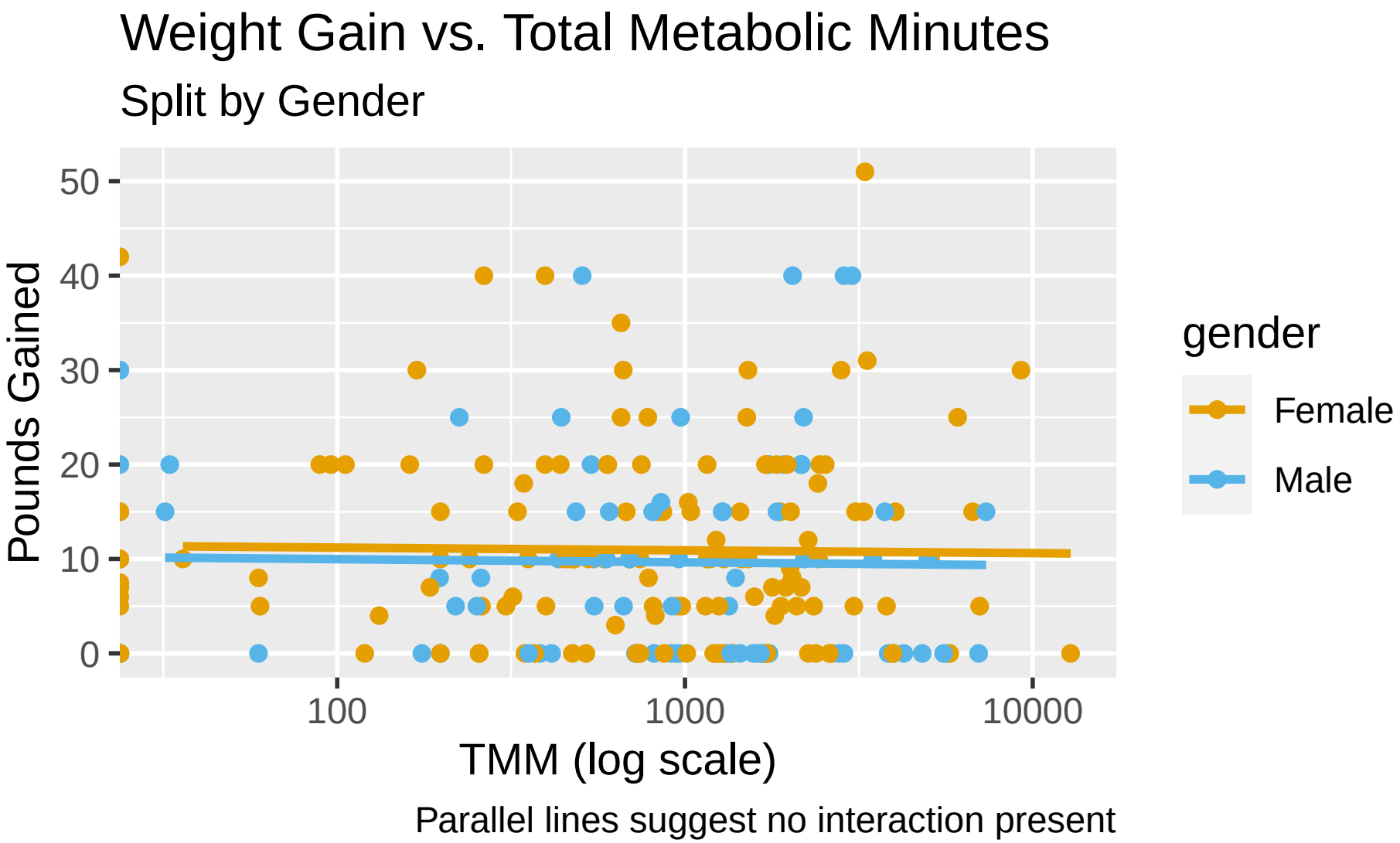
Beginning Weight and Shift Interaction



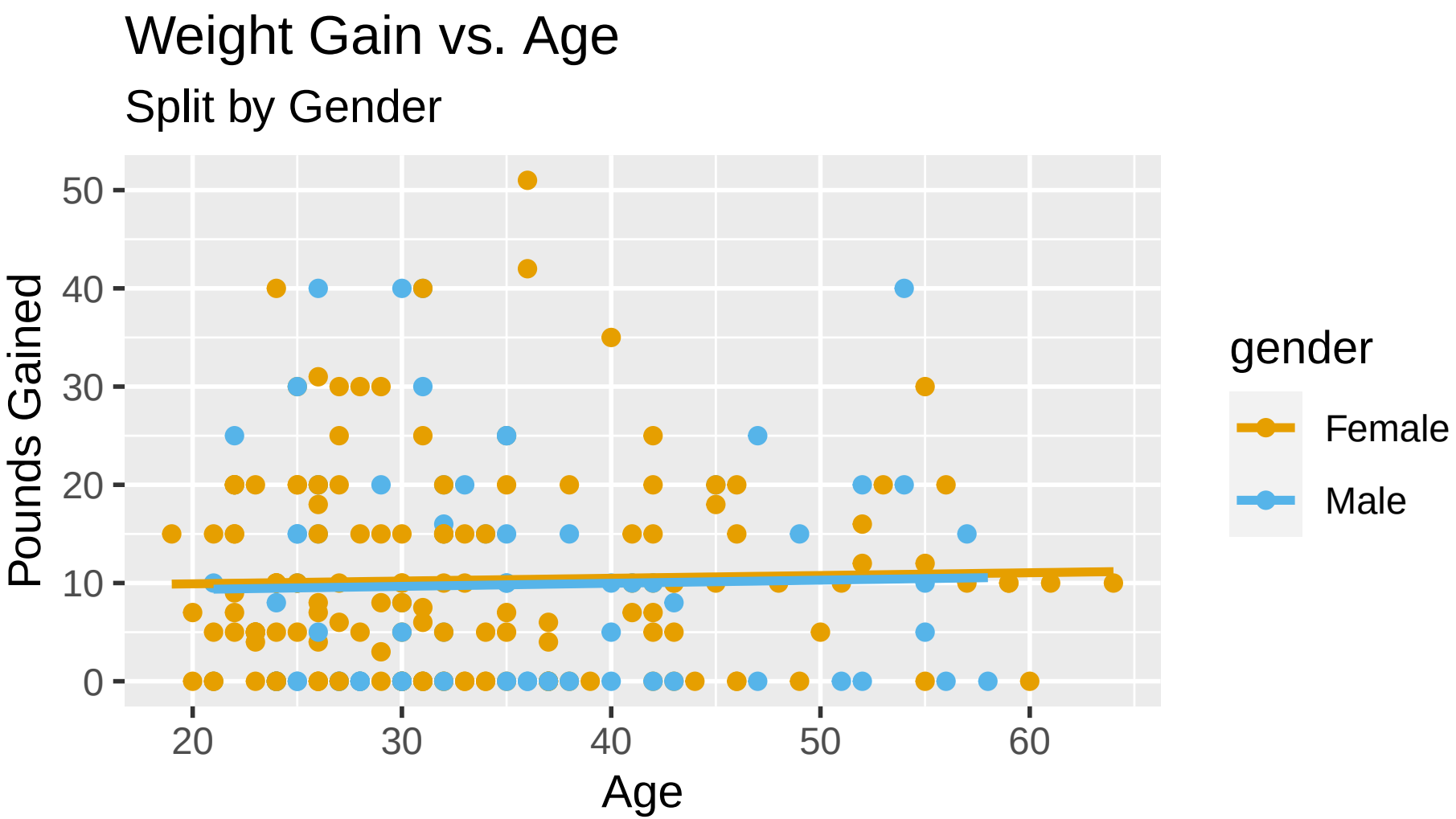
Gender and Shift Interaction



TMM and Gender Interaction



Age and Gender Interaction



Parallel lines suggest no interaction present

Beginning Weight and Gender Interaction