THE POTENTIAL BENEFITS OF TIME-RESTRICTED EATING AND THE HEALTH IMPLICATIONS FOR THE INLAND EMPIRE

By

Joanna C. Sung

A capstone project submitted for
Graduation with University Honors

June 1, 2020

University Honors
University of California, Riverside

APPROVED

_____

Dr. Stephanie Dingwall
Department of Biochemistry

_____

Dr. Richard Cardullo, Howard H Hays Jr. Chair, University Honors

Abstract

Based on the UCLA Center for Health Policy Research (2016) [20], more than 50% of the Inland Empire of Southern California have diabetes or prediabetes, 30.5% of San Bernardino County has high blood pressure, and greater than 66% of this population is overweight. Many have limited access to health care due to their lower socioeconomic status, and the shortage of doctors further compounds their access to care. Also, there is a lack of access to healthy, nutritious foods in the area. Due to convenience and the cheap cost of fast foods, the diets of many people are high in fat and calories, thus exacerbating the current ailments that plague this community. Researchers such as Dr. Satchidananda Panda of the Regulatory Biology Laboratory at the Salk Institute have shown that time-restricted eating (TRE) in rats, regardless of the type of diet, may help reduce diabetes, obesity, and cardiovascular disease. TRE is a specific form of intermittent fasting and specifically works in sync with the circadian clock to help the body perform at its best capacity. In this capstone project, a research survey will be conducted among the young adult population, focusing mainly on college level students from different colleges in the US, to see if indeed TRE has any health effects. The hope is that this research will give a better understanding of TRE and that it may be used in conjunction with other treatments to help alleviate the problems that plague this community.

Acknowledgements

I want to first thank God for allowing me to finish this capstone project.

Special thanks to my capstone mentor Dr. Stephanie Dingwall for mentoring me and giving me guidance on how to do this project. Thank you for always making time for me during these past two years despite your busy schedule, and for advising me and teaching me. I want to also convey my thanks to Dr. Brandon Brown for helping me write my survey questions and giving me advice on how to conduct research, especially with navigating through the IRB process. I am also grateful to Dr. Richard Cardullo for suggesting to me to find if there were any differences between Honors students and non-Honors students as well as introducing me to the SMART BMI.

To my Honors counselor Mayra Jones, thank you for your coordination in administering the survey. I would not have gotten that many participants without it. And to all the participants who took the time to take my survey: especially the Honors students, my friends, the select few who also shared it to everyone they knew to help me increase my sample size, and to my hallmates, your data was invaluable to my study, thank you.

I could not have finished this capstone without the many prayers of my parents, especially my mom, and their continual support. Thank you to mom and dad for introducing me to time-restricted eating in the first place and encouraging me to continue this project.

Table of Contents

Introduction

People have practiced a form of fasting since early times [15]. Even during the hunter-gatherer age, people would eat at certain time periods, and not eat during the late evenings [16]. They would fast during the night, and break it in the morning or whenever they found something to eat [16]. Even with the development of civilization and more food available, people still fasted for religious reasons. Fast forward to the Industrial Age and the Agricultural Revolution, where more food was available in more developed countries [13]. Because there was more food available throughout the day and a large proportion of the population had better access to food, there emerged an epidemic of obesity, type 2 diabetes, and cardiovascular disease [13]. Previously, researchers thought that the health crisis was due to large caloric intake and the emergence of fast food restaurants [13]. However, addressing that did not seem to fix the problem. Currently, scientists are studying the circadian rhythm, and the results are now making scientists wonder if the disruption of the biological clock from the Industrial Revolution may be a factor in this current health epidemic. For example, researchers are finding metabolism to be closely linked to the circadian rhythm [2].

Current Findings on Animal Models

There seems to be an increasing amount of strong evidence that shows that the disruption of the circadian rhythm may have an impact in one's general health. Some of the health consequences they found were an increase in cardiovascular disease, obesity, and cancer [8]. Organs such as the liver seem to also be affected by the circadian clock. When researchers looked at mouse liver, they found that food availability as well as the feeding time period affected hepatic rhythmic transcription, showing the important role the circadian clock and fasting had in liver function [19].

Other researchers have also corroborated the circadian research and showed that with mice that were fed a high fat diet between an 8-15 hour period, the rodents were protected from several metabolic diseases compared to the other ones who ate sporadically [12]. They also found some weight loss and a decrease in inflammation. These results showed the potential of using time-restricted eating within the human population, for possible weight loss as well as lowering their risk in being diagnosed with metabolic diseases.

Testing with Human Population

Contrary to what most people might think, many humans eat within a 15 hour timespan. In a pilot study among adults in India, the daily caloric intake among study participants was found to be highly erratic and differed from a three-meal convention of eating within a 12-hour interval. Among 93 individuals, more than 50% ate within 15 hours or longer [5]. In addition, Rydall et. al, found out that about a third of diabetic young women had an eating disorder and because of that, was more likely to suffer from diabetic complications, which was namely retinopathy [17].

Different methods have been used to help study the effects of time-restricted eating. A smartphone app which was developed by Gill et. al was used to keep track of the eating patterns of eight overweight US adults who ate their meals longer than a 14 hour timespan [4]. Their average age was 34.4 years [4]. For 16 weeks, participants were required to consume all food or beverages within a 10 to 12 hour timeframe [4]. Also, every time the participants consumed such food or beverages, they were required to use the app and send pictures or written descriptions of their food or drink to the researchers [4]. Based on such data, the total caloric intake for the participants were calculated [4]. There were no restrictions to limit caloric intake or change what they ate, but results showed sustained weight loss and improved quality of sleep up to one year [4]. Another study done by Wilkinson et al. also used a similar app and found identical results

[21]. For 12 weeks, seventeen US adults with metabolic syndrome consumed all their food or drink within a 10 hour time frame [21]. The average age of the participants was 59 years [21]. Even with no change in physical activity, they found a significant reduction in weight, blood pressure, and blood glucose [21].

Other studies on time-restricted eating have shown some mixed results. Gabel et al. had found that when 23 obese participants participated in time-restricted eating over the course of 12 weeks, there were weight loss and blood pressure reduction, but no significant difference in the fasting insulin and glucose levels [3]. The control group came from a previous weight loss study and were told to maintain their eating or physical habits [3]. Some of the limitations the researchers noted were the short duration of the trial period, and that the data from the participants were self-reported [3]. More research on time-restricted eating and its long term effects were suggested.

Another study has also concluded the need for more research on time-restricted eating. Twenty-nine healthy young men from Utah who were 18-26 years of age were assessed on the effects of restricting their night-time eating [9]. Participants were required to consume all their foods and beverages between 6 am and 7pm, for it was shown that night-time eating syndrome occurred after 7pm [9]. Compared to the controls who were instructed to maintain the same eating and physical habits, the participants under study lost some weight [9]. Though this study helped support the hypothesis that there was a reduction of energy intake if one did not eat late during the night, the researchers expressed caution when showing their results [9]. Because the study lasted only two weeks and the data from the participants were self-reported, the researchers could only make conclusions on the short term benefits and could not prove any long term effects [9].

In general, researchers note that regardless of the circadian rhythm, some form of fasting helps to improve overall health. Called intermittent fasting, this type of diet has shown to not only help reduce weight, but, as found with time-restricted eating, help reduce other metabolic diseases [15]. Halberg et. al also found in their study among Caucasian men that insulin had an enhanced effect on weight loss after intermittent fasting [7]. In addition, intermittent fasting seemed to ameliorate Alzheimer's disease in mice [6].

Concerns

More research is needed because previous studies had conflicting results. When Anson et. al, put mice on an intermittent fasting diet, they found that the mice's body weight remained the same [1]. However, they still found reduced serum glucose and insulin levels, leading them to conclude that intermittent fasting could help with some metabolic processes other than caloric intake.

Another concern that was raised was the impact of such fasting on patients. Mostly healthy individuals were utilized in these studies and the impacts fasting may have on the patients were not yet examined. Also, problems such as diabetes could not be fixed by just one solution. Multiple problems all worked together to cause that effect. There needed to be more research done on how fasting would affect the lifestyle of the patients in the long term [22].

Methods

Based on all these evidence, it seemed that time-restricted eating had the potential to curb a number of diseases including obesity, diabetes, and cardiovascular disease. Though humans had practiced such a form of diet early on, the exact recordings of its potential effects were recent. More research study needed to be done to see whether in fact disrupting one's circadian clock resulted in the onset of biological problems. Due to this limitation, my capstone project consisted

of a survey, mainly with college students, to see whether a correlation could be made with their health and with their time of eating.

The platform used to generate the questions was Google Forms. The survey included sixteen questions, including fill-in-the-blank and multiple choice. The expected time to complete the survey was about 10 to 15 minutes. All recorded responses were confidential and anonymous. There was no reimbursement for those who completed the survey. However, to address food insecurity, several resources for participants were posted at the very end. IRB approval was obtained in fall of 2019. The survey was then advertised on social media platforms such as Facebook and Twitter and emailed to the University Honors community. Prior approval was obtained from University Honors before the survey was sent out to all the students. A copy of the questions asked and the type of answer choices used are found below.

Table 1: Survey of Questions Asked to Participants

Question Asked	**Answer Choice Available**
1. Are you a college student? If so, what year are you?	Fill in the Blank
2. Do you currently go to UCR?	Yes UCR alumni No
3. Are you part of UCR Honors?	Yes No
4. How old are you? (in whole numbers)	Fill in the Blank
5. Which of these racial backgrounds best describe you? Check all that apply.	White/Caucasian (non-Hispanic) White (Hispanic) Black/African American Asian Native Hawaiian/Pacific Islander

	American Indian/Alaskan Native More than one race Other Decline to Answer
6. How would you perceive your health?	Excellent Very good Good Fair Poor
7. What is your height (in feet)?	Fill in the Blank
8. What is your weight (in pounds)?	Fill in the Blank
9. On weekdays, when is the average time you wake up? What time on weekends? (please put am or pm)	Fill in the Blank
10. On weekdays, when is the average time you first eat/drink something? What time on weekends? (please put am or pm)	Fill in the Blank
11. On weekdays, when is the average time you sleep? What time on weekends? (please put am or pm)	Fill in the Blank
12. On weekdays, when is the average time you last eat/drink something before you sleep? What time on weekends? (please put am or pm)	Fill in the Blank
13. Are you diabetic or have prediabetes?	Yes No I don't know
14. Do you have a family history of cardiovascular disease?	Yes No
15. Do you consider yourself physically active most of the time? (e.g., exercising 30 min per day)	Yes No
16. Are you food insecure? (not having enough food to eat because of financial	Yes No

reasons)	
Resources To Help with Food Insecurity: Calfresh (anyone living in US): http://mycalfresh.org/the-basics/ R'pantry (UCR students): https://basicneeds.ucr.edu/rpantry Local Food Pantries in Riverside: https://www.freefood.org/c/ca-riverside	N/A

Results/Data

The following tables and graphs highlight the results from this study.

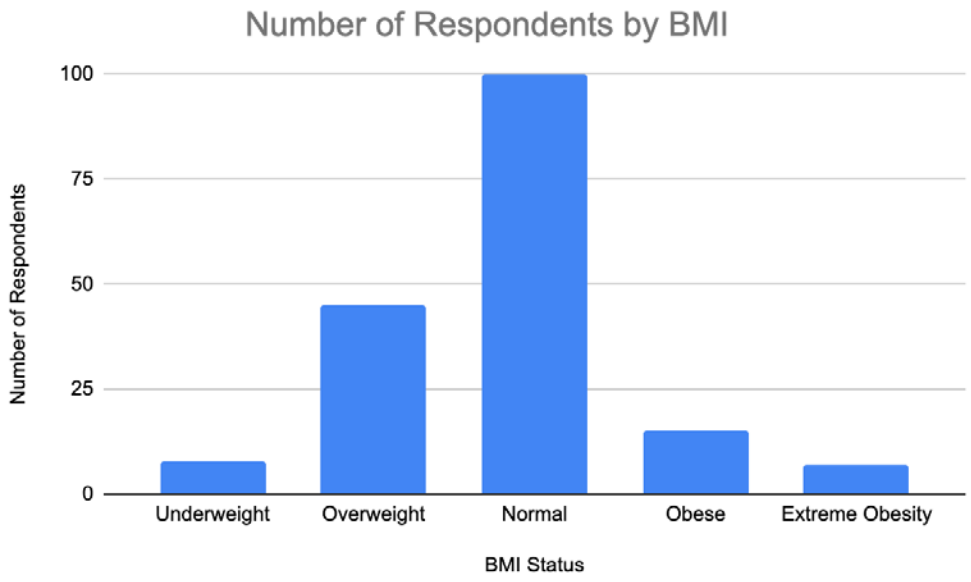

Figure 1

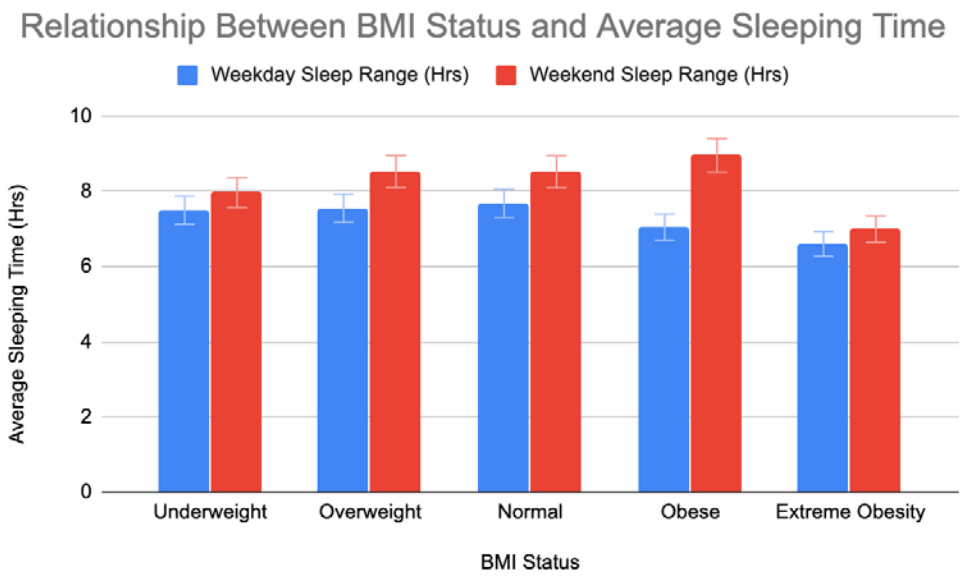

Figure 2

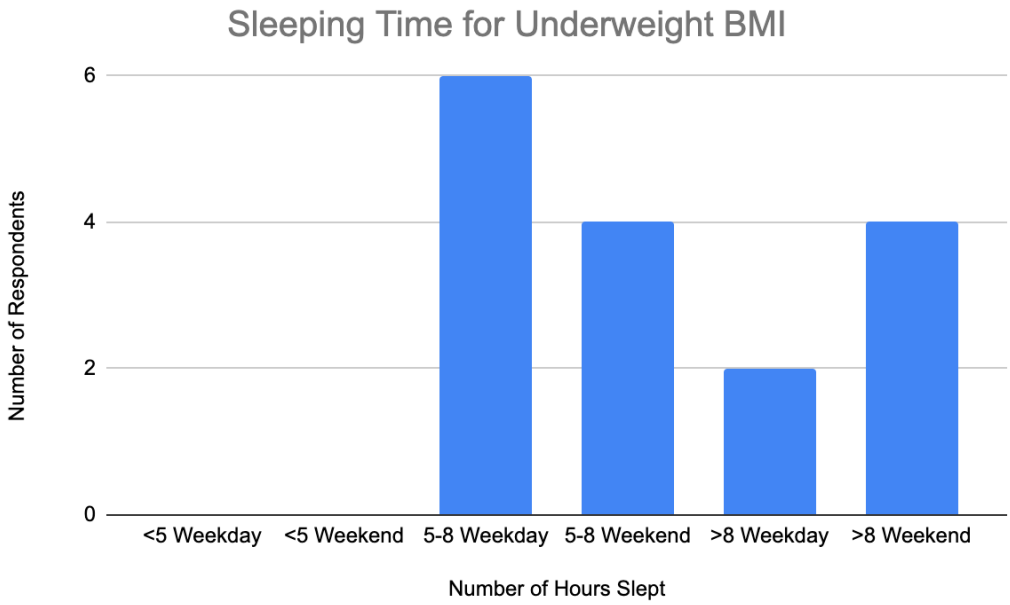

Figure 2.1

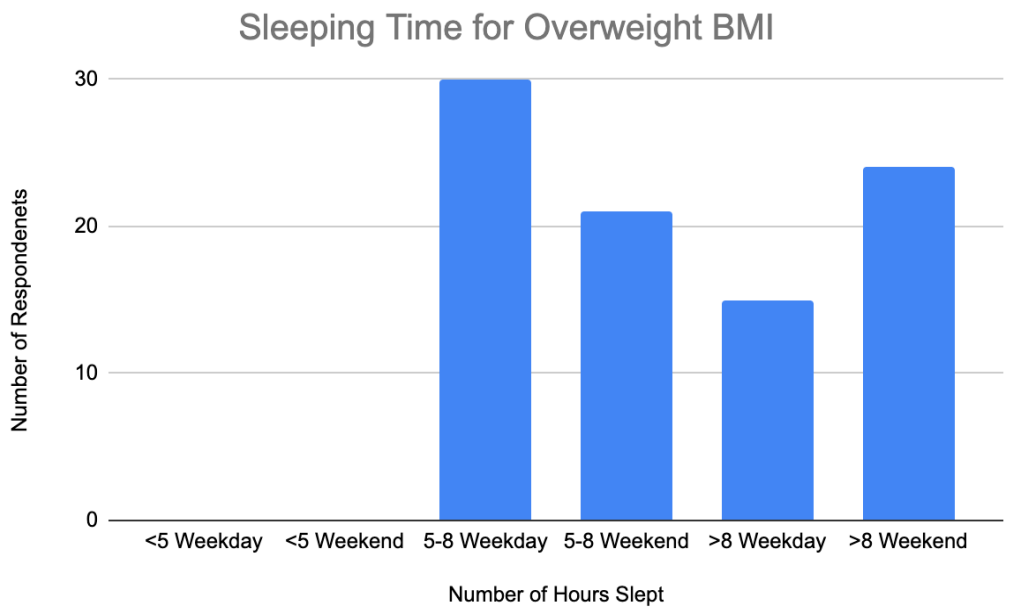

Figure 2.2

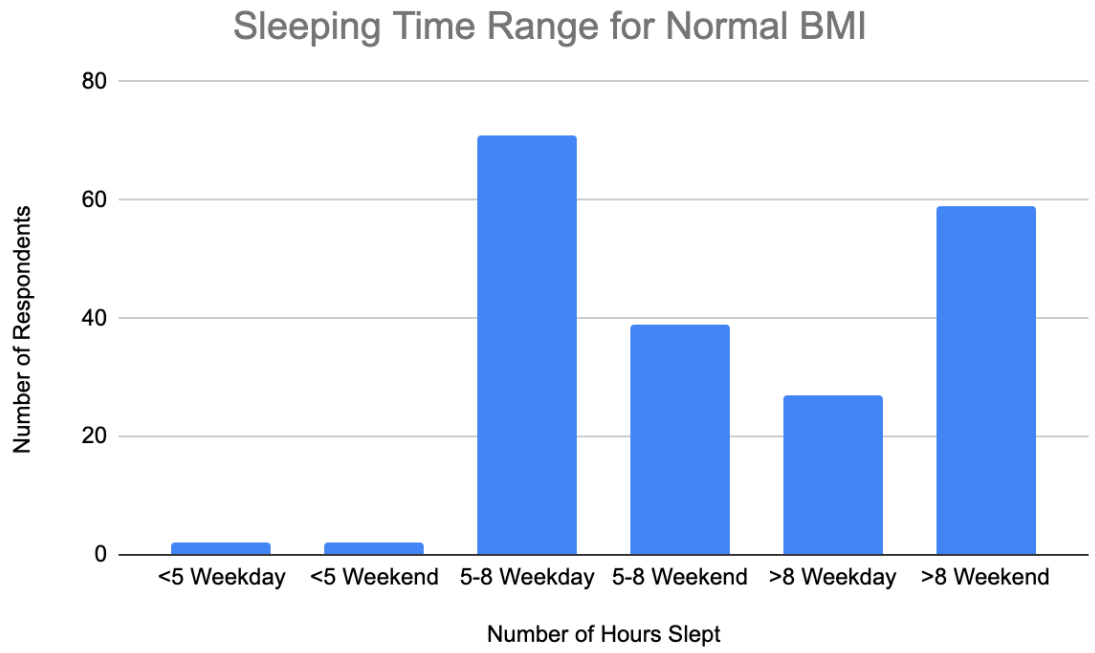

Figure 2.3

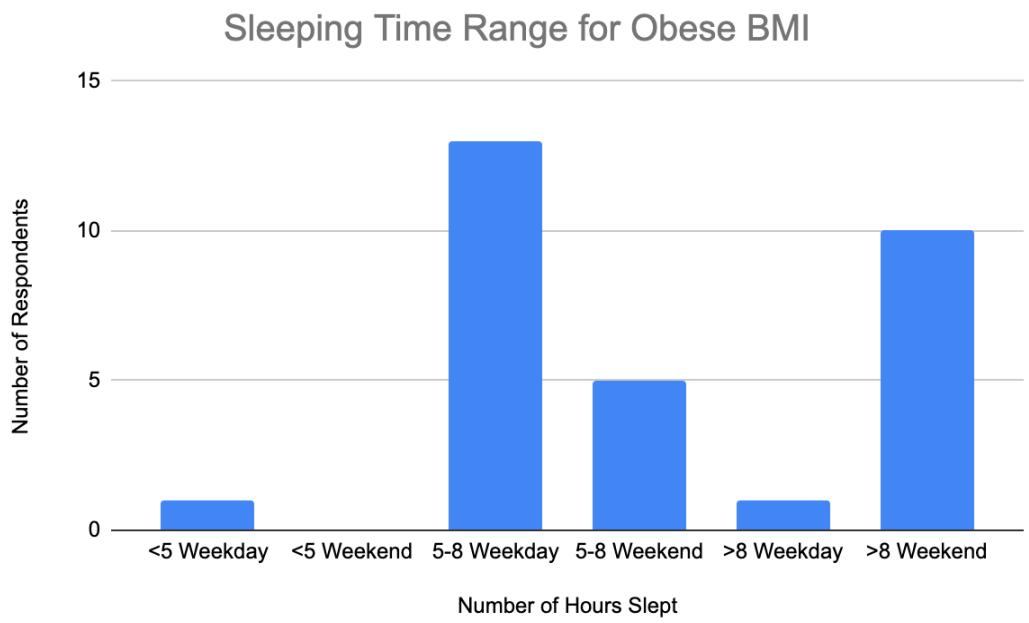

Figure 2.4

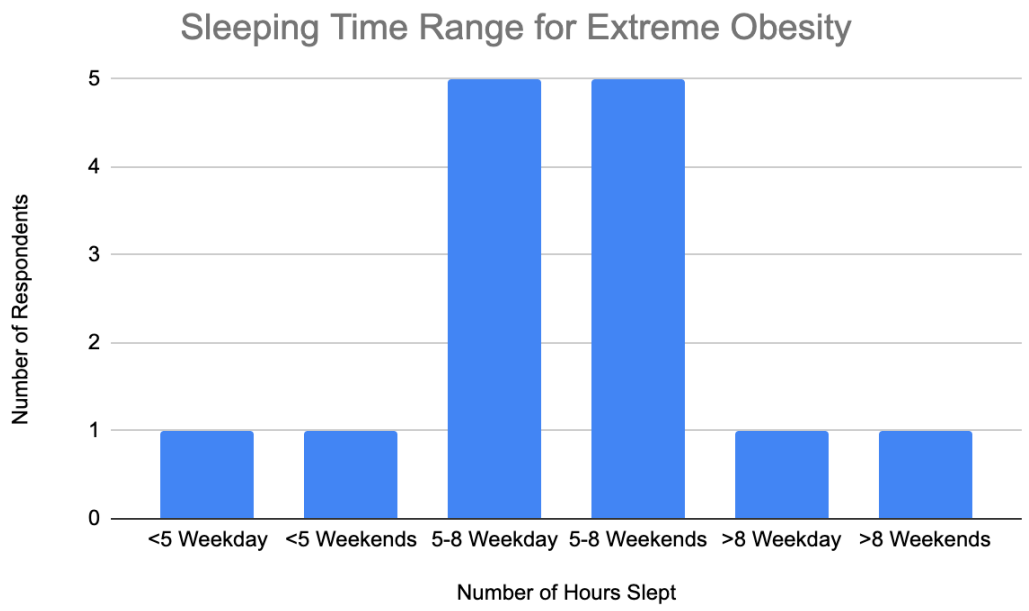

Figure 2.5

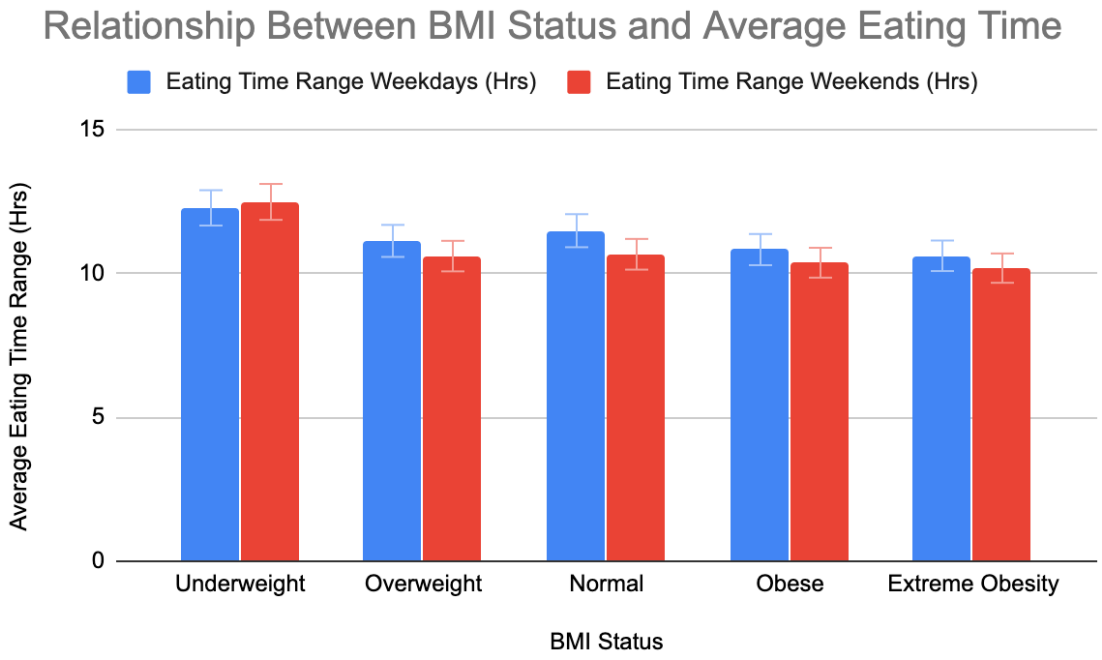

Figure 3

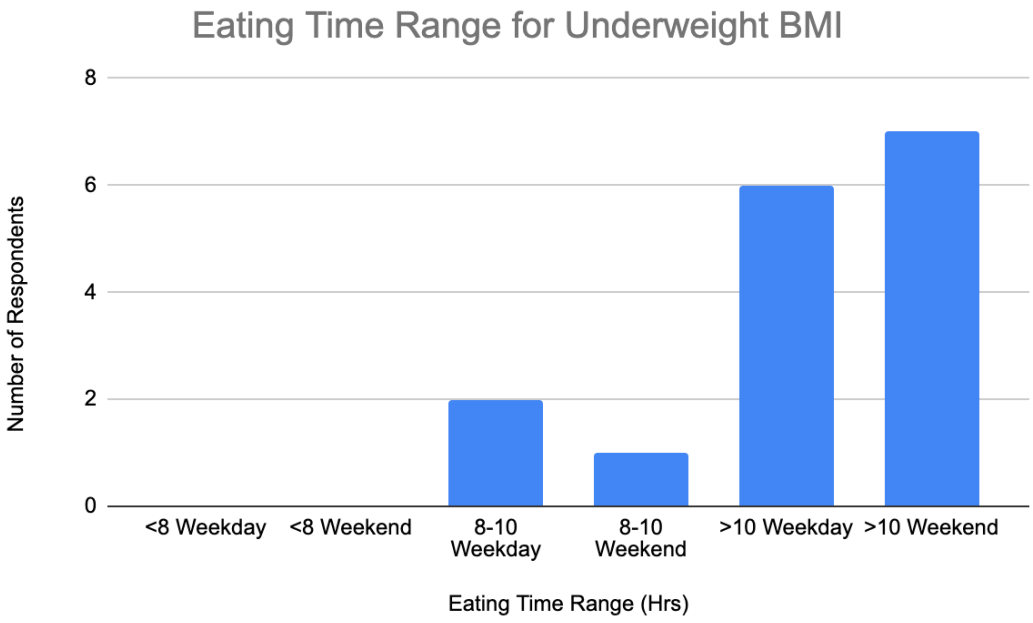

Figure 3.1

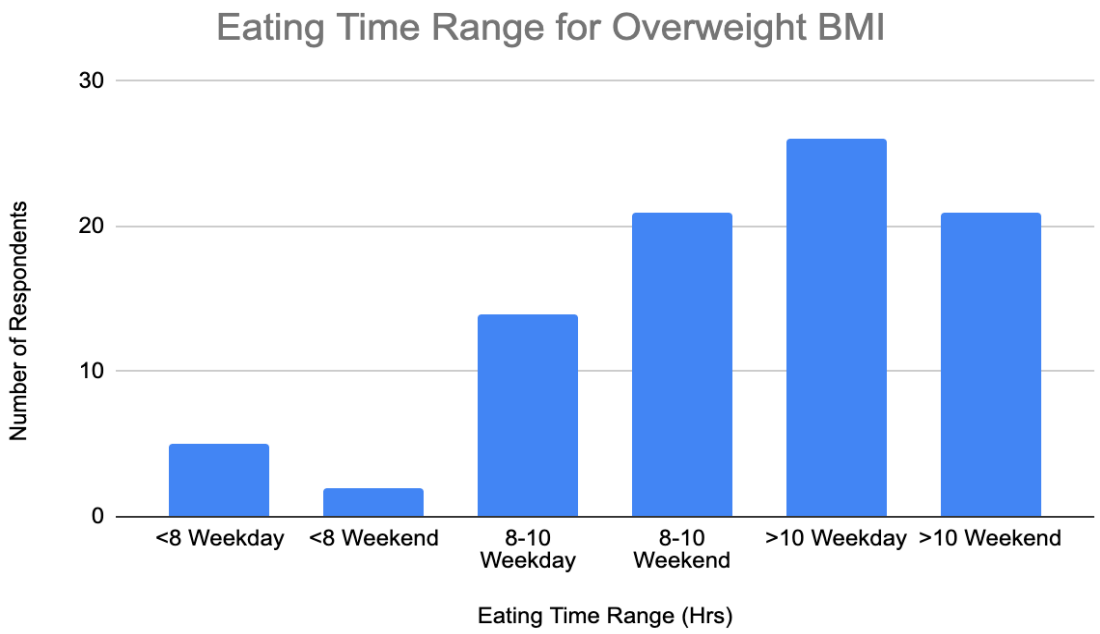

Figure 3.2

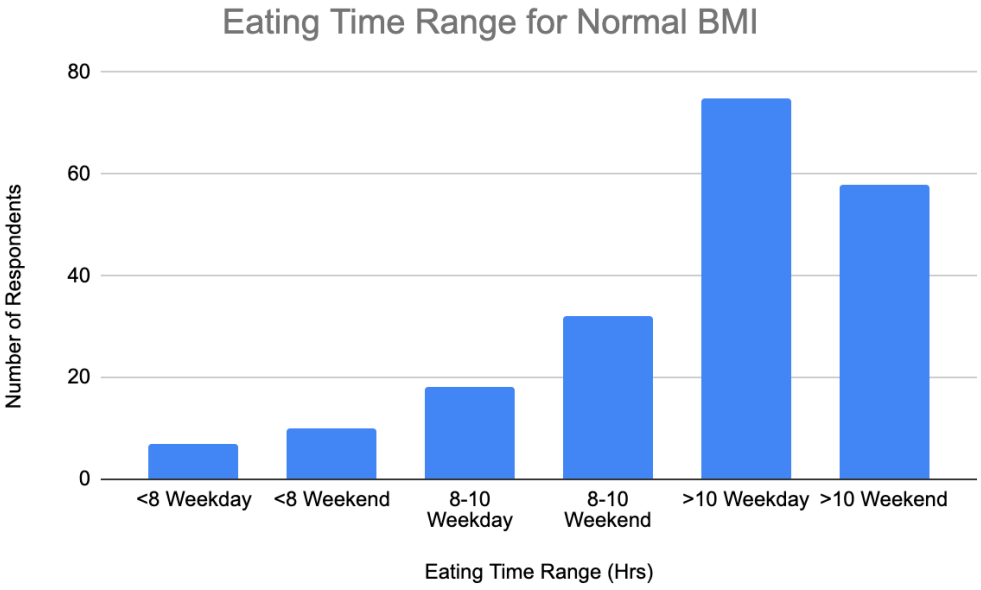

Figure 3.3

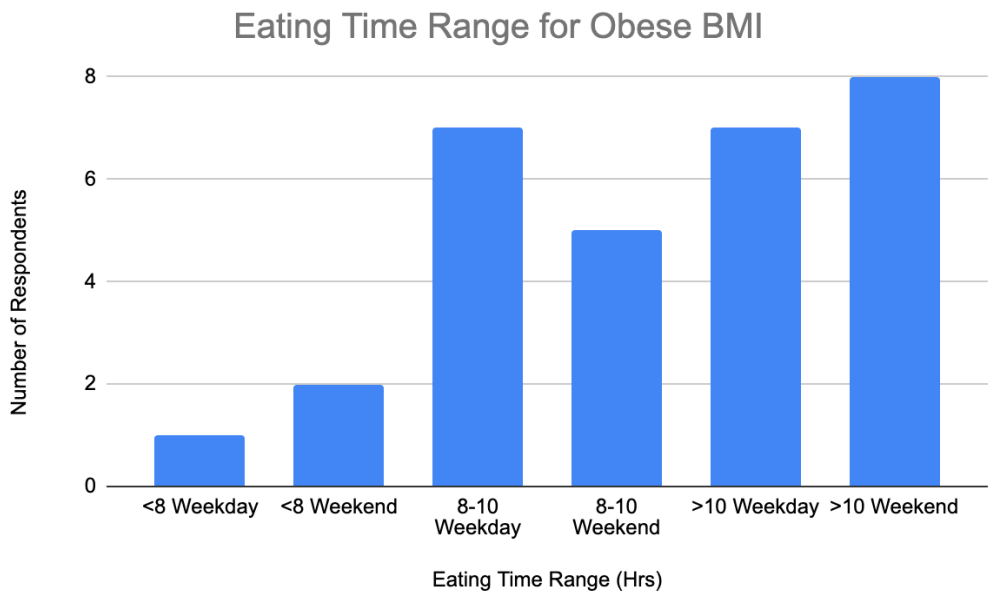

Figure 3.4

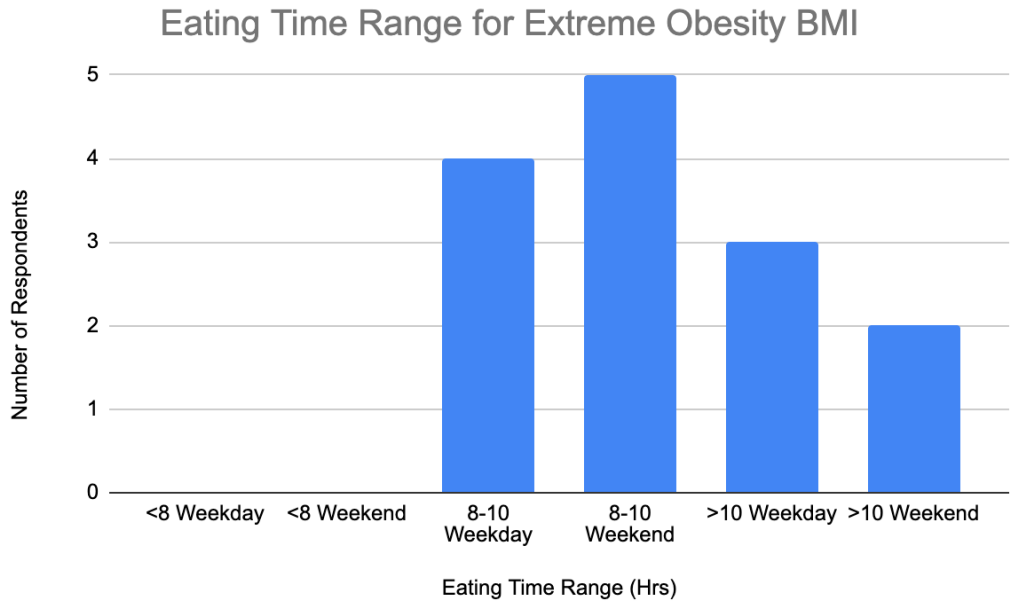

Figure 3.5

Table 2: Percentage Of Those Reported 'Yes' To Question

	BMI Status				
Question	**Extreme Obesity**	**Obese**	**Overweight**	**Normal**	**Underweight**
Diabetes	28.57%	13.33%	2.22%	1.00%	0.00%
Family History Cardiovascular	57.14%	53.33%	22.22%	17.00%	25.00%
Physically Inactive	57.14%	60.00%	44.44%	36.00%	50.00%
Food Insecurity	28.57%	6.67%	11.11%	9.00%	12.50%

Table 3: Comparison of UCR Honors vs Non-Honors Participants

Question	**Diabetic**	**Family History Cardiovascular Disease**	**Physically Inactive**	**Food Insecurity**
Total who answered 'Yes" to Quest.	6	41	102	18
Honors	3.82%	24.43%	67.18%	12.21%
Non-Honors	2.27%	20.45%	31.82%	4.55%

Discussion

Based on research found in Longo and Panda, the hypothesis of this study was that eating within 8-12 hours helped reduce obesity, cardiovascular disease, and diabetes [11]. After

analyzing a total of 175 participants (10 had to be excluded due to being underage or unclear responses)[1], 84% were students from University of California, Riverside (UCR) and 74.3% of the total respondents were part of UCR's University Honors program. The most prevalent response group was Asian, which comprised 44.6% of the surveyed population. The next most common was White (Hispanic) with 25.1% and White/Caucasian (non-Hispanic) with 21.7%. Black/African American was 6.9% of the surveyed population. American Indian/Alaskan was 0.6%, Native Hawaiian/Pacific Islander was 1.1%, other 7.4%, more than one race was 9.7%, and 1.7% declined to answer.[2] The age range was between 18 to 50 years old, with college-age level being the most common (18 to 21 years old) at 84.6%. 88.6% of the participants considered their overall health excellent, very good, or good. However, 42.9% of the surveyed population had a Body Mass Index (BMI) that was outside of normal: underweight, overweight, obese, or extreme obesity. 55.4% of the respondents reported having or experiencing diabetes, food insecurity, or physical inactivity.

Overall, the sleeping range for each BMI (underweight, normal, overweight, obese, or extreme obesity) had a higher value during the weekends compared to that of weekdays. Participants slept more hours during the weekends compared to weekdays, though the exact values varied from BMI. Correspondingly, the eating time range, which was the time span the participants consumed all their food or beverages for that day, for each BMI, other than those who were underweight, was lower during the weekends compared to that of weekdays. Those who were underweight had a slightly higher eating time range (12.5 hours during the weekend, 12.3 hours during the weekday). A paired t-test was conducted for each BMI to see whether there

[1] See notes for specific criteria why participants' responses were excluded

[2] It was possible for participants to select all of the options that applied, which caused the total percentages to be over 100%.

was any significance between the weekdays and weekends for sleeping and eating time range. The results showed that for sleeping time there was no significance between the weekdays and weekends for all individuals (underweight, normal, overweight, obese, or extremely obese). The results were the same for eating time range.

For normal individuals with regards to their eating time, the average range was 11.5 hours during the weekdays and 10.7 hours during the weekends. Though these values matched the targeted eating time range which was between 8 to 12 hours [11], it could not be used to conclusively determine that eating within a certain time range helped contribute to one's BMI. The reason was that other than underweight individuals who exceeded the 12 hour eating time range, the rest of the participants who did not have a normal BMI (overweight, obese, or extreme obese) also had an eating time range that was within the 8 to 12 hour limit. These values included the weekdays and weekends. Thus, based on this study, one could not conclude that time-restricted eating helped contribute to BMI.

The lack of correlation for the different BMI between the weekdays and weekends for eating and sleeping showed that there was no clear relationship between a change in circadian rhythm and BMI. This was contrary to the study's hypothesis that individuals had a significant change in eating and sleeping patterns during the weekends compared to that of the weekdays and thus had an increased chance of getting obesity and other health related problems.

The trends from Table 2 matched the expected pattern that with increased BMI there is an increase in metabolic diseases as diabetes [22]. However, based on this data, it could not be determined on whether time-restricted eating played a role in reducing cardiovascular disease or diabetes. Because it was difficult to correlate eating within an 8 to 12 hour period with one's

BMI, one could not conclude that time-restricted eating could help with the reduction of metabolic diseases.

One other aspect this study attempted to learn was whether there was a change in circadian rhythm. To determine this, participants were asked the average time they woke up and the average time they went to bed during the weekdays and weekends. From such data points, participants' average sleep times were calculated. After doing a paired t-test, it was determined that there were no changes in sleeping patterns during weekdays and weekends for all participants (underweight, normal, overweight, obese, or extreme obese). The results showed that it was not possible to conclude that a change in circadian rhythm was present among participants' daily lives.

Though this study showed that there was no significance in time-restricted eating, this did not mean that it had no impact on a person's overall health or wellbeing. Time-restricted eating may work. It was just that this study was unable to show its benefits. There were several limitations with this study, which included an unequal proportion of racial or ethnic groups, a focus on college level students, and the inability to actually measure glucose tolerance and body fat levels. In addition, the information provided was from self-reported data. The study was not an experiment where participants were instructed to follow a time-restricted diet and then compared to a control to see if there was any significance. That type of study would have provided more conclusive results in testing whether time-restricted eating and/or following in sync with one's circadian rhythm had any health benefits.

Future Directions

Future directions for this study are to consider smart BMI rather than normal BMI. The smart BMI adjusts the scale to age, sex, and ethnicity [25]. The results in this study may have been

skewed due to the fact that different races were not represented equally. Though the study attempted to survey a more representative population, there was not an equal distribution of different races. Asians comprised a large proportion of this study, which did not match the statistics for race and Hispanic origin in the Inland Empire, a region that included Riverside and San Bernardino Counties. Based on the US Census (2010-2019) for Riverside County, 49.6% were Hispanic or Latino compared to 7.1% Asian [23], and in San Bernardino County 54.0% were Hispanic or Latino compared to 7.8% Asian [24]. The reason why the results may need to be interpreted more carefully was that Asians are now known to have a lower BMI status than other racial groups, but they still have a higher rate of metabolic diseases [14]. Thus, the trend that increased BMI led to increased metabolic diseases could not be used for Asian Americans. Rather, a different criteria needed to be used to assess their BMI. This assessment was further reinforced by another study which showed that when Asian Pacific BMI standards were used, it resulted in an improved recovery of Chronic Obstructive Pulmonary Disease (COPD) patients compared to those who used WHO BMI standards [10].

Another factor that may have contributed to the disparity of the results was that there was a higher proportion of UCR Honors students (74.3%) compared to those who were not (25.7%). In all respects regarding the number of those who had diabetes, family history of cardiovascular disease, physical inactivity, and food insecurity, Honors students had a higher percentage overall compared to those who were not Honors. In order to standardize the numbers, the values were calculated by dividing the variable (number of diabetics, physical inactivity, etc.) by the total number of students in each cohort (Honors vs non-Honors). The data showed that Honors students were twice as likely than non-Honors participants to be physically inactive and three times higher than non-Honors participants to have food insecurity. There was no statistical

difference for diabetes or family history of cardiovascular disease. More study, however, needed to be done, to conclusively say that Honors students were less physically active and more food insecure than others. This disparity warranted further exploration and needed to be studied more extensively before any conclusions were made.

The greatest limitation, however, with this study seemed to be the age range. The majority of surveyed participants were college level students. As people grew older, their metabolism decreased, body fat increased, and glucose tolerance decreased [18]. As a result, older individuals were at a higher risk for metabolic diseases as cardiovascular disease and insulin resistance in type 2 diabetes. A more accurate assessment could have been made with a longitudinal cross-sectional study over the Inland population tracking participants who were middle aged and older. From there, more sophisticated testing that took into account blood glucose levels, cholesterol levels, and body fat percentage could be used to determine whether time-restricted eating had an effect. In addition, by reassessing the number of hours they slept and ate during the weekdays and weekends, an improved evaluation could be made on whether eating within a certain time period and following in sync with one's circadian rhythm could help one live a healthier life.

One potential problem, the researcher foresees is the difficulty in getting patient approval for participating in these types of studies, thus limiting the sample size. This problem may be overcome if the researcher is able to procure funding for this research and provide a monetary incentive to the research participants who complete the study.

Additional Notes

If the BMI was above 40, it was determined to be extreme obesity. Some values were outside the BMI chart used from the NIH, National Heart, Lung, Blood Institute and had to be calculated

by hand to determine the BMI. When doing the calculations, the values were not rounded, i.e. 18.479 was considered to be underweight because it was under the threshold of 18.5.

When participants provided fractions as part of their answers, the values were rounded as whole numbers, i.e. 5.6 ¼ was rounded to 5.6. If there was only one time present for the weekend, weekday question, it was calculated as the time for both. If they provided a range, the average hour was calculated and used. There were several cases where participants provided Not Available as their answer for certain questions. Only the parts where they did not answer were disregarded. The participants themselves were still included as data points for the sample population. Ten participants, however, had to be completely disregarded because they were either underage, unclear, or provided 'did not know' responses.

Some backtracking had to be done when participants provided the wrong units or when the values they provided sometimes contradicted with the previous values.

Conclusion

Though there were many limitations to this study, this project showed that more conclusive research needed to be done for time-restricted eating before it could be used as a possible treatment option for patients. With more research and validated results supporting its benefits, time-restricted eating had the promise of helping thousands of lives in an efficient and cost-effective way.

Works Cited

[1] Anson, R. Michael et al. "Intermittent Fasting Dissociates Beneficial Effects of Dietary Restriction on Glucose Metabolism and Neuronal Resistance to Injury from Calorie Intake." PNAS, National Academy of Sciences, 13 May 2003.

[2] Asher, Gad et al. "Crosstalk Between Components of Circadian and Metabolic Cycles in Mammals." Cell Metabolism, U.S. National Library of Medicine, 2 Feb. 2011.

[3] Gabel, Kelsey et al. “Effects of 8-Hour Time-restricted Feeding on Body Weight and Metabolic Disease Risk Factors in Obese Adults: A Pilot Study.” Nutrition and Healthy Aging, IOS Press, 15 June 2018.

[4] Gill, Shubhroz et al. “A Smartphone App Reveals Erratic Diurnal Eating Patterns in Humans That Can Be Modulated for Health Benefits.” Cell Metabolism, U.S. National Library of Medicine, 3 Nov. 2015.

[5] Gupta, Neelu Jain et al. “A Camera-Phone Based Study Reveals Erratic Eating Pattern and Disrupted Daily Eating-Fasting Cycle Among Adults in India.” PLOS ONE, Public Library of Science, 6 Mar. 2017.

[6] Halagappa, Veerendra Kumar Madala et al. “Intermittent Fasting and Caloric Restriction Ameliorate Age-Related Behavioral Deficits in the Triple-Transgenic Mouse Model of Alzheimer's Disease.” Neurobiology of Disease, U.S. National Library of Medicine, Apr. 2007.

[7] Halberg, Nils et al. “Effect of Intermittent Fasting and Refeeding on Insulin Action in Healthy Men.” Journal of Applied Physiology, U.S. National Library of Medicine, Dec. 2005.

[8] Hastings, Michael H et al. “A Clockwork Web: Circadian Timing in Brain and Periphery, in Health and Disease.” Nature Reviews. Neuroscience, U.S. National Library of Medicine, Aug. 2003.

[9] LeCheminant, James D et al. “Restricting Night-Time Eating Reduces Daily Energy Intake in Healthy Young Men: A Short-Term Cross-Over Study.” The British Journal of Nutrition, U.S. National Library of Medicine, 14 Dec. 2013.

[10]Lim, Jeong Uk. “Comparison of World Health Organization and Asia-Pacific Body Mass Ind: COPD.” International Journal of Chronic Obstructive Pulmonary Disease, Dove Press, 21 Aug. 2017.

[11]Longo, Valter D., and Satchidananda Panda. 2016. “Fasting, Circadian Rhythms, and Time-Restricted Feeding in Healthy Lifespan.” Cell Metabolism 23 (6): 1048–59.

[12] Mattson, Mark P et al. “Beneficial Effects of Intermittent Fasting and Caloric Restriction on the Cardiovascular and Cerebrovascular Systems.” The Journal of Nutritional Biochemistry, U.S. National Library of Medicine, Mar. 2005.

[13] Manoogian, Emily N C et al. “Circadian Rhythms, Time-Restricted Feeding, and Healthy Aging.” Ageing Research Reviews, U.S. National Library of Medicine, Oct. 2017.

[14]Palaniappan, L P. et al. “Asian Americans Have Greater Prevalence of Metabolic Syndrome despite Lower Body Mass Index.” International Journal of Obesity (2005), U.S. National Library of Medicine, Mar. 2011.

[15] Patterson, Ruth E, et al. “Intermittent Fasting and Human Metabolic Health.” Journal of the Academy of Nutrition and Dietetics, U.S. National Library of Medicine, Aug. 2015.

[16] Panda, Satchidananda. “A Brief History of Harnessing Light.” *Lose Weight, Supercharge Your Energy, and Transform Your Health from Morning to Midnight*, Rodale, 2018, pp. 13-15.

[17] Rydall, Anne C., et al. “Disordered Eating Behavior and Microvascular Complications in Young Women with Insulin-Dependent Diabetes Mellitus: NEJM.” New England Journal of Medicine, 26 June 1997.

[18] Shimokata, H. et al. “Aging, Basal Metabolic Rate, and Nutrition.” Japanese Journal of Geriatrics, U.S. National Library of Medicine, July 1993.

[19] Vollmers, Christopher, et al. “Time of Feeding and the Intrinsic Circadian Clock Drive Rhythms in Hepatic Gene Expression.” PNAS, National Academy of Sciences, 15 Dec. 2009.

[20]Wall, Stephen. 2016. “HEALTH: Inland Diabetes Rates ‘alarming,’ Study Says.” Press Enterprise. Press Enterprise. March 10, 2016. https://www.pe.com/2016/03/10/health-inland-diabetes-rates-alarming-study-says/.

[21] Wilkinson, Michael, et al. “TIME-RESTRICTED EATING PROMOTES WEIGHT LOSS AND LOWERS BLOOD PRESSURE IN PATIENTS WITH METABOLIC SYNDROME.” JACC, Journal of the American College of Cardiology, 12 Mar. 2019.

[22] Wing, Rena R., et al. “Behavioral Science Research in Diabetes.” Diabetes Care, American Diabetes Association, 1 Jan. 2001.

[23] “U.S. Census Bureau QuickFacts: Riverside County, California.” Census Bureau QuickFacts, US Census, www.census.gov/quickfacts/fact/table/riversidecountycalifornia#.

[24] “U.S. Census Bureau QuickFacts: San Bernardino County, California.” Census Bureau QuickFacts, www.census.gov/quickfacts/fact/table/sanbernardinocountycalifornia/INC110218.

[25] “What Is the Smart Body Mass Index?” What Is the SBMI?, Apr. 2020, www.smartbmicalculator.com/why-sbmic.html.