Is the caloric midpoint associated with food cravings and food intake in pregnant women?

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Abstract

The chrononutrition area suggests that mealtime can influence the food intake. Studies on this topic have associated caloric midpoint –time at which 50% of the daily energy is consumed– with different aspects of food consumption, but its relationship with food craving is still little explored. This cross-sectional study investigated the association of caloric midpoint with food craving and food consumption in pregnant women. The study included 233 pregnant women categorized in early eaters (caloric midpoint ≤ 1:00pm) and late eaters (caloric midpoint >1:00pm). Food craving were collected by Food Craving Trait and State Questionnaires. Energy and nutrient intake and mealtimes were assessed using a 24-hour food recall. No association between caloric midpoint and food craving was found. However, late eaters consumed more calories (2039.47 kcal vs 1843.44 kcal; p <0.001), carbohydrates (255.06g vs 211.12g; p=0.002), total fat (73.1g vs 64.8g; p=0.003), monounsaturated fat (21.33mg vs 18.59mg; p=0.002) and saturated fat (24.37mg vs 22.21mh; p=0.01) and had a higher consumption of calories and macronutrients in the first (calories: 275.63 vs 213.41, p=0.007; carbohydrate: 170.42 vs 142.54, p=0.01; total fat: 56.49 vs 50.17, p=0.04) and second (calories: 213.21 vs 151.59, p=0.04; carbohydrate: 130.44 vs 96.6, p=0.04; protein: 15.17 vs 13.71, p=0.03) afternoon snack, dinner (calories: 576.89 vs 412.4, p<0.001; carbohydrate: 230.76 vs 169.45, p<0.001; protein: 80.48 vs 68.9, p=0.02; total fat: 212.77 vs 147.12, p<0.001) and late night snack (calories: 135.75 vs 68.3, p=0.04; total fat: 13.23 vs 22.45, p=0.04) than early eaters. We conclude that pregnant women who concentrate their meals at later times consumed more calories, macro and micronutrients throughout the day and in the night meals when compared to early eaters.

keywords: food craving, caloric midpoint, mealtime, pregnancy, chrononutrition.

1. INTRODUCTION

During the gestational period, weight gain occurs to accommodate the growing fetus (Rogozińska et al., 2019), however, excessive gestational weight gain contributes to some complications in the health of pregnant women and newborns, such as gestational hypertension (Simko et al., 2019), child obesity (Schack-Nielsen et al., 2009), preeclampsia, cesarean delivery (Hung et al ,2015). Therefore, given the potential of the gestational period to increase women's weight and increase the risk of obesity in women, studies that seek a better understanding of the factors related to the food consumption of pregnant women appear as a priority.

Chrononutrition is an emerging area that shows that not only what and how much we eat, but also when we eat has a significant effect on diet quality and nutritional status (Gontijo et al., 2020).Growing evidence on this topic has shown that eating late is associated with markers of poor eating (Gontijo et al., 2020; Gontijo et al., 2018; Aljuraiban et al., 2015) and obesity (Baron e al., 2011, Wang et al., 2014, Maukonen et al., 2019) and such associations have also been observed in pregnant women (Gontijo et al., 2020). These studies have shown that the timing of eating seems to impact the quality of food (Gontijo et al., 2020; Gontijo et al., 2018) and also increase gestational weight gain (Gontijo et al., 2020).

An important factor that can influence eating behaviour during pregnancy is food craving (Tierson et al., 1985), defined as an intense desire to eat a specific food that is difficult to resist (Preedy et al.,2011; Weingarten & Elston, 1991. According to Gendall et al. (1997) although most women have a history of pre-pregnancy food cravings, a portion of these women have food cravings exclusively during pregnancy. Therefore, our hypothesis is that food craving, which is quite prevalent during the gestational period (Teixeira et al, 2019b), may be increased in pregnant women with a later caloric midpoint, and lead to an increased energy and macronutrient intake. The caloric midpoint reflects the time at which 50% of the daily energy is consumed (McHill et al. 2017) and has been used as a marker of food temporality, which indicates whether a population or an individual tends to be early or late in terms of food consumption (Teixeira et al, 2019b). A recent study by our group (Teixeira et al., 2019a) evaluated the distribution of food intake using the caloric midpoint and the results show that individuals who eat at later times consume more calories throughout the day and after 9 pm. This is an emerging topic and more studies are needed to better understand this during pregnancy. Furthermore, to the best of our knowledge it is still unclear in the scientific literature if mealtime is associate with food craving in pregnant women. Thus, the aim of the present study was to evaluate the association of caloric midpoint with food craving and food consumption in pregnant women.

2. MATERIALS AND METHODS

2.1 Participants and Ethics

The study comprised a cross-sectional study conducted with 233 pregnant women, attending the prenatal clinics in the public health service in the city of Uberlandia, Minas Gerais, Brazil, that agreed to participate and formalized with written consent.

The present study included pregnant women aged 18 years or older in different gestational trimesters. Those women who did not provide the necessary information for the development of the study were excluded, as well as those who reported using illicit substances or previously diagnosed with acquired immunodeficiency syndrome, toxoplasmosis or syphilis.

The present study was approved by the Ethics Committee of the Federal University of Uberlandia (CAAE: 43473015.4.0000.5152/2015).

2.2 Evaluations

2.2.1 Preliminary questionnaire

An initial questionnaire was applied by the researchers to evaluate age, education level, physical activity habits, menarche age, previous pregnancy, gestational data, and clinical conditions such as vomiting, nausea, heartburn and food desire.

2.2.2 Food intake

Food intake and mealtimes were assessed using a 24-hour food recall applied by a trained team. Volunteers were instructed to provide as much detail as possible about the food and liquids consumed the day before the interview, including brand names and homemade food recipes. Portion sizes were estimated using common household measurements such as cups, glasses, teaspoons, and tablespoons, in addition to individual food items/units. For the definition of each meal (breakfast, lunch, snacks or dinner) and mealtimes, the participants reports were considered according to their individual perceptions (Trancoso et al.,, 2010) and the type of food frequently consumed by the Brazilian population at every meal (Gambardella et al., 1999). The eating duration was defined according to the interval between the first and the last meal of the day (Gill & Panda, 2015), and diurnal variation intake was determined by caloric midpoint, that reflects the time at which 50% of the daily energy was consumed (McHill et al. 2017).

2.2.3 Food craving

Food craving was assessed by Food Craving Questionnaire Trait (FCQ-T) and Food Craving Questionnaire State (FCQ-S) validated for the Brazilian population by Cepeda-Benito et al. (2000). The FCQ-T consists of 39 statements grouped according to categories that cause food craving and was developed to access aspects of the intense desire for food over time and in various situations, considering them as a usual (trait) behaviour of the respondent. Items are scored on a six-point scale from never/not applicable (1) to always (6). Thus, sum scores can range between 39 and 243, with higher scores indicating more frequent and intense food cravings. The FCQ-T is grouped into the subscales: (i) intentions and plans to consume food; (ii) anticipation of positive reinforcement that may result from eating; (iii) anticipation of relief from negative states and feeling as a result of eating; (iv) lack of control over eating; (v) thoughts and preoccupations with food; (vi) craving as a physiological state; (vii) emotions that may be experienced before or during food craving or eating; (viii) cues that may trigger food craving; and (ix) guilt from craving and/or for giving into them (Cepeda-Benito et al., 2000). The FCQ-S is composed of 15 statements and is an instrument sensitive to changes in contextual, psychological and physiological states in response to specific situations (e.g., stressful events or food deprivation), considering the intense desire for food as a sporadic behaviour of the respondent. Higher scores in this questionnaire are associated with increased food deprivation, negative experiences related to eating and increased susceptibility to triggers that lead to eating. The FCQ-S contains 15 items to form five subscales: (i) an intense desire to eat; (ii) anticipation of positive reinforcement that may result from eating; (iii) anticipation of relief from negative states and feelings as a result of eating; (iv) lack of control overeating; and (v) craving as a physiological state (Cepeda-Benito et al., 2000).

2.2.4 Anthropometric variables

Height and current weight were measured and the body mass index (BMI) was calculated. The pre-pregnancy weight was obtained from the pregnant woman's medical record. The collected data were used to calculate the pre-pregnancy and current body mass index (BMI). Current BMI was classified according to the gestational week suggested by Atalah et al. (2017).

2.2.5 Sleep patterns

Pregnant women were asked to report their usual bedtimes and waking times on weekdays and weekends, as described previously by Gontijo et al. (2018). Chronotype was assessed via mid-sleep time (MSFsc) on free days with correction for calculated sleep debt, which was assessed as the difference between average sleep duration on the weekends and the average sleep on weekdays (Roenneberg et al., 2007). Those women with MSFsc chronotype ≤03.59 a.m were classified as morning type, pregnant women with MSFsc chronotype between 04.00 h and 04.59 a.m were classified as intermediate type, and women with MSFsc chronotype ≥05.00 a.m were classified as evening type (Roenneberg et al., 2012).

Social jetlag is defined as a behavioral indicator of circadian misalignment and was calculated based on the absolute difference between midsleep time – moment that individual reaches 50% of total sleep time – on weekdays and weekends (Wittmann et al. 2006).

Sleep quality was assessed via a self-reported sleep quality scale, which ranges from 0 to 10, with 0 being very poor and 10 being very good.

2.3 Statistical analysis

Fisrt, Kolmogorov–Smirnov normality test was performed. Then, we determined the caloric midpoint median and this value was used to classify the participants into two groups: early eaters (caloric midpoint ≤ 1:00 pm) and late eaters (caloric midpoint > 1:00 pm). Kruskal-Wallis and Chi-square tests were performed to compare linear and proportion variables between groups, respectively. Generalized linear models (GzLM) were used to determine the association between caloric midpoint and food intake and mealtimes. Linear regression was used to determine the association between caloric midpoint and food craving. All analysis were adjusted for age, gestational trimester, vomiting, nausea, heartburn, physical activity, chronotype score and sleep quality. P-value < 0.05 was considered statistically significant.

3. RESULTS

The sample characterization data according to caloric midpoint are presented in table 1. The groups were the same for most of the variables analysed. However, early eaters had higher values for weight (p=0.03), current BMI (p=0.01) and frequency of vomiting (p=0.04) compared to late eaters. In addition, the frequency of morning type and intermediate type of pregnant women is higher among early eaters (p=0.01) and the late eaters group had a higher frequency of evening chronotype (Table 1).

Mealtime data according to caloric midpoint are also shown in table 1. As expected, pregnant women with midpoint ≤1:00 pm perform first meal (p <0.001), last meal (p =0.01), breakfast (p <0.001), lunch (p <0.001), dinner (p=0.03) and late night snack (p = 0.03) earlier than those with caloric midpoint > 1:00 pm (Table 1).

Table 2 shows that pregnant women who present caloric midpoint after 1:00 pm consume more total calories (p < 0.001), more total carbohydrates (p = 0.002), total fat (p = 0.003), monounsaturated fat (p = 0.002) and saturated fat (p=0.01) compared to pregnant women who present caloric midpoint before 1:00 pm (Table 2).

Regarding the consumption of calories and macronutrients for each meal, early eaters have a higher consumption of calories in the morning snack (p=0.03) and late eaters have a higher consumption of calories (p=0.007), carbohydrates (p=0.01) and fats (p=0.04) in the first afternoon snack, higher consumption of calories (p=0.04), carbohydrates (p=0.04) and proteins (p=0.03) in the second afternoon snack, higher consumption of calories (p<0.001), carbohydrates (p<0.001), proteins (p=0.02) and fats (p<0.001) at dinner and higher consumption of calories (p=0.04) and fats (p=0.04) at late night snack compared to early eaters (Table 3).

The analysis of the usual food craving and the sporadic food craving according to the caloric midpoint is shown in table 4. The groups did not differ for the total score and for all the subscales analysed.

4. DISCUSSION

The present study investigated whether the caloric midpoint is associated with food craving and food intake in pregnant women. Our results showed that there was no relationship between caloric midpoint and food craving. However, higher consumption of total calories, carbohydrate, total fat, monounsaturated fat and saturated fat was found among pregnant women with a caloric midpoint after 1:00 pm (late eaters). In addition, a lower consumption of calories in the morning snack and higher consumption of calories and macronutrients in the first and second afternoon snack, dinner and late night snack were found among late eaters. Our results partially corroborate our initial hypothesis, since pregnant women who concentrate their meals at later times of the day consume more calories and macronutrients. However, food craving does not seem to be associated with these results.

Mealtimes are closely linked to health markers (Gallant et al., 2012) and can promote an important circadian misalignment in physiological, endocrine, metabolic and behavioural aspects (Garaulet & Gómez-Abellán, 2014). In this perspective, eating at later times has been related to dysregulation of the hunger and satiety mechanism (McHill et al., 2017). A study developed with 867 individuals found that food consumption at morning promotes greater satiety throughout the day, reducing total calorie intake (De Castro, 2004). In this same line, a clinical trial developed with 32 individuals found that those who ate at later times showed an increase in ghrelin secretion and a decrease in satiety signalling (Carnell et al., 2017). In addition, Jakubowicz et al. (2012) and Berti et al. (2015) demonstrated that eating at night and daily energy distribution are related to energy distribution throughout the day. In this way, a higher energy intake in the morning and at midday can promote a lower consumption of food at night. Another possible explanation predicts that greater habitual food intake during the night, provides a greater probability of altering the energy distribution pattern, since after a large night meal, the individual may not be in a fully post-absorptive state the next morning (Goo et al., 1987), which may result in skipping breakfast or lower consumption at this meal and a consequent increase in energy intake at evening meals (Fong et al., 2017). These previous studies support and help explain our results, which show a greater consumption of calories and macronutrients in the first and second afternoon snack, dinner and late night snack of pregnant women who present later midpoint, reinforcing the importance of a better distribution of energy throughout the day.

Evidence has shown that later eating is also associated with eating disorders, stronger emotional eating tendencies, and more frequent food cravings (Meule et al.,, 2014; Konttinen et al., 2014). Pelchat (1997), in a study carried out with 98 participants, found that, although intense cravings varied according to age and sex and did not present a uniformity of occurrence, they tended to occur in the late afternoon or early evening. More recently, it was found that pregnant women with the evening chronotype have greater food cravings as usual behaviour (Teixeira et al, 2019b). However, our study showed no association between the caloric midpoint and the usual food craving in pregnant women. The lack of association between these variables may be due to hormonal changes inherent to the gestational period (Boden, 1996), which can trigger food cravings in women who did not have intense cravings in the pre-pregnancy period (Gendall et al., 1997), attenuating the influence of mealtimes, as well as the caloric midpoint, on food craving. Thus, further studies are needed to confirm these findings.

There are some limitations to the present study. The experimental design of this exploratory study was cross-sectional, which limits its ability to establish causal relationships, although we performed analyses that removed the effects of possible confounding factors. In addition, some evaluations were performed using questionnaires that are subjective and dependent on the memory and motivation of participants. Lastly, our results are based on only 233 pregnant women who had regular consultations in the public health care system, and the generalisation of results for all pregnant women cannot be made.

We concluded that there were no differences between caloric midpoint groups regarding habitual and sporadic food cravings. However, pregnant women who concentrate their meals at later times (caloric midpoint >1:00 pm) consume more calories, carbohydrates and fats throughout the day and have a higher consumption of calories and macronutrients in the first and second afternoon snacks and dinner, compared to pregnant women with caloric midpoint before 1:00 pm.

AUTHOR CONTRIBUTIONS

The authours' responsibilities were as follows: CAC, YCPM, CAG and LCTB designed the study. CAG, LCTB, WMF and GPT collected the data. CAP, GPT and SGM analysed and interpreted the data. SGM and GPT wrote the initial manuscript. CAP, YCPM, CAG, LCTB, WMF revised the manuscript. All authors approved the final version of the manuscript submitted for publication.

FUNDING SOURCES

The authors would like to thank the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and Fundação de Amparo à Pesquisa de Minas Gerais (FAPEMIG).

The authors declare no conflict of interest.

5. REFERENCES

Atalah, S.E., Castillo, C.L., & Gomez, C. (1997). Propuesta de um nuevo estandar de evaluacion nutricional em embarazadas. *Rev Med Chile*, 125, 1429-1436.

Aljuraiban, G. S., Chan, Q., Oude Griep, L. M., Brown, I. J., Daviglus, M. L., Stamler, J., Horn, L.V., Elliott, P., Frost, G. S. (2015). The Impact of Eating Frequency and Time of Intake on Nutrient Quality and Body Mass Index: The INTERMAP Study, a Population-Based Study. *Journal of the Academy of Nutrition and Dietetics, 115,* 528–536.e1. https://doi.org/10.1016/j.jand.2014.11.017.

Baron, K. G., Reid, K. J., Kern, A. S., & Zee, P. C. (2011). Role of Sleep Timing in Caloric Intake and BMI. *Obesity*. 19, 1374–1381. https://doi.org/10.1038/oby.2011.100

Berti, C., Riso, P., Brusamolino, A., & Porrini, M. (2015). Benefits of breakfast meals and pattern of consumption on satiety-related sensations in women. *International Journal of Food Sciences and Nutrition*, *66,* 837–844. https://doi.org/10.3109/09637486.2015.1093611.

Boden, G. (1996). Fuel metabolism in pregnancy and in gestational diabetes mellitus. *Obstetrics and Gynecology Clinics of North America,* 23, 1-10. https://doi.org/10.1016/s0889-8545(05)70241-2.

Carnell, S., Grillot, C., Ungredda, T., Ellis, S., Mehta, N., Holst, J., & Geliebter, A. (2017). Morning and afternoon appetite and gut hormone responses to meal and stress challenges in obese individuals with and without binge eating disorder. *International Journal of Obesity, 42*, 841–849. https://doi.org/10.1038/ijo.2017.307.

Cepeda-Benito, A., Gleaves, D. H., Williams, T. L., & Erath, S. A. (2000). The development and validation of the state and trait food-cravings questionnaires. *Behavior Therapy*, *31*, 151–173. https://doi.org/10.1016/s0005-7894(00)80009-x.

De Castro, J. M. (2004). The Time of Day of Food Intake Influences Overall Intake in Humans. *The Journal of Nutrition, 134,* 104–111. https://doi.org/10.1093/jn/134.1.104.

Fong, M., Caterson, I. D. & Madigan, C. D. (2017). Are large dinners associated with excess weight, and does eating a smaller dinner achieve greater weight loss? A systematic review and meta-analysis. *British Journal of Nutrition, 118,* 616–628. https://doi.org/10.1017/s0007114517002550.

Gambardella, A. M. D., Frutuoso, M. F. P., & Franch, C. (1999). Prática alimentar de adolescentes. *Revista de Nutrição, 12,* 55–63. https://doi.org/10.1590/s1415-52731999000100005.

Gallant, A. R., Lundgren, J., & Drapeau, V. (2012). The night-eating syndrome and obesity. *Obesity Reviews, 13,* 528–536. https://doi.org/110.1111/j.1467-789x.2011.00975.x

Garaulet, M., & Gómez-Abellán, P. (2014). Timing of food intake and obesity: A novel association. *Physiology & Behavior, 134,* 44–50. https://doi.org/10.1016/j.physbeh.2014.01.001.

Gendall, K. A., Joyce, P. R., & Sullivan, P. F. (1997). Impact of Definition on Prevalence of Food Cravings in a Random Sample of Young Women. *Appetite, 28(1),* 63–72. https://doi.org/10.1006/appe.1996.0060.

Gill, S., & Panda, S. (2015). A Smartphone App Reveals Erratic Diurnal Eating Patterns in Humans that Can Be Modulated for Health Benefits. *Cell Metabolism, 22,* 789–798. https://doi.org/10.1016/j.cmet.2015.09.005.

Gontijo, C. A., Balieiro, L. C. T., Teixeira, G. P., Fahmy, W. M., Crispim, C. A. & Maia, Y. C. P. (2020). A higher energy intake at night-time impacts daily energy distribution and contributes to excessive weight gain during pregnancy. *Nutrition,* 110756. https://doi.org/10.1016/j.nut.2020.110756

Gontijo, C. A., Cabral, B. B. M., Balieiro, L. C. T., Teixeira, G. P., Fahmy, W. M., Maia, Y. C. de P., & Crispim, C. A. (2018). Time-related eating patterns and chronotype are associated with diet quality in pregnant women. *Chronobiology International,* 1–10. https://doi.org/10.1080/07420528.2018.1518328.

Goo, R. H., Moore, J. G., Greenberg, E., & Alazraki, N. P. (1987). Circadian variation in gastric emptying of meals in humans. *Gastroenterology, 93(3),* 515–518. https://doi.org/10.1016/0016-5085(87)90913-9.

Horne, J. A, Ostberg, O. A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. Int J Chronobiol. 4:97–110. 1976

Hung, T.-H., Chen, S.-F., Hsu, J.-J., & Hsieh, T.-T. (2015). Gestational weight gain and risks for adverse perinatal outcomes: A retrospective cohort study based on the 2009 Institute of Medicine guidelines. *Taiwanese Journal of Obstetrics and Gynecology, 54(4),* 421–425. https://doi.org/10.1016/j.tjog.2015.06.010

Jakubowicz, D., Froy, O., Wainstein, J., & Boaz, M. (2012). Meal timing and composition influence ghrelin levels, appetite scores and weight loss maintenance in overweight and obese adults. *Steroids, 77(4),* 323–331.https://doi.org/10.1016/j.steroids.2011.12.006.

Konttinen, H., Kronholm, E., Partonen, T., Kanerva, N., Männistö, S., & Haukkala, A. (2014). *Morningness–eveningness,* depressive symptoms, and emotional eating: A population-based study. *Chronobiology International, 31,* 554–563. https://doi.org/10.3109/07420528.2013.877922.

Maukonen, M., Kanerva, N., Partonen, T., & Männistö, S. (2018). Chronotype and energy intake timing in relation to changes in anthropometrics: a 7-year follow-up study in adults. *Chronobiology International,* 1–15. https://doi.org/10.1080/07420528.2018.1515772.

Meule, A., Roeser, K., Randler, C., Kübler,A. (2012). Skipping breakfast: Morningness eveningness preference is differentially related to state and trai t food cravings. Eat. Weight Disord. 17: 4. 304-8.

Meule, A., Allison, K. C., & Platte, P. (2014). A German version of the Night Eating Questionnaire (NEQ): Psychometric properties and correlates in a student sample. *Eating Behaviors, 15,* 523–527. https://doi.org/10.1016/j.eatbeh.2014.07.002.

McHill, A. W., Phillips, A. J., Czeisler, C. A., Keating, L., Yee, K., Barger, L. K., Klerman, E. B. (2017). Later circadian timing of food intake is associated with increased body fat. *The American Journal of Clinical Nutrition,* ajcn161588. https://doi.org/10.3945/ajcn.117.161588.

Preedy V.R, Watson R.R & Martin CR. (2011). Handbook of Behavior, Food and Nutrition

Pelchat, M. L. (1997). Food cravings in young and elderly adults. *Appetite, 28,* 103–113. https://doi.org/10.1006/appe.1996.0063.

Poslusna, K., Ruprich, J., de Vries, J. H. M., Jakubikova, M., & van't Veer, P. (2009). Misreporting of energy and micronutrient intake estimated by food records and 24 hour recalls, control and adjustment methods in practice. *British Journal of Nutrition, 101,* S73. https://doi.org/10.1017/s0007114509990602.

Rogozińska, E ., Zamora, J ., Marlin, N ., Betrán, A., Astrup, A., Bogaerts, A., Cecatti, J. G., Dodd, J. M., Facchinetti, F., Geiker, N. R. W., Haakstad, L. A. H., Hauner, H., Jensen, D. M., Kinnunen, T. I., Mol, B. W. J., Owens, J., Phelan, S., Renault, K. M., Salvesen, K. Å., Shub, A., Surita, F. G., Stafne, S. N., Teede, H., van Poppel, M. N. M., Vinter, C. A., Khan, K. S., & Thangaratinam, S. (2019). Gestational weight gain outside the Institute of Medicine recommendations and adverse pregnancy outcomes: analysis using individual participant data from randomised trials. *BMC Pregnancy and Childbirth,* 19, 322–. https://doi.org/10.1186/s12884-019-2472-7

Roenneberg, T., Kuehnle, T., Juda, M., Kantermann, T., Allebrandt, K., Gordijn, M., & Merrow, M. (2007). Epidemiology of the human circadian clock. *Sleep Medicine Reviews, 11,* 429–438. https://doi.org/10.1016/j.smrv.2007.07.005.

Roenneberg T, Allebrandt KV, Merrow M, Vetter C. (2012). Social jetlag and obesity. *Curr Biol,* 22, 939–943. https://doi.org/10.1016/j.cub.2012.03.03

Schack-Nielsen, L., Michaelsen, K. F., Gamborg, M., Mortensen, E. L., & Sørensen, T. I. A. (2009). Gestational weight gain in relation to offspring body mass index and obesity from infancy through adulthood. *International Journal of Obesity, 34,* 67–74. https://doi.org/ 10.1038/ijo.2009.206.

Simko, M., Totka, A., Vondrova, D., Samohyl, M., Jurkovicova, J., Trnka, M., Cibulkova, A., Stofko, J., Argalasova, L. (2019). Maternal Body Mass Index and Gestational Weight Gain and Their Association with Pregnancy Complications and Perinatal Conditions. *International Journal of Environmental Research and Public Health, 16(10), 1751.* https://doi.org/ 10.3390/ijerph16101751

Teixeira, G. P., Balieiro, L. C. T., Gontijo, C. A., Fahmy, W. M., Maia, Y. C. P., & Crispim, C. A. (2019b*).* The association between chronotype, food craving and weight gain in pregnant women. *Journal of Human Nutrition and Dietetics*, 1418-1428. https://doi.org/10.1111/jhn.12723.

Teixeira, G. P., Barreto, A. de C. F., Mota, M. C., & Crispim, C. A. (2019a). Caloric midpoint is associated with total calorie and macronutrient intake and body mass index in undergraduate students. *Chronobiology International*, 1-11. https://doi.org/10.1080/07420528.2019.1652830.

Trancoso, S.C., Cavalli, S.B., Proença, R. P. C. (2010). Café da manhã: caracterização, consumo e importância para a saúde. *Revista de Nutrição, 23*, 859-869. https://doi.org/10.1590/S1415-52732010000500016.

Tierson. F.D, Olsen, C. L & Hook, E.B. (1985) Influence of cravings and aversions on diet in pregnancy. *Ecol Food Nutr ,17,* 117–129. https://doi.org/10.1080/03670244.1985.9990886.

Wittmann, M., Dinich, J., Merrow, M., & Roenneberg, T. (2006). Social Jetlag: Misalignment of Biological and Social Time. *Chronobiology International*, *23(1-2*), 497–509. https://doi.org/10.1080/07420520500545979.

Weingarten, H. P., & Elston, D. (1991). Food cravings in a college population. *Appetite, 17*, 167–175. https://doi.org/10.1016/0195-6663(91)90019-o.

Wang, J. B., Patterson, R. E., Ang, A., Emond, J. A., Shetty, N., & Arab, L. (2013). Timing of energy intake during the day is associated with the risk of obesity in adults. *Journal of Human Nutrition and Dietetics, 27*, 255–262. https://doi.org/10.1111/jhn.12141.

Table 1: Descriptive data of pregnant women according to caloric midpoint (n = 233).

	Early eaters Median [interquartile range]/ Frequency % (n) (n = 117)	**Late eaters** Median [interquartile range]/ Frequency % (n) (n = 116)	p-value
Age (years)	27.5 [19 – 42]	25.5 [18 – 45]	0.14
Menarche age (years)	13 [9 – 17]	12 [9 – 15]	0.14
Gestational age (weeks)	27.5 [4 – 40]	25 [4 – 40]	0.61
Gestational trimester			0.98
First trimester	24.8 (29)	24.1 (28)	
Second trimester	28.4 (33)	27.4 (32)	
Third trimester	47.4 (55)	47.9 (56)	
Previous pregnancy (yes)	59.8 (70)	55.1 (64)	0.51
Weight pre-pregnancy (kg)	67 [44 – 115]	63 [44.5 – 140]	0.07
BMI pre-pregnancy (kg/m²)	25 [18 – 42.2]	24 [16 – 46]	0.05
Underweight	2.5 (3)	7.7 (9)	0.14
Normal	44.4 (52)	48.2 (56)	
Overweight	32.4 (38)	22.4 (26)	
Obese	17.9 (21)	18.9 (22)	
Current Weight (kg)	74.3 [45 – 122]	69.5 [51 – 145]	**0.03**
Current BMI (kg/m²)	28.4 [18 – 44.8]	26 [12.8 – 47.36]	**0.01**
Underweight	3.4 (4)	12 (14)	0.05
Normal	35.8 (42)	37.9 (44)	
Overweight	35.8 (42)	25 (29)	
Obese	22.2 (26)	18.1 (21)	
Education level			
Primary incomplete/complete	13.6 (16)	8.5 (10)	0.62
Secondary incomplete/complete	52 (61)	55.9 (65)	
Higher incomplete/complete	32.4 (38)	31.8 (37)	
Marital status			
Married	45.2 (53)	48.2 (56)	0.85
Living with partner	33.3 (39)	30.1 (35)	
Single	17.9 (21)	17.2 (20)	
Work (yes)	63.2 (74)	60.3 (70)	0.42
Heartburn (yes)	64.7 (75)	65 (76)	0.82
Nausea (yes)	56.4 (66)	45.6 (53)	0.11
Vomit (yes)	47.4 (55)	33.6 (39)	**0.04**
Food desire (yes)	32.4 (38)	33.6 (39)	0.81
Physical activity (yes)	18.8 (22)	15.5 (18)	0.52
Chronotype			
Morning	55.5 (65)	42.2 (49)	**0.01**
Intermediate	23 (27)	22.4 (26)	
Evening	15.3 (18)	31.8 (37)	
Social jetlag > 30min	66.6 (78)	49.1 (57)	**0.006**
Meal timing			
First meal (h:min)	8:00 [7:30 – 8:40]	9:00 [7:55 – 9:45]	**<0.001**
Last meal (h:min)	20:30 [20:00 – 22:00]	21:00 [20:00 – 22:05]	**0.01**
Eating duration (h:min)	12:30 [11:30 – 14:00]	12:30 [11:00 – 13:45]	0.89
Breakfast (h:min)	8:00 [7:30 – 8:35]	8:47 [7:40 – 9:30]	**<0.001**

Morning snack (h:min)	10:00 [9:30 – 10:20]	10:00 [9:30 – 10:30]	0.15
Lunch (h:min)	12:00 [11:45 – 12:30]	12:30 [12:00 – 13:15]	**<0.001**
First afternoon snack (h:min)	15:35 [15:00 – 16:10]	15:42 [15:00 – 16:20]	0.57
Second afternoon snack (h:min)	17:30 [17:00 – 18:00]	17:50 [17:00 – 18:07]	0.24
Dinner (h:min)	20:15 [19:30 – 21:00]	20:30 [20:00 – 21:30]	**0.03**
Late night snack (h:min)	22:00 [21:05 – 22:30]	22:30 [22:00 – 24:00]	**0.03**

Note: Kruskal-Wallis test was perform to linear variables and Chi-square test was perform to categorical variables.

Table 2: Energy and nutrients intake according to caloric midpoint (n = 233).

	Early eaters Median [interquartile range] (n = 117)	**Late eaters** Median [interquartile range] (n = 116)	Wald X^2	df	p-value
Energy (kcal/day)	1843.44 [1313.78 – 2314.09]	2039.47 [1473.55 – 2632.33]	15.02	1	**<0.001**
Carbohydrate (g/ day)	211.12 [154.84 – 291.68]	255.06 [185.07 – 338.74]	9.26	1	**0.002**
Protein (g/ day)	57.51 [42.33 – 81.55]	59.6 [43.32 – 87.98]	1.70	1	0.10
Total fat (g/ day)	64.8 [44.46 – 91.2]	73.1 [55.11 – 103.22]	8.73	1	**0.003**
Fiber (g)	18.24 [13.34 – 29.08]	19.04 [13.55 – 27.99]	0.34	1	0.55
Cholesterol (mg)	194.38 [111.96 – 317.53]	223.18 [132.35 – 358.51]	0.053	1	0.81
Monounsaturated fat (mg)	18.59 [13.49 – 25.84]	21.33 [13.88 – 34.85]	9.34	1	**0.002**
Poly-insaturated fat (mg)	17.86 [13.88 – 34.85]	20.19 [12.81 – 32.02]	2.87	1	0.09
Saturated fat (mg)	22.21 [15.24 – 30.89]	24.37 [15.15 – 36.01]	5.80	1	**0.01**

Note: Generalized linear models adjusted for age, gestational trimester, vomit, nausea, heartburn, physical activity, chronotype score and sleep quality.

Table 3: Energy and macronutrients intake in each meal according to caloric midpoint (n = 233).

	Early eaters Median [interquartile range] (n = 117)	**Late eaters** Median [interquartile range] (n = 116)	Wald X^2	df	p-value
Breakfast					
Energy (kcal)	319.85 [193.91 – 436.33]	280.84 [188.45 – 379.49]	0.69	1	0.40
Carbohydrate(kcal)	191.44 [127.44 – 301.44]	172.51 [117.2 – 268.38]	0.13	1	0.71
Protein (kcal)	22.32 [14.64 – 40.34]	19.48 [12.66 – 31.12]	0.59	1	0.43
Total fat (kcal)	64.65 [37.81 – 125.89]	76.23 [38.16 – 114.93]	0.05	1	0.82
Morning snack					
Energy (kcal)	121 [59.17 – 257.74]	94,9 [53.74 – 178.05]	4.60	1	**0.03**
Carbohydrate(kcal)	111.81 [47.14 – 169.44]	79.43 [42.59 – 140.42]	1.78	1	0.18
Protein (kcal)	6.83 [2.73 – 18.65]	5.64 [2.38 – 13.6]	2.53	1	0.11
Total fat (kcal)	9.2 [0.04 - 46.23]	7.44 [0.31 – 49.2]	0.88	1	0.34
Lunch					
Energy (kcal)	643.51 [458.86 – 854.32]	526.84 [348.18 – 724.51]	1.58	1	0.20
Carbohydrate(kcal)	211.48 [139.58 – 324]	197.62 [138 – 272.8]	0.18	1	0.67
Protein (kcal)	115.56 [69.72 – 159.24]	87.11 [51.7 – 141.78]	2.01	1	0.15
Total fat (kcal)	239.04 [159.66 – 368.18]	178.72 [117.58 – 277.29]	0.70	1	0.40
First afternoon snack					
Energy (kcal)	213.41 [126.36 – 351.97]	275.63 [144.53 – 503.08]	7.40	1	**0.007**
Carbohydrate(kcal)	142.54 [76.94 – 225.41]	170.42 [110.55 – 350.1]	6.31	1	**0.01**
Protein (kcal)	16.1 [9.69 – 25.6]	18.65 [9.68 – 36.34]	0.49	1	0.48
Total fat (kcal)	50.17 [14.28 – 88.2]	56.49 [17.68 – 140.01]	4.07	1	**0.04**
Second afternoon snack					
Energy (kcal)	151.59 [59.91 – 321.52]	213.21 [99.09 – 439.33]	4.17	1	**0.04**
Carbohydrate(kcal)	96.6 [57.53 – 200.12]	130.44 [72.6 – 296.12]	3.97	1	**0.04**
Protein (kcal)	13.71 [3.43 – 36.44]	15.7 [6.16 – 51.69]	4.25	1	**0.03**
Total fat (kcal)	30.46 [3.98 – 76.99]	47.38 [17.47 – 135.2]	3.16	1	0.07
Dinner					
Energy (kcal)	412.4 [272.46 – 602.42]	576.89 [329.94 – 945.46]	25.26	1	**<0.001**
Carbohydrate(kcal)	169.45 [110.7 – 259.54]	230.76 [145.45 – 364.31]	16.64	1	**<0.001**
Protein (kcal)	68.9 [25.65 – 109.34]	80.48 [48.18 – 136.8]	5.02	1	**0.02**
Total fat (kcal)	147.12 [85.48 – 204.77]	212.77 [121.72 – 359.16]	15.08	1	**<0.001**
Late night snack					
Energy (kcal)	68.3 [42.55 – 165.05]	135.75 [60.84 – 313.62]	3.89	1	**0.04**
Carbohydrate(kcal)	38.48 [23.72 – 152.8]	83.81 [39.98 – 163.48]	1.45	1	0.22
Protein (kcal)	6.71 [2.06 – 11.88]	10.11 [4.32 – 26.67]	1.34	1	0.24
Total fat (kcal)	13.23 [1.26 – 31.14]	22.45 [3.5 – 63.92]	4.02	1	**0.04**

Note: Generalized linear models adjusted for age, gestational trimester, vomit, nausea, heartburn, physical activity, chronotype score and sleep quality.

Table 4: Linear regression between caloric midpoint and food craving questionnaires according to caloric midpoint (n = 233)

	All (n = 233)		**Early eaters** (n = 117)		**Late eaters** (n = 116)	
	β (95% CI)	**p-value**	**β (95% CI)**	**p-value**	**β (95% CI)**	**p-value**
FCQ-T total	0.008 (-1.21 – 1.35)	0.9	0.019 (-5.67 – 6.87)	0.8	0.030 (-1.81 – 2.42)	0.7
Subscale 1 FCQ-T *Intentions and plans to consume food*	0.032 (-0.10 – 0.16)	0.6	-0.089 (-0.94 – 0.36)	0.3	0.46 (-0.18 – 0.29)	0.6
Subscale 2 FCQ-T *Anticipation of positive reinforcement that may result from eating*	0.033 (-0.17 – 0.28)	0.6	-0.021 (-1.18 – 0.96)	0.8	0.14 (-0.36 – 0.42)	0.8
Subscale 3 FCQ-T *Anticipation of relief from negative states and feelings as a result of eating*	-0.061 (-0.19 – 0.07)	0.3	0.017 (-0.58 – 0.69)	0.8	-0.12 (-0.25 – 0.22)	0.9
Subscale 4 FCQ-T *Lack of control overeating*	-0.023 (-0.27 – 0.19)	0.7	-0.12 (-1.19 – 1.05)	0.9	0.65 (-0.26 – 0.51)	0.5
Subscale 5 FCQ-T *Thoughts and preoccupations with food*	-0.014 (-0.25 – 0.20)	0.8	0.012 (-0.99 – 1.11)	0.9	-0.37 (-0.47 – 0.32)	0.7
Subscale 6 FCQ-T *Craving as a physiologic state*	0.092 (-0.06 – 0.30)	0.2	0.076 (-0.55 – 1.18)	0.4	0.72 (-0.20 – 0.42)	0.4
Subscale 7 FCQ-T *Emotions that may be experienced before or during food craving or eating*	-0.034 (-0.23 – 0.14)	0.6	0.043 (-0.70 – 1.07)	0.6	-0.005 (-0.33 – 0.31)	0.9
Subscale 8 FCQ-T *Cues that may trigger food craving*	0.049 (-0.11 – 0.23)	0.4	-0.005 (-0.88 – 0.84)	0.9	0.19 (-0.27 – 0.32)	0.8
Subscale 9 FCQ-T *Guilt from craving and/or for given into them*	-0.041 (-0.15 – 0.08)	0.5	0.122 (-0.25 – 1.03)	0.2	0.71 (-0.12 – 0.24)	0.5
FCQ-S total	-0.001 (-0.63 – 0.62)	0.9	0.37 (-2.51 – 3.66)	0.7	0.164 (-0.18 – 1.84)	0.1
Subscale 1 FCQ-S	-0.024 (-0.14 – 0.10)	0.7	-0.031 (-0.68 – 0.50)	0.7	0.052 (-0.16 – 0.26)	0.6

Intense desire to eat						
Subscale 2 FCQ-S	-0.003 (-0.13 – 0.13)	0.9	-0.019 (-0.69 – 0.55)	0.8	0.088 (-0.13 – 0.31)	0.4
Anticipation of positive reinforcement that may result from eating						
Subscale 3 FCQ-S	-0.115 (-0.20 – 0.02)	0.1	0.10 (-0.54 – 0.59)	0.9	-0.021 (-0.19 – 0.16)	0.8
Anticipation of relief from negative states and feelings as a result of eating						
Subscale 4 FCQ-S	-0.080 (-0.17 – 0.05)	0.2	0.93 (-0.30 – 0.77)	0.3	-0.182 (-0.34 – 0.02)	0.09
Lack of control over eating						
Subscale 5 FCQ-S	-0.040 (-0.47 – 0.27)	0.5	0.10 (-0.91 – 2.66)	0.3	-0.179 (-1.18 – 0.74)	0.08
Craving as a physiologic state						

Note: adjusted for age, gestational trimester, vomit, nausea, heartburn, physical activity, chronotype score and sleep quality. FCQ-T: Food Craving Questionnaire Trait. FCQ-S: Food Craving Questionnaire State.