

# Does the CPAP Machine Improve the Amount of Sleep for People with Obstructive Sleep Apnea?

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# Outline

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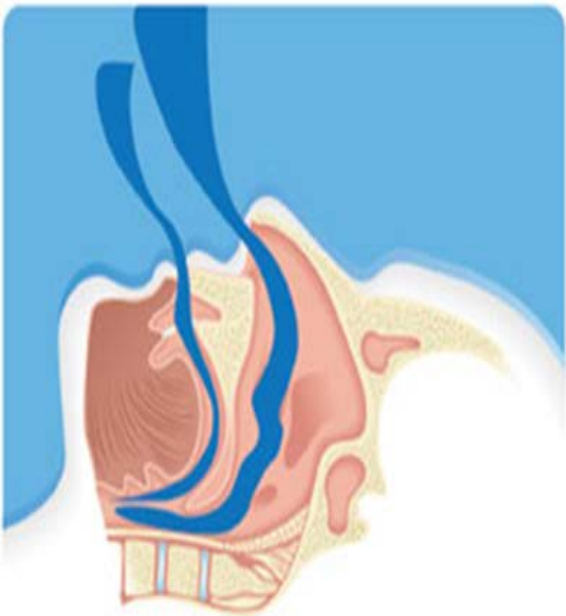
1. Introduction to OSA/CPAP machines
2. Questions of Interest
3. Methods of Data Collection
4. Statistical Methods
5. Results
6. Discussion

# Obstructive Sleep Apnea

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- Obstructive Sleep Apnea occurs when a patient's throat muscles relax and blocks the airway during sleep causing shortness of breathe.
- Risk Factors: BMI >25, Male, >40 years old, and Smoker
- Symptoms: Snoring, Headaches, Insomnia
- Treatment: mouthpiece, CPAP Machine, or surgery

## Normal Airflow



Wide Airway



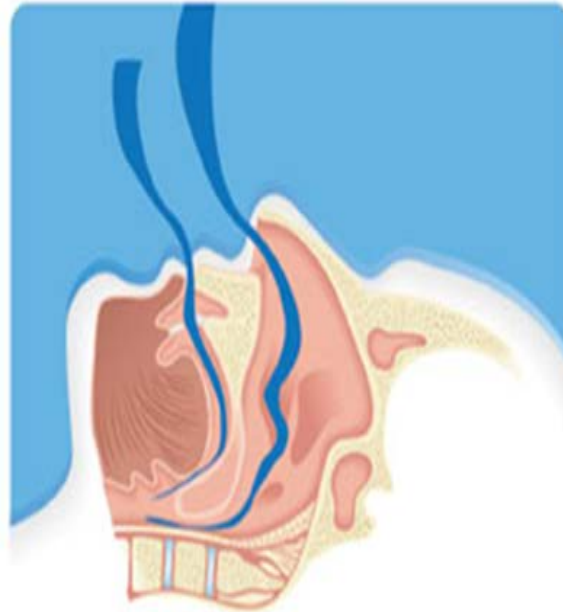
Normal Oxygen



Healthy Heart



## Sleep Apnea



Narrowed Airway



Low Oxygen



Stressed Heart



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# CPAP Machine

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- CPAP - Continuous Positive Airway Pressure
- The CPAP Machine was developed to increase the amount of air pressure that a given patient needs to breathe at night
- The CPAP Machine is made of three parts: a mask, prongs, and tubes

# Continuous Positive Airway Pressure (CPAP) Machine



CPAP machine with nasal pillow mask, ballcap-style straps



Full face mask, side straps



Nasal pillow mask, ballcap-style straps



Nasal pillow mask, side straps

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# Which One is Right for You?

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Nasal



Nasal Pillow



Full Face



[http://www.summitmedicalgroup.com/library/adult\\_health/aha\\_cpap/](http://www.summitmedicalgroup.com/library/adult_health/aha_cpap/)

<http://www.topsnoringmouthpieces.com/i-cant-tolerate-a-cpap-machine-what-alternatives-are-available/>

# Questions of Interest

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1. How does sleep time change over time?
2. How does the CPAP usage change over time?
3. Does sleep time change with CPAP usage?
4. What demographic covariates affect the above?

# Methods of Data Collection

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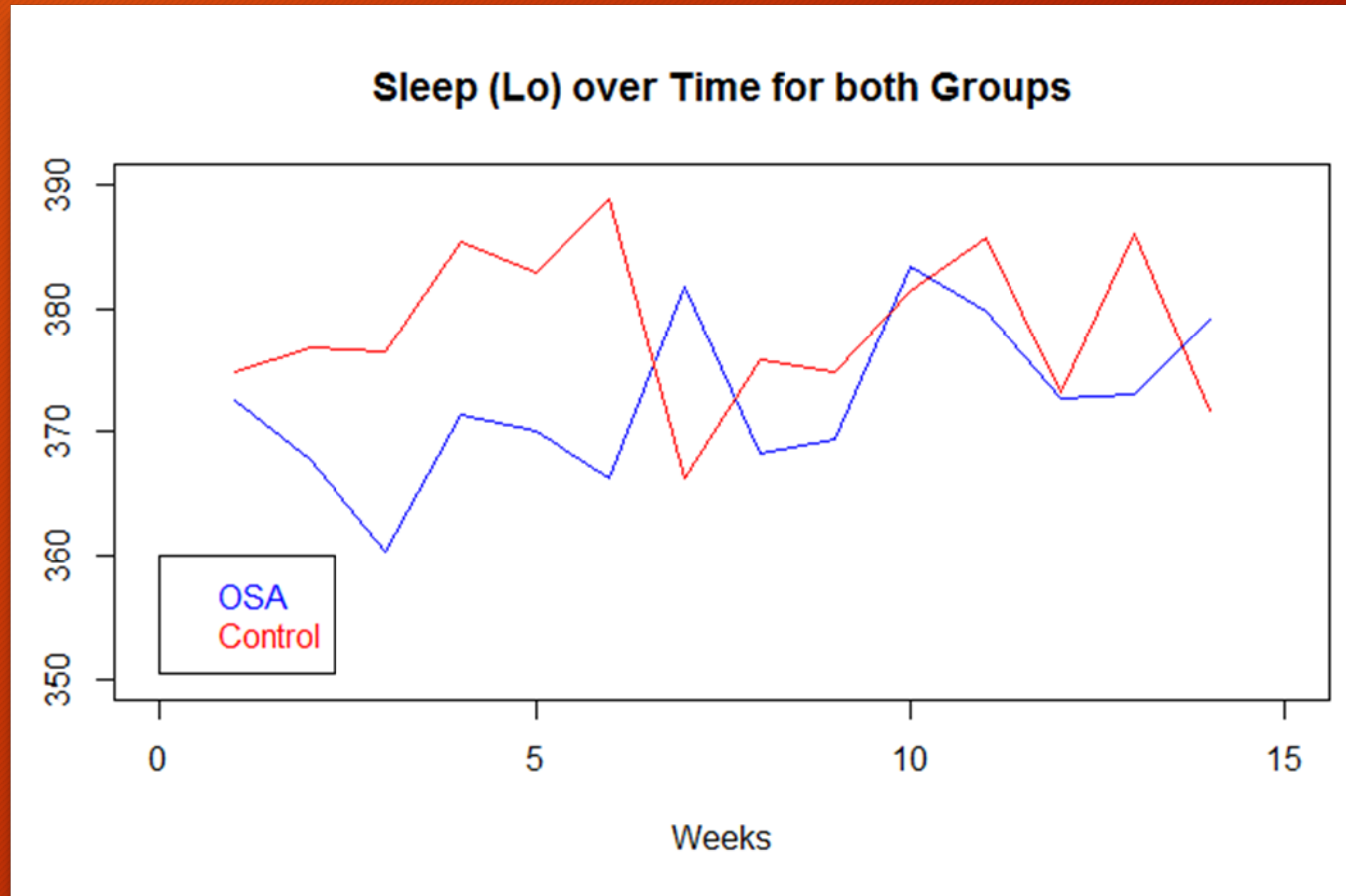
- Subjects wore special watches to measure how much they slept.
- CPAP machines were fitted with a chip to measure their usage.
- OSA subjects receive CPAP machines starting around the second week.
- Initially 80 OSA subjects (53 male), and 50 control subjects (32 male).
- OSA Group: 77, Control Group: 49; 82 Males, 44 Females
- We looked at data for the first 14 weeks.



Week	OSA	Control	Overall
1	372.5009	374.8563	373.4755
2	367.8209	376.8809	371.6571
3	360.3212	376.4148	367.1976
4	371.3807	385.3309	377.3594
5	370.1149	382.9278	375.6397
6	366.3585	388.9174	375.9354
7	381.7126	366.2762	375.1819
8	368.2483	375.8707	371.4497
9	369.3689	374.8919	371.6465
10	383.4583	381.4586	382.6421
11	379.8029	385.6913	382.2665
12	372.6208	373.2621	372.8919
13	373.1059	386.1015	378.4102
14	379.0834	371.6597	376.2553
Average	372.3842	378.7438	375

# Average of Weekly Sleep Time

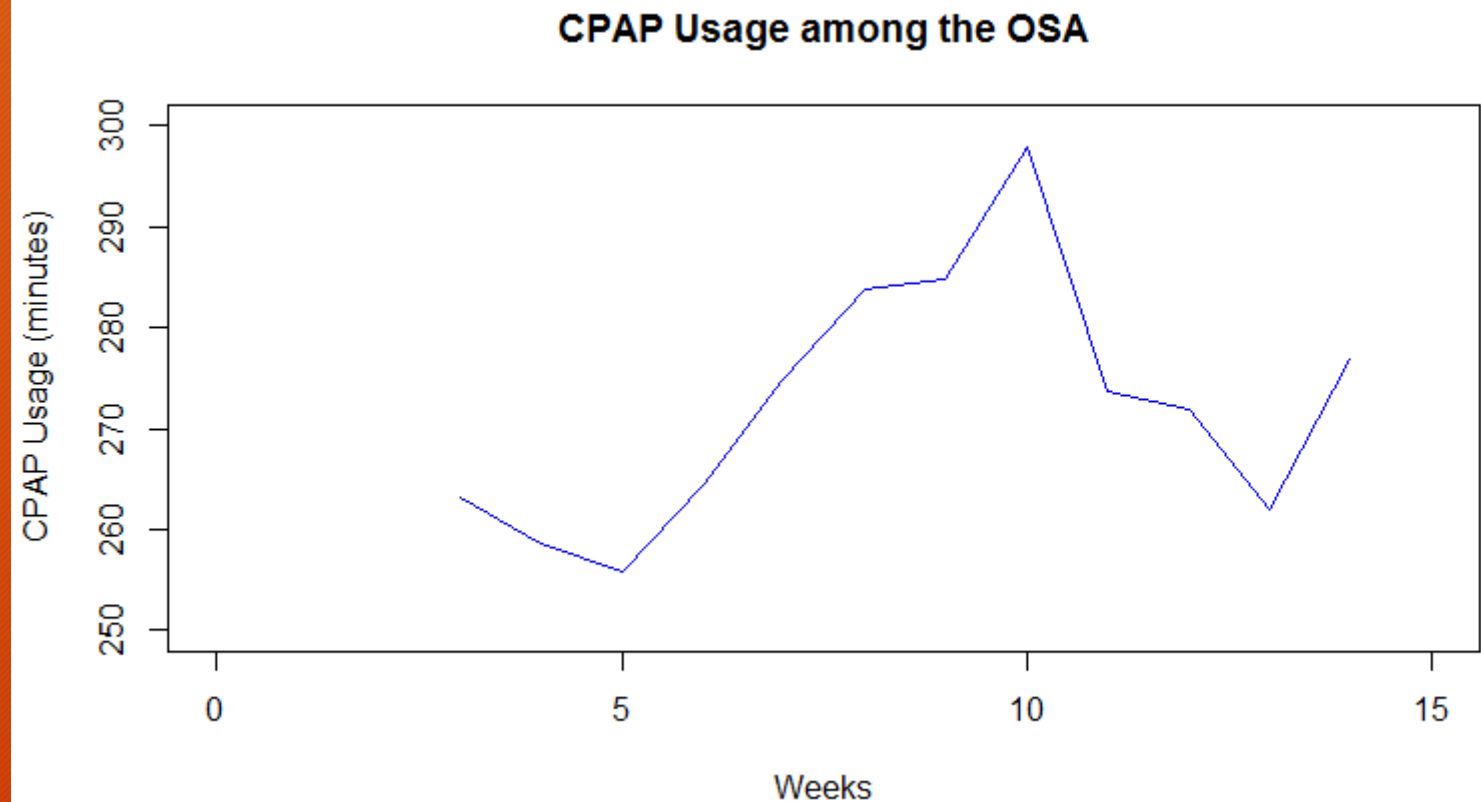
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# Average CPAP Usage among OSA

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Week	OSA
3	263.2297
4	258.546
5	255.94
6	264.2827
7	274.862
8	283.7241
9	284.7584
10	297.9151
11	273.6025
12	271.8275
13	262.0133
14	276.7912



# Statistical Methods

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- Two-Sample T-tests
  - Welch Two Sample T-test to compare OSA and control groups
  - Paired Two Sample T-test to compare OSA/ control to itself across weeks.
  - `t.test()` function built into R
- Mixed Model linear regression
  - `lme()` function , in the 'nlme' library in R.
  - Used a different intercept to take into account the subject effect.
- Collapsed daily values into weekly averages.

# OSA vs Control T-test (Sleep Time)

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- Total of 14 tests, one for each week
- $\mu_{OSA}$  is the average sleep time for the OSA Group by week
- $\mu_{con}$  is the average sleep time for the Control Group by week
- $H_0: \mu_{OSA} = \mu_{con}$
- $H_A: \mu_{OSA} \neq \mu_{con}$
- Based on P-value, we are only able to reject week 6.  $p = .022$  (OSA had a lower sleep time average).

# OSA T-test(week $i$ vs week 1)

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- Paired T-Test
- $\mu_1$  is the average sleep time for the OSA group from week 1
- $\mu_i$  is the average sleep time for the OSA group from week 2 - 14
- $H_0: \mu_1 = \mu_i$
- $H_A: \mu_1 \neq \mu_i$
- Based on the P-value, we failed to reject any week

# Control T-test(week i vs week 1)

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- Paired T-Test
- $\mu_1$  is the average sleep time for the Control group from week 1
- $\mu_i$  is the average sleep time for the Control group from week 2 - 14
- $H_0: \mu_1 = \mu_i$
- $H_A: \mu_1 \neq \mu_i$
- Based on P-value, we would only be able to reject week 6,  $p = .01$

# CPAP Usage T-test(week i vs week 3)

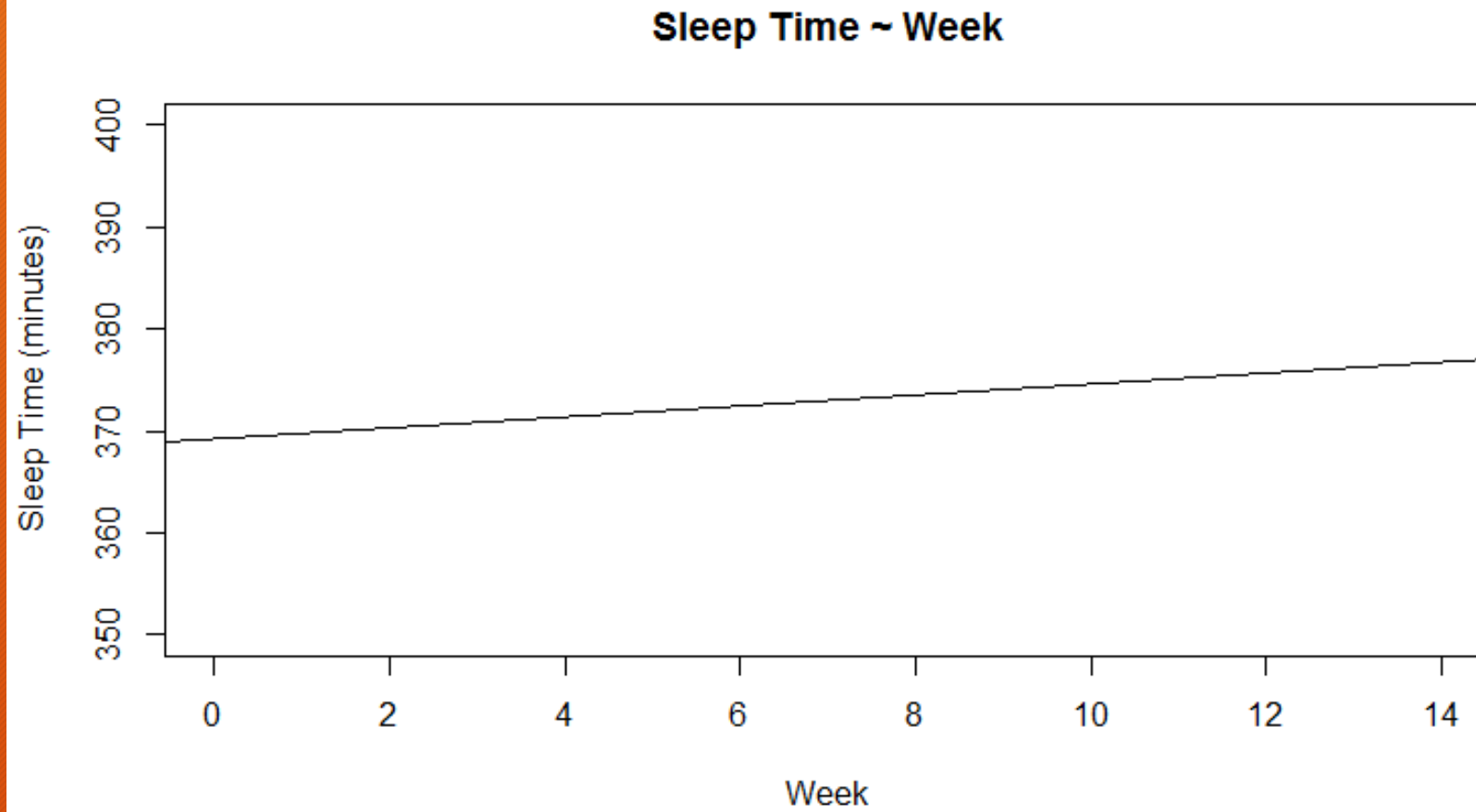
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- Paired T-Test
- $\mu_3$  is the average CPAP usage for the OSA group from week 3
- $\mu_i$  is the average CPAP usage for the OSA group from week 4 - 14
- $H_0: \mu_3 = \mu_i$
- $H_A: \mu_3 \neq \mu_i$
- Based on P-value, we would only be able to reject week 8 and week 10

Week	P-Value	Confidence Interval
4	0.738	(-19.484, 27.345)
5	0.55	(-23.474, 43.616)
6	0.197	(-12.68, 60.034)
7	0.097	(-6.0747, 71.509)
<b>8</b>	<b>0.023</b>	<b>(6.448, 82.149)</b>
9	0.051	(-0.255, 81.106)
<b>10</b>	<b>0.014</b>	<b>(10.914, 93.256)</b>
11	0.161	(-11.583, 67.821)
12	0.25	(-18.408, 69.178)
13	0.378	(-24.097, 62.485)
14	0.067	(-2.98, 84.338)

# Sleep ~ Week

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# Sleep ~ Week and Group

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Average Sleep Time =  $378.489 + \text{week}(-.092) + \text{group}(-15.879) + \text{week}(\text{group})(1.079)$

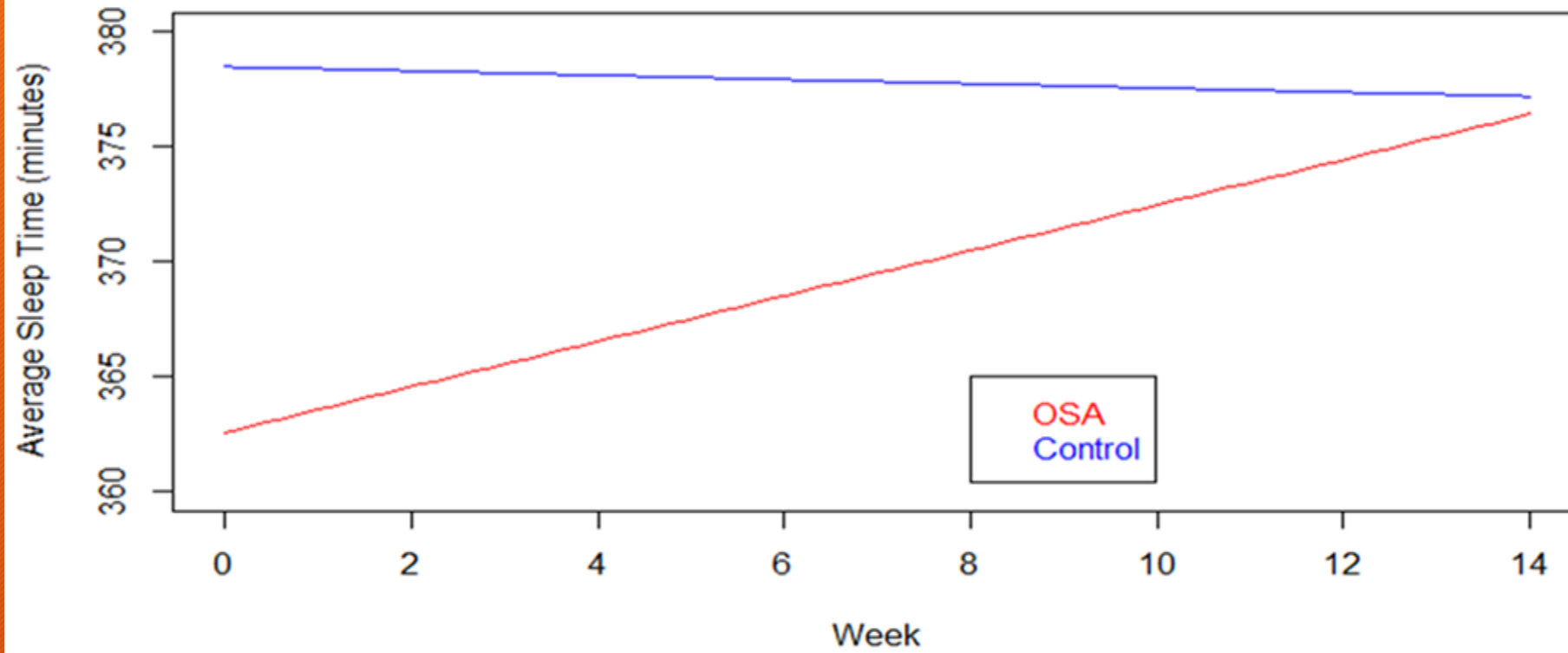
The Standard Deviation of the Intercept is 43.529

The Standard Deviation of the Residual is 37.707

Variables	P-Value
Week	.814
Group	.084
Week & Group	.036

- Found a statistically significant interaction between group and week, warranting further investigation.

### Sleep Trends: OSA vs. Control



# Sleep ~ Week and Sex

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Average Sleep Time =  $377.325 + \text{Week}(-.367) + \text{Sex}(-12.714) + \text{Week}(\text{Sex})(1.408)$

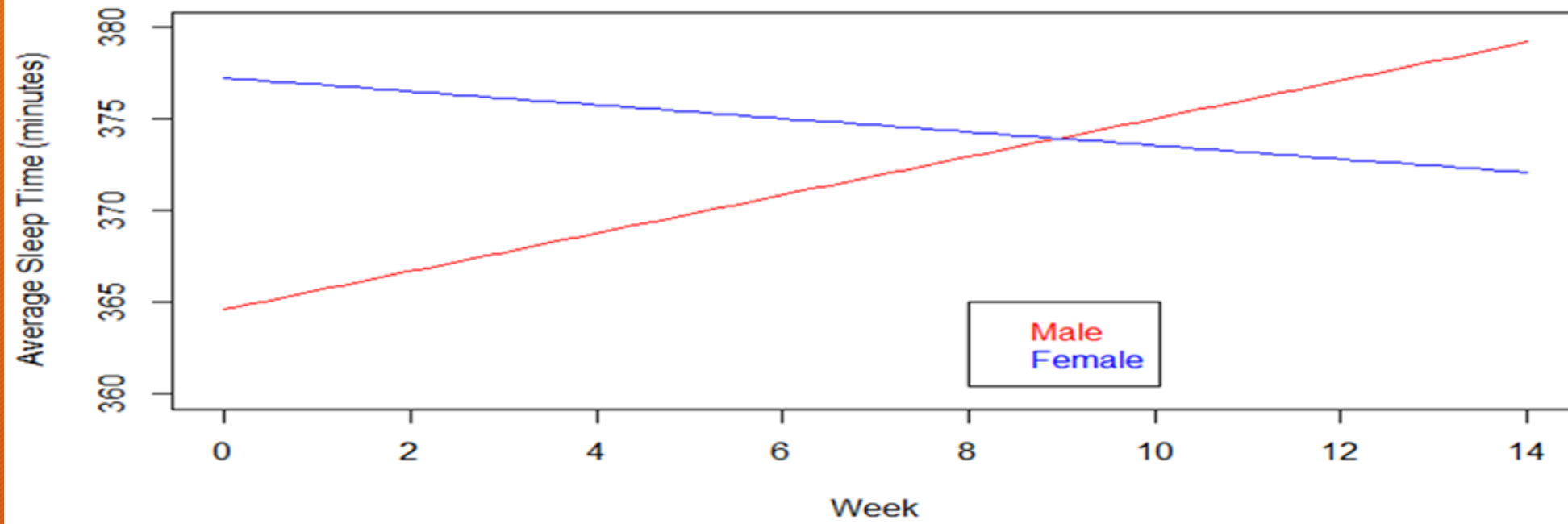
The Standard Deviation of the Intercept is 43.672

The Standard Deviation of the Residual is 37.671

Variables	P-Value
Week	.386
Sex	.176
Week & Sex	.008

Finds a statistically significant interaction.

### Sleep Trends: Male vs. Female



# Sleep ~ Week and Marital Status

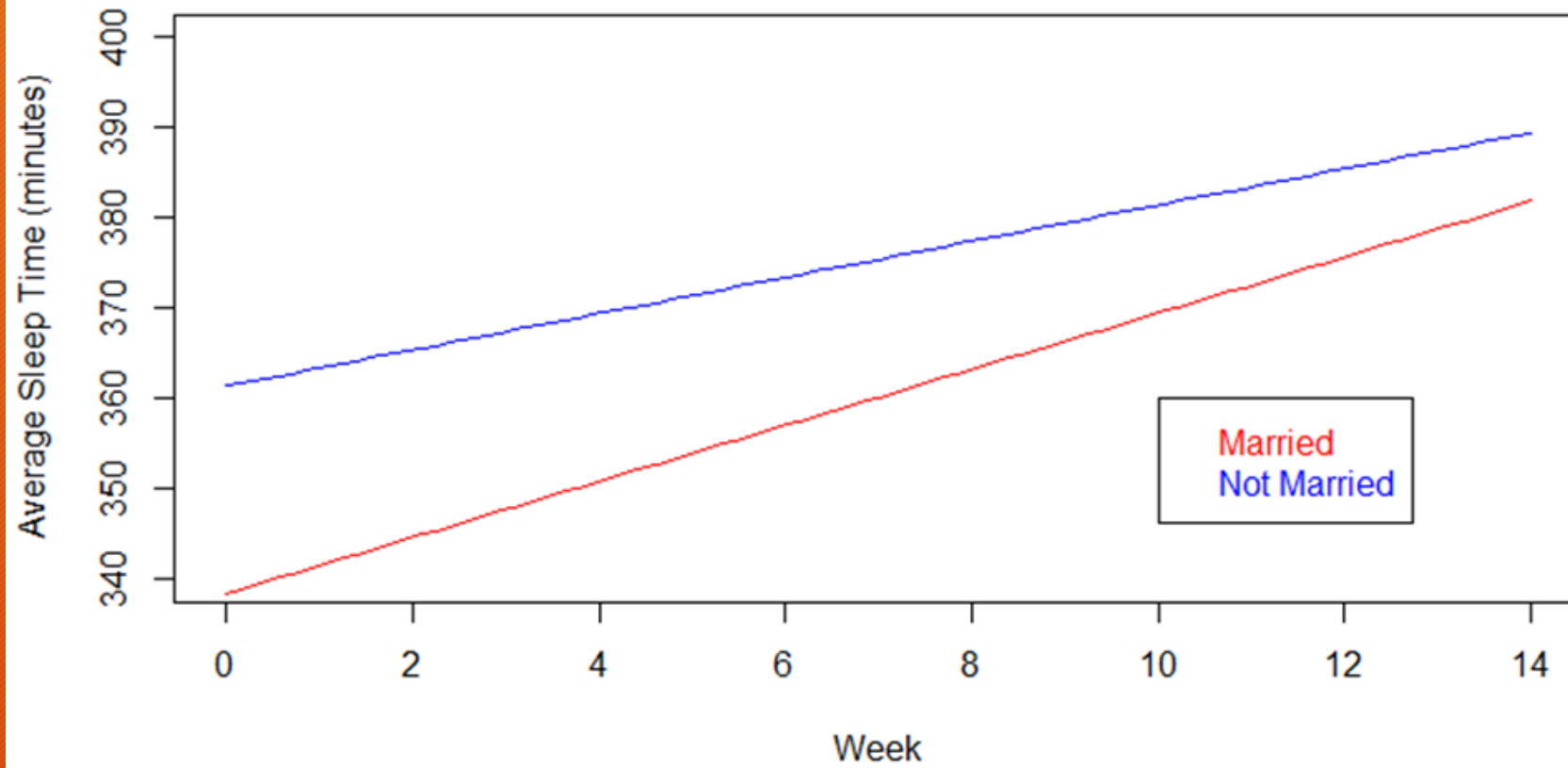
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Average Sleep Time =  $361.4 + 2 \cdot \text{week} + 11.76 \cdot \text{married} - 2.2 \cdot \text{week} \cdot \text{married}$

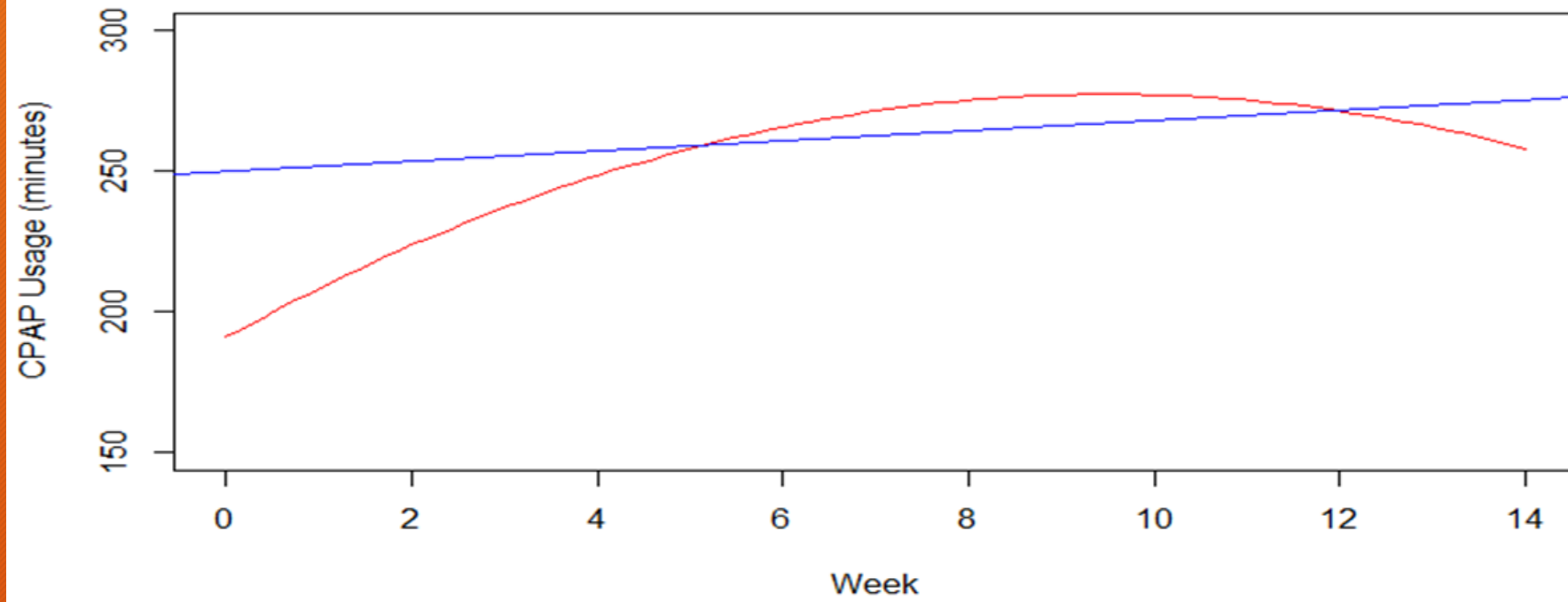
Parameter	P-Value
Week	< .001
Married	.220
Married*Week	<.001

We found a statistically significant interaction, encouraging us to make separate models for the married vs. not married subjects.

### Sleep Trends: Married vs. Not Married



CPAP Usage ~ Week



# CPAP ~ week and sex

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Average CPAP Usage =  $287 + -.5*week + -148*sex + .07*week^2 + 28.9*week*sex + -1.6*week^2*sex$

Standard Deviation of the Intercept is 138.31

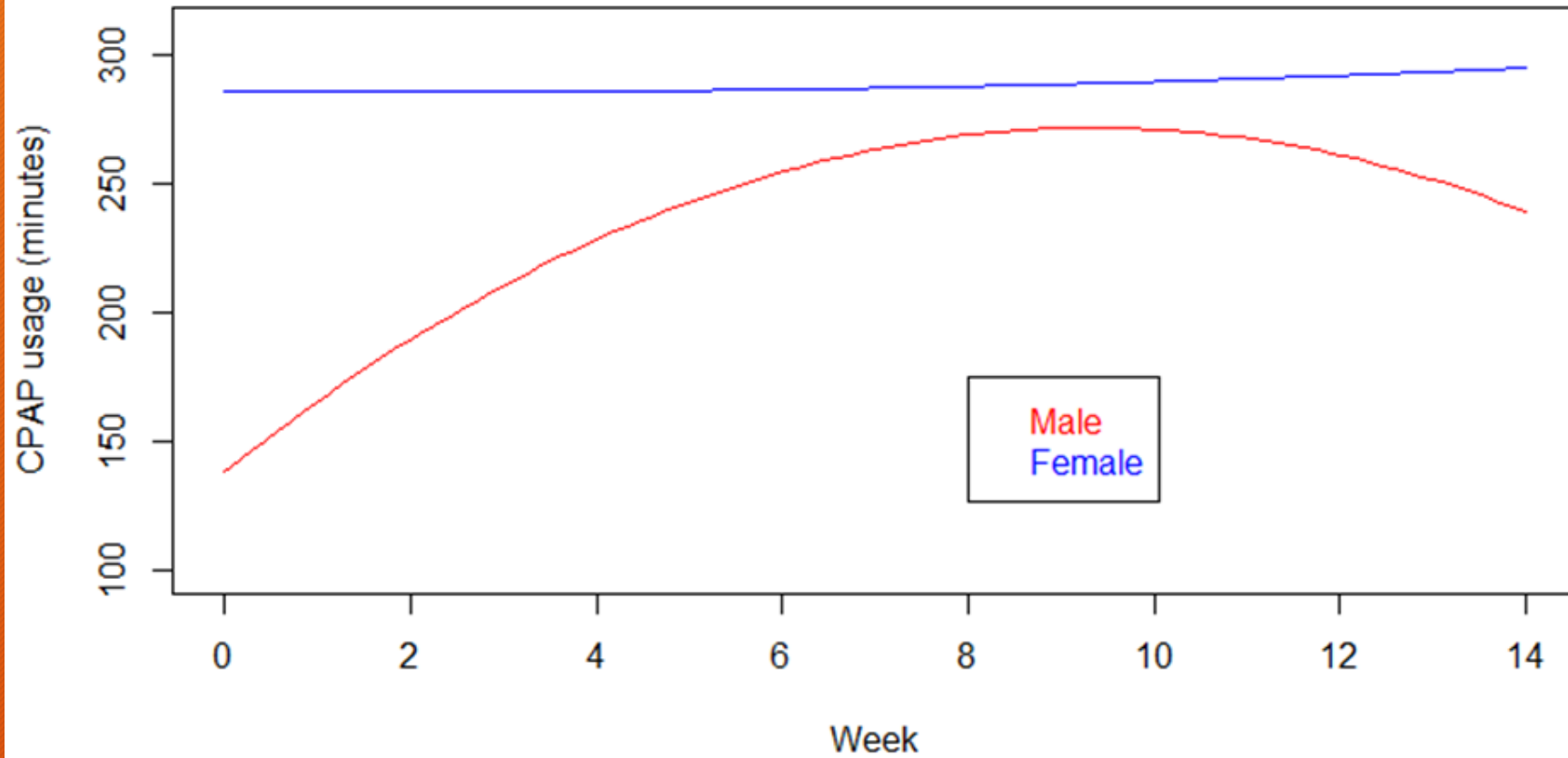
Standard Deviation of the Residuals is 74.28

Variables	P-Value
Week	.948
Week^2	.858
sex	.004
Sex*week	.002
Sex*week^2	.003

- Finds statistically significant interactions, warranting further interaction.



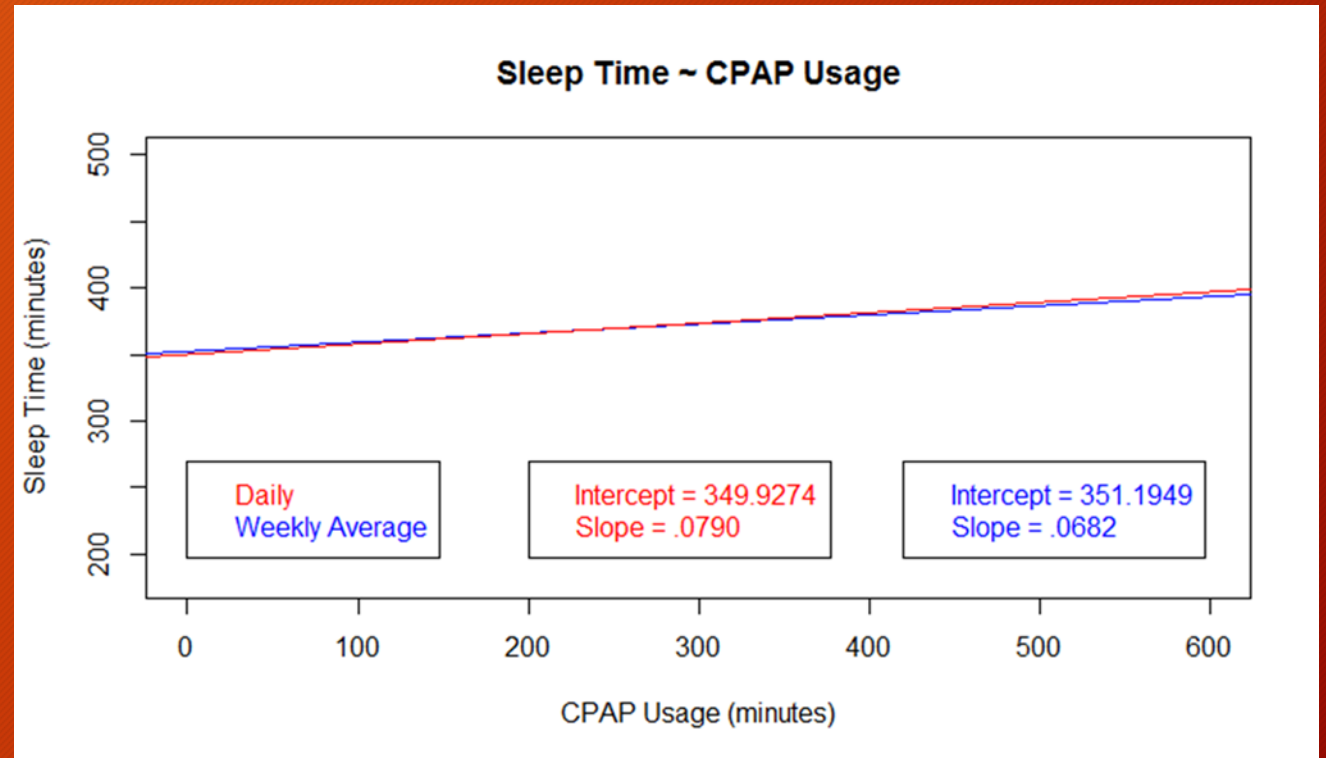
### CPAP Usage Trends: Male vs. Female



# Sleep ~ CPAP usage

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- Should the data be modeled based on daily values, or weekly averages?
- It turns out that both produce roughly the same model.



# Sleep ~ CPAP and Covariates

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We looked at the same covariates as the other models, but found no statistically significant interactions.

- Age
- Sex
- Marital Status
- Education Years
- Race

## Discussion/ Conclusion

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- T-tests showed few differences between baseline and subsequent weeks, but regressions revealed certain trends.
- When subset by sex, we to find an increase in CPAP usage and sleep for males, but not for females.
- Possibly due to fewer women using the CPAP machine.
- It also makes sense that sleep increased across weeks for OSA, but not for control.
- CPAP seems to help sleep the same amount, regardless of sex, marital status, education, age and race.

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# Thank You

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