

# 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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# Research Questions

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

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

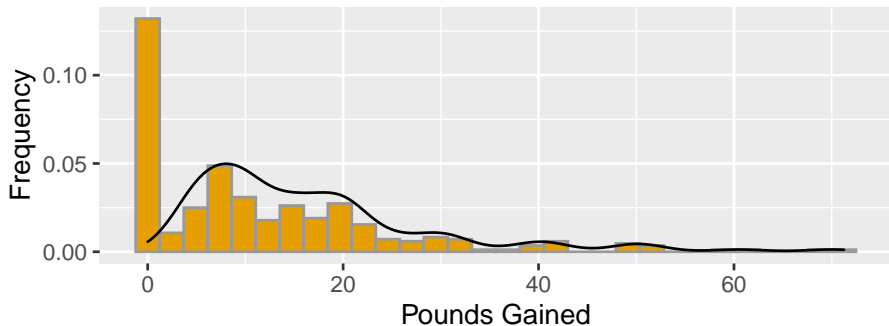
Q2: What is the effect of shift times (earlier to later) on weight gain?

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

## 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

### Histogram of Pounds Gained



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  $1.5 \times \text{IQR}$  range
- Model fit improved with omission of these 8 observations
  - 1 Log-likelihood rises from -1115 to -767.7
  - 2 Diagnostic plots are improved

## Causal Elicitation

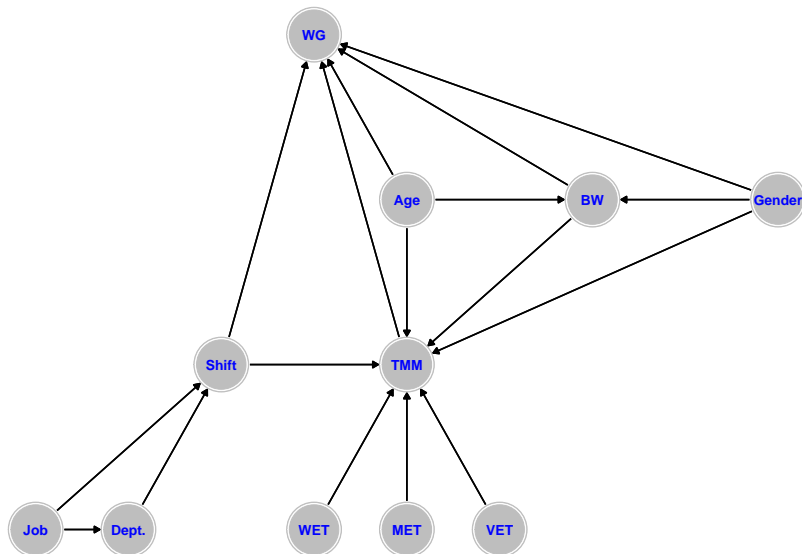
- Causal questions require explicit modeling of causation
- Use caution in interpretation (this was not a RCT)

## 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 non-parallel slopes

# Our Model

DAG of Causal Model



## with Shift

- Total Metabolic Minutes
- Age
- Beginning Weight
- Gender

## with Gender

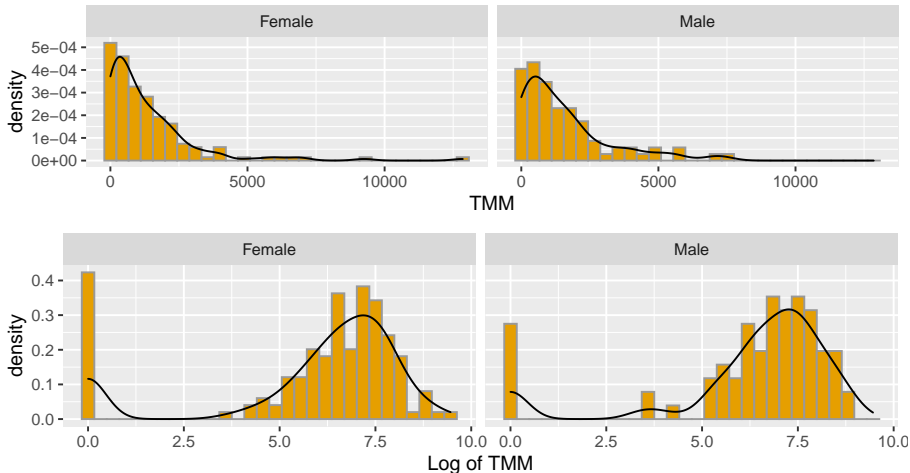
- Beginning Weight
- Shift



# Transformations

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

Histograms of Total Metabolic Minutes



# Final Regression Results

## Zero-Inflated Poisson Model

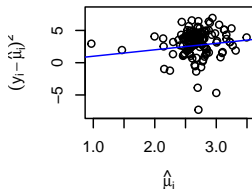
- Binomial model for gaining weight or not:
  - Coefficients represent the change in log-odds of gaining weight
  - No significant predictors found in this part of the model
- Poisson Model for number of pounds gained:
  - Coefficients represent change in log-mean pounds gained
  - 6 significant predictors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

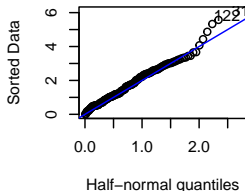
# Poisson Diagnostic Plots

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

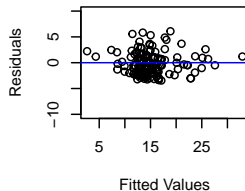
Variance vs. Mean



QQ Plot



Residuals vs. Fitted



# 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
  - Should be tested further
- Study does not distinguish between healthy and unhealthy weight gain

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

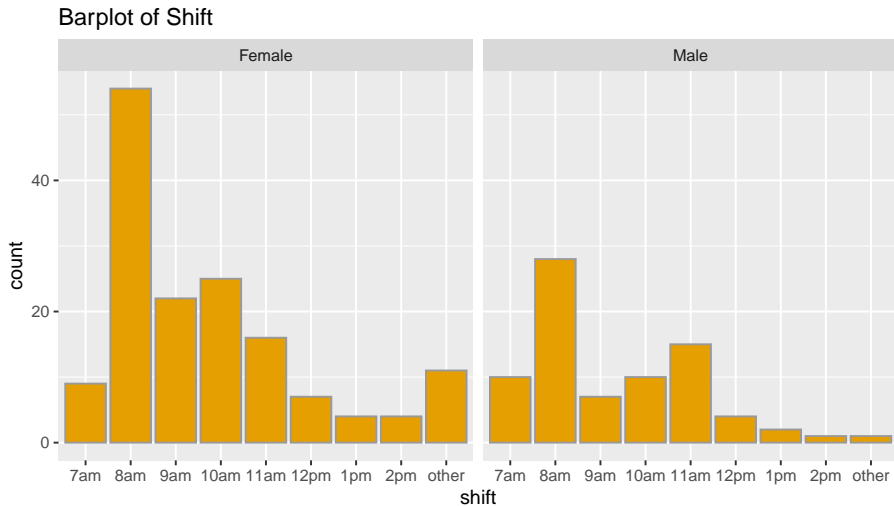
	Estimate	Std. Error	Pr(> z )
(Intercept)	2.697	0.318	0.000
oshift	-0.208	0.064	0.001
genderMale	-0.124	0.309	0.687
log(Total_Met_Min + 1)	-0.097	0.023	0.000
beg_weight	0.004	0.002	0.008
Age	-0.001	0.002	0.469
oshift:log(Total_Met_Min + 1)	0.038	0.006	0.000
oshift:beg_weight	0.000	0.000	0.112
oshift:genderMale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

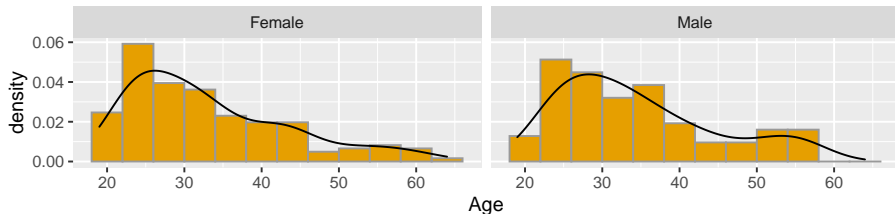
	Estimate	Std. Error	Pr(> z )
(Intercept)	-0.039	2.077	0.985
oshift	-0.109	0.468	0.815
genderMale	-0.137	1.729	0.937
log(Total_Met_Min + 1)	-0.031	0.121	0.799
beg_weight	0.000	0.013	0.984
Age	-0.014	0.015	0.363
oshift:log(Total_Met_Min + 1)	-0.022	0.030	0.459
oshift:beg_weight	0.001	0.003	0.766
oshift:genderMale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

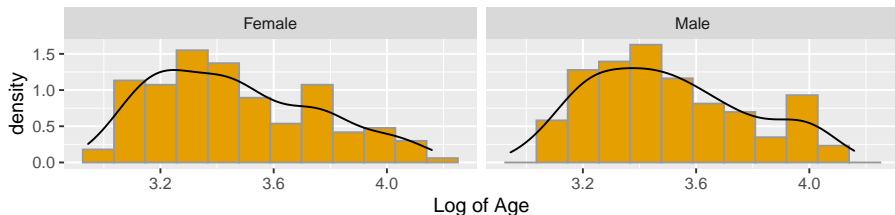


# Age and Log-transformation

a. Histogram of Age

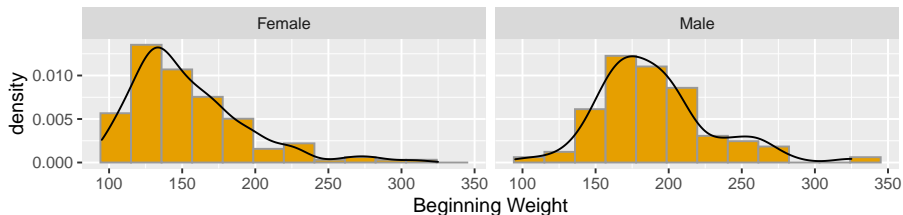


b. Histogram of log(Age)

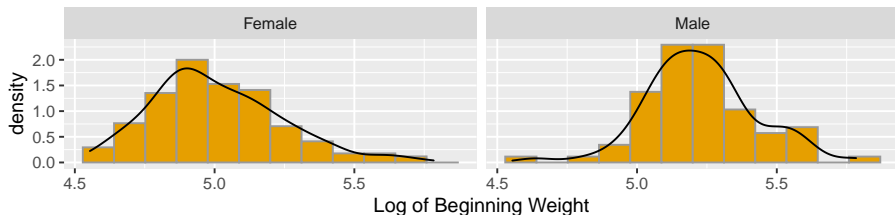


# Weight and Log-Transformation

## Histogram of Beginning Weight

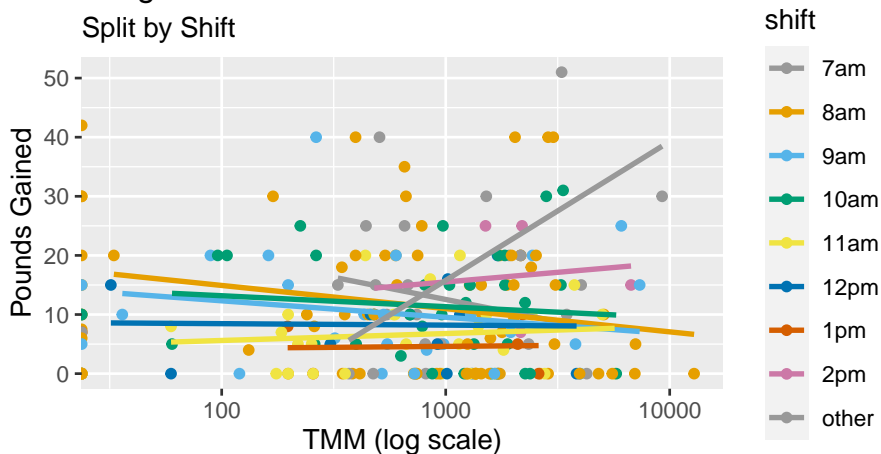


## Histogram of log(Beginning Weight)



# TMM and Shift Interaction

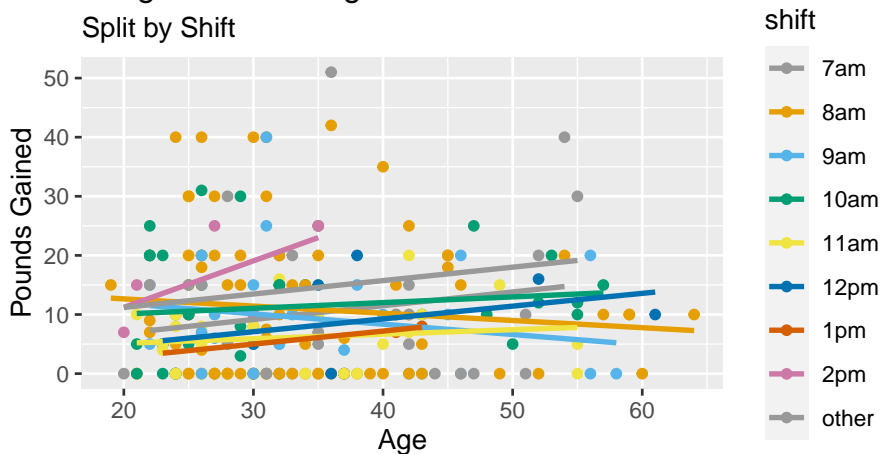
Weight Gain vs. Total Metabolic Minutes  
Split by Shift



Non-parallel lines suggest interaction present

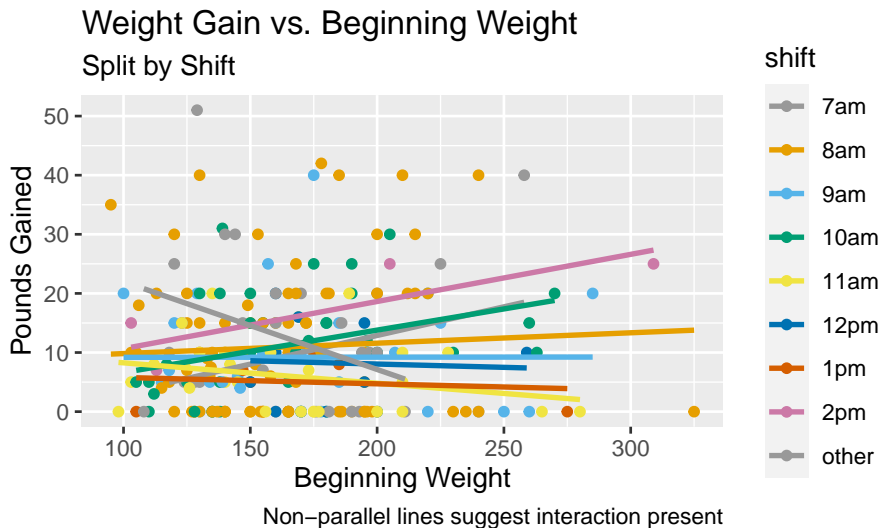
# Age and Shift Interaction

Weight Gain vs. Age  
Split by Shift



Non-parallel lines suggest interaction present

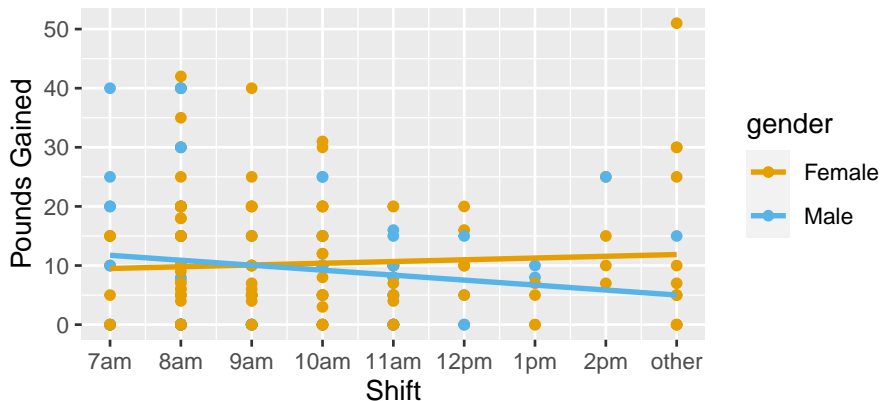
# Beginning Weight and Shift Interaction



# Gender and Shift Interaction

## Weight Gain vs. Shift

Split by Gender

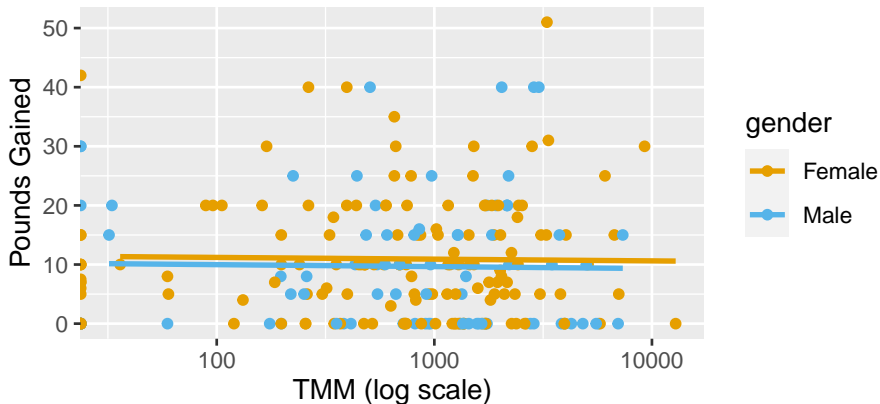


Non-parallel lines suggest interaction present



# TMM and Gender Interaction

Weight Gain vs. Total Metabolic Minutes  
Split by Gender

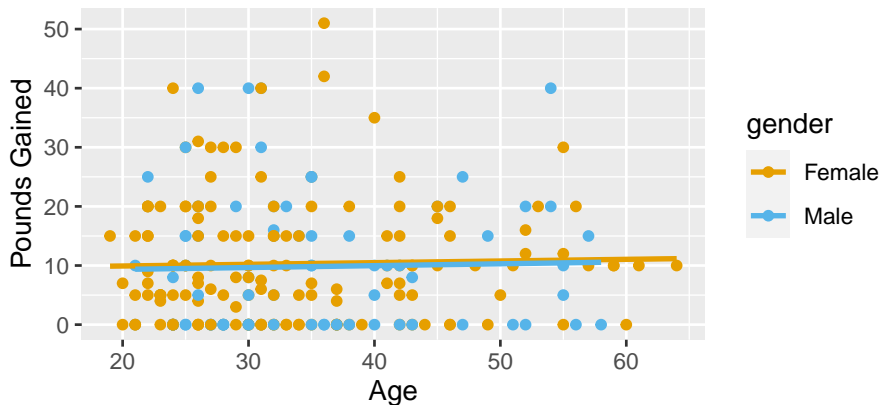


Parallel lines suggest no interaction present

## Age and Gender Interaction

## Weight Gain vs. Age

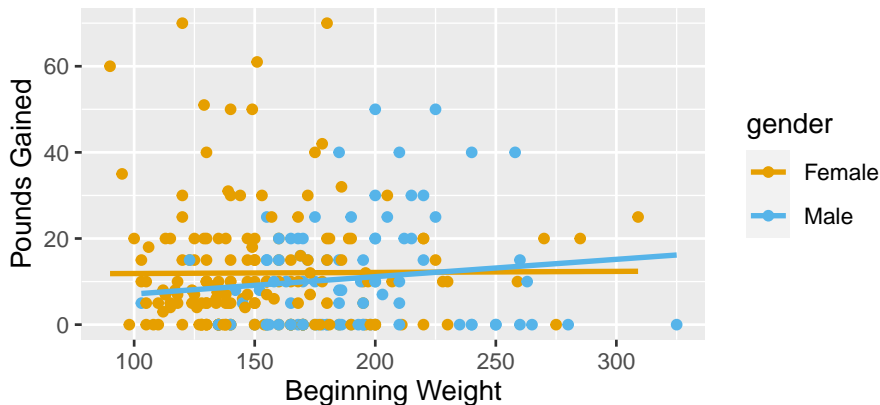
### Split by Gender



Parallel lines suggest no interaction present

# Beginning Weight and Gender Interaction

Weight Gain vs Beginning Weight  
Split by Gender



Non-parallel lines suggest interaction present