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Timing of food consumption in Hispanic adolescents with obesity

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Summary

Background: Little is known about the normal eating time periods in adolescents with obesity and how these patterns change throughout development. As the obesity epidemic continues to rise in adolescence, it becomes imperative to understand developmentally appropriate eating behaviours and to create weight management strategies that build on those innate patterns and preferences. The purpose of this study was to determine the most common habitual eating windows observed in adolescents with obesity.

Methods: Participants were 101 Hispanic adolescents (mean age 14.8 ± 2.1 years; 48 male/53 female) with obesity (BMI ≥95th percentile) who were recruited as part of a larger clinical trial. Dietary intake and meal timing was determined using multiple pass 24-hours recalls. Histograms were utilized to determine the natural distribution of percent consumption of total kilocalories, carbohydrates and added sugar per hour.

Results: The majority of total kilocalories (65.4%), carbohydrates (65.3%) and added sugar (59.1%) occurred between 11:00 and 19:00. Adolescents were 2.5 to 2.9 times more likely to consume kilocalories, carbohydrates, and added sugar during the 8-hour window between 11:00 AM and 19:00 PM than other time windows examined (all $P < .001$). The consumption of these calories did not differ between weekdays and weekend ($P > .05$) or by sex.

Conclusions: In this cohort, more than 60% of calories, carbohydrates and added sugar were consumed between 11:00 AM and 19:00 PM, which is concordant with an afternoon/evening chronotype that is common in adolescents. Our findings support this 8-hour period as a practical window for weight loss interventions that target pre-specified eating periods in this population.

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CONFLICT OF INTEREST
The authors have no financial relationships or conflict of interest relevant to this article to disclose.

Keywords

obesity; pediatrics; time limited eating

1 | INTRODUCTION

Little is known about the normal eating time periods in adolescents with obesity and how the developmental, shifting chronotype impacts these patterns.[1,2] Daytime specific energy intake and eating frequency is affected by individual chronotype patterns.[1,3] Chronotype is defined as the individual variations of sleep timing and diurnal preferences, and is proposed to be influenced by age, developmental stage, environmental light, and genetics.[4] Children have natural tendencies toward specific circadian patterns that change throughout their childhood.[5] It has been postulated that chronotype may be impacted by sex-specific hormonal changes and thus the shifting begins during the period of pubertal progression and is more delayed in males concordant with later pubertal onset than females.[1,3] During this transition, adolescents will shift from a morning chronotype, well described in pre-pubertal children with an early morning wake time and early bedtime, to an evening chronotype as they start to stay up later and sleep in later.[1,5,6] Adolescents ages 17 to 19 are on average the latest chronotypes, and their delayed sleep-wake behaviours clash with traditional eating patterns, school start times and other scheduled activities of daily living.[1–3]

As the obesity epidemic continues to rise in adolescence, it becomes imperative to understand developmentally appropriate eating behaviours and to create weight management strategies that build on those innate patterns and preferences.[7] Evidence-based dietary interventions are effective when adolescents are able to consistently adhere to intervention recommendations.[8–11] Unfortunately, a majority of adolescents with obesity have poor adherence to such interventions, resulting in minimal BMI status reduction.[12–15] It could be postulated that adherence may improve if dietary recommendations mirror an eating pattern that best fits with the usual weekly routine and chronotype.[1,4,6]

One dietary intervention that is gaining in popularity is time limited eating (TLE)[16–19] TLE has been shown to be an effective pattern for weight loss and to improve glycaemic control in adults with obesity and type 2 diabetes (T2D).[20–22] Although this approach may align well with normal adolescent eating patterns, it has not been well studied in adolescents with obesity.[23,24] There is a growing body of evidence, obtained from rodent models, that TLE improves glucose tolerance, reduces hepatosteatosis and improves markers of cardiovascular health.[25,26] One TLE approach involves interspersing an 8 to 10 hour period of normal daily caloric intake with a 14 to 16 hour period of fasting several times a week.[18,27] There have been several studies evaluating the impact of skipping breakfast in both children and adults but it remains unclear whether early morning fasting negatively impact body weight and glucose homeostasis.[28–31] An afternoon/evening TLE based approach may be uniquely suited for adolescents with obesity, as it has the potential to be more aligned with their habitual social eating patterns and thus more feasible, flexible, and non-stigmatizing given that it does not require calorie counting or macro-nutrient monitoring.[19,32] However, it remains unknown which eating window would align most closely with the normal chronotype seen at this developmental stage.[24,33]

There is a paucity of literature describing the normal timing of eating in adolescents with obesity.[1,34,35] This gap is important to address because although there are multiple dietary interventions available for weight management, it is unknown which are uniquely suited for this developmental stage. Therefore, the present study aimed to classify the most common eating windows observed in adolescents with obesity. We hypothesized that adolescents with obesity would consume the majority of their total kilocalories, carbohydrates, and added sugar in the afternoon and evening in conjunction with their shifting chronotype.

2 | METHODS

2.1 | Overall study design and location

This study was a cross sectional analysis in 101 Hispanic adolescents with obesity recruited from various clinical programs (Figure 1). The adolescents were recruited to participate in a randomized controlled trial of a dietary intervention, focused on sugar reduction in Hispanic youth. This study was limited to Hispanic youth to align with the larger clinical trial aims given that Hispanic youth with obesity are disproportionally affected by sugar intake and risk of Non-alcoholic fatty liver disease (NAFLD), thus the intervention was created for delivery to this specific cohort.[36] For the purpose of this study, only baseline data was utilized. Study procedures were approved by the Children's Hospital Los Angeles (CHLA) Institutional Review Board and is in accordance with the Helsinki Declaration of 1975, as revised in 2008. The study was reported according to the Consolidated Standards of Reporting Trials (CONSORT) statement for randomized trials of non-pharmacological treatments and is registered with ClinicalTrials.gov (NCT02948647). Written informed consent was obtained from the adolescents and one parent or guardian.

2.2 | Participant eligibility criteria

Eligible participants were males and females who self-identified as Hispanic and were ages 12 to 18 years with BMI ≥95th percentile for age and sex. Youth was excluded if they had: (a) previous diagnosis of pre-diabetes, diabetes, Polycystic Ovarian Syndrome (PCOS) or NAFLD; (b) current use of medication that impacts weight or executive functioning (eg, antipsychotics-bupropion/naltrexone, stimulants, sedatives, hypnotics, off-label obesity medication-metformin, topiramate, phentermine, glucagon-like-1 peptide agonists, and insulin); (c) current participation in other inter-ventional studies; (d) previous diagnosis of intellectual disability or syndrome form of obesity (eg, Prader-Willi syndrome) (e) smoking; or (f) pregnancy. Participants were recruited from: (a) paediatric gastroenterology clinics at Los Angeles-County and University of Southern California Medical Centre and CHLA; (b) the paediatric gastroenterology clinic in Long Beach; and (c) the Obesity/Endocrinology Clinics at CHLA.

2.3 | Primary outcomes

2.3.1 | Nutrient data system recall 24 hour dietary recall—Dietary intake was collected using the 24-hours multiple-pass recall technique, and was obtained at least in duplicate (1 weekday and 1 weekend day) or triplicate (2 weekdays and 1 weekend day) by bilingual and trained research personnel under the supervision of a registered dietitian. This study utilized dietary recalls collected at baseline. When possible, recalls were not collected during holidays or periods in which the participant's schedule was not representative of their typical day. Each recall collection was completed within the same week (collection of 2 weekdays and 1 weekend) prior to randomization. All data collection occurred prior to the COVID-19 pandemic. The procedures used in the 1985 to 1986 United States Department of Agriculture Continuing Survey of Food Intakes of Individuals (USDA-CSFII) were followed and all recalls were collected in a personal interview using a standardized protocol based on the "multiple pass" method which was developed and tested by the USDA for use in the 1994 to 1996 CSFII in an effort to limit the extent of under-reporting.[37] The standard multi-pass method includes the "Quick List", "Forgotten Foods", "Time and Occasion", the "Detail Cycle", and a "Final Probe".

The dietary data collected by recall was analysed and compiled using the most current version of the nutrient data system recall (NDSR) which was developed by the Nutrition Coordinating Centre, University of Minnesota, and is considered the "gold standard" of nutrition databases for 24-hour recall dietary assessment. The NDSR time-related database updates analytic data while maintaining nutrient profiles true to the version used for data collection, thereby reflecting the marketplace throughout the study. The first recall was performed in person at our laboratory with the use of food models, portion handouts and measuring cups to assist in estimating serving sizes. The interviewer asked the adolescent to list in sequence all foods and beverages consumed during the previous day, identify omissions in the initial list, and then provide details (eg, portion sizes, brand names, preparation methods) for each item. The remaining recalls were conducted by telephone with the adolescents without parental contribution.

2.3.2 | Eating time windows—After plotting the total consumption by hour to determine the natural distribution throughout the 24-hour window, three 8-hour time windows were defined prior to conducting the analysis in an effort to capture the predicted eating periods in this age group that captured early, mid-day and evening eating periods. The timing of these categories were determined based on: (a) the most common lunch time schedule at schools within the Los Angeles Unified School District, (b) average self-reported timing of dinner consumption from a small clinical sample (n = 15) and (c) multiple TLE based approaches have recommended 8 to 10 hour feeding windows either defined in the early AM or afternoon/evening.[23,27,38]

2.4 | Demographics and medical history

At baseline, participant demographics, completed by the family member, including family member's or caregiver's age, family member and adolescent's race/ethnicity, household composition, socioeconomic status (education, income), as well as family and adolescent's medical history were collected.

2.5 | Statistical analysis

Descriptive statistics were used to describe the demographic data shown in Table 1. Continuous variables were summarized using mean with SE and median with inter-quartile range (IQR). Categorical variables were summarized using frequency and percentage. The primary analytic endpoints in this analysis were daily intake of calories (kcal/day), carbohydrates (grams/day) and added sugar (grams/day). A histogram was created to determine the natural distribution of consumption per hour over the 24 hour period and then percent consumption for each endpoint was plotted. Generalized estimating equations model based on gamma distribution was used to assess the difference in calories consumption variables across three 8-hour eating window groups. Then, multiple comparisons with Bonferroni adjustment was used for pairwise comparisons. The results are summarized as relative calorie ratio with 95% confidence interval (CI) and P values. Statistical significance was set at 5% level with two-sided test throughout. All statistical computations are done using Stata/SE 15.1 (StataCorp, College Station, Texas).

3 | RESULTS

A total of 101 Hispanic adolescents with obesity (male/female: 48/53), a mean age of 14.9 ± 2.1 years and baseline body mass index (BMI) of 34.2 ± 6.5 kg/m^2 completed a 24-hour dietary recall. The baseline participant characteristics are shown in Table 1. In this cohort, on average, participants consumed 3648 (2593–4872) kcal/day, 455 (326–627) grams/day of carbohydrates (50% of total daily caloric intake) and 100 g/day (56–148) of added sugar (11% of total daily caloric intake), 101 g/day of fat (25% of total daily caloric intake) and 127 g/day of protein (14% of total daily caloric intake). The majority of consumption of total calories (65 [52, 79.4] %), carbohydrates (65 [50.7, 78.0] %) and added sugar (59 [31.5, 92.2] %) occurred between 11:00 and 19:00 (Figures 1–3 and Table 2.) The percent of total daily caloric intake of kilocalories (kcal, Figure 1), carbohydrates (grams, Figure 2) and added sugar (grams, Figure 3) by hour out of the 24-hour period was classified. In this cohort, most of the consumption occurred between 11:00 AM and 19:00 PM on both weekday and weekend day (Figures 1–3). Seventy-two percent of participants reported their first meal of the day as lunch, whereas the remainder ate less than one-third of their total daily caloric intake before 11 AM On weekdays, the percent consumption in total calories and carbohydrates started to increase from 09:00 AM to 13:00 PM followed by a decrease in consumption between 13:00 PM and 14:00 PM with a subsequent rise in percent consumption (Figure 1). These findings were similar on weekend days. Timing of intake and percent consumption of total calories, carbohydrates and added sugars did not differ by sex ($P = .32$). Generalized estimating equations model was utilized to assess the difference in total calories, carbohydrate and added sugar consumption between three 8-hour eating windows that captures early morning, afternoon/evening and night periods (0300–1059, 1100–1859, 1900–0259; all $P < .002$) on both weekdays and weekend days. Adolescents were 2.5 to 2.9 times more likely to consume calories (RR 2.7, 95% CI = 2.3, 3.1, $P < .001$), carbohydrates (RR 2.5, 95% CI = 2.2, 2.9, $P < .001$), and added sugars (RR 2.9, 95% CI = 2.4, 3.6, $P < .001$), between 1100 and 1859 than the other time windows. The consumption of these calories did not differ between weekdays and weekend (all interaction term $P > .05$).

4 | DISCUSSION

The present study assessed the cross-sectional relationship between time of day and macronutrient consumption in a sample of Hispanic adolescents with obesity. The patterns of total energy and macronutrient intake captured by the 24-hour dietary recall resembled the normal chronotype observed in this developmental stage, with a shift toward afternoon and evening activities that include the timing of food consumption. In this cohort of adolescents with obesity, the number of daily calories, carbohydrates and added sugars consumed each day were higher than current age-appropriate recommendations.[39] Specifically added sugar intake was almost double the recommended daily allowance which has been directly correlated with obesity related comorbidities, specifically non-alcoholic fatty liver disease.[40–42]

The majority of adolescents in this cohort consumed their total kilocalories, carbohydrates and added sugar between 1100 and 1900, consuming about 65% of their total calories during this period with less than one-third of calories consumed before 11 AM These findings differ from those seen in pre-pubertal children in which a larger portion of total calories are consumed before 11 AM including breakfast and morning snack.[43] Interestingly, in our cohort there was no difference in timing of food intake by sex which differs from previously studies which have suggested that chronotype may be impacted by sex-specific hormonal changes and thus eating windows may differ by sex.[3] The sex differentiation has previously been reported to start in the later tanner stages, around age 16 to 19 years.[3] The lack of differentiation in our cohort may be explained by the small sample size.

These findings suggest that Hispanic adolescents with obesity eat most of their daily food intake in the afternoon/evening period. Previous studies have shown that adolescents chronotype shifts from a morning profile to an afternoon/evening profile which may impacts their eating schedules as well and explain these findings. It remains unclear if this shift in the timing of eating negatively influences metabolic outcomes or promotes overweight and obesity. It has been suggested that there is a link between skipping breakfast and obesity in adolescents, however many of the results are conflicting. Recent NHANES data shows that only 76% of adolescent males and 69% of adolescent females consume breakfast; this is a stark decrease when compared to those ages 2-to-5 years old in which 95% consume breakfast daily.[44] A recent meta-analysis conducted in young adults reported that skipping breakfast increased the risk of overweight/obesity by 48% in cross-sectional studies and 44% in cohort studies.[45,46] However, none of the reviewed articles discussed specific eating windows nor commented on how skipping breakfast extends the eating period.

Time Limited Eating is a novel dietary approach that may be particularly effective in adolescents given its simple implementation strategy.[24,27,47] There is a growing body of literature to support that TLE approaches are effective in both body fat reduction and improvement in cardiometabolic outcomes in adults; however, their success is based on good adherence and sustainability.[18,23,38,48] It remains poorly understood whether the efficacy of TLE is based on the timing of eating or the caloric restriction that occurs due to the narrowing of the eating window. There is a paucity of literature directly comparing the various potential eating time windows.[33,38,49] In addition, the accept-ability and long-term feasibility of implementing an early TLE approach in real life settings remains unclear. To successfully utilize this technique in adolescents, a population well-known for poor adherence and sustainability, one potential strategy may be to pre-scribe an eating window that aligns with their usual daily activity and eating pattern. Based on this cohort an afternoon/evening TLE approach would lead to a 30% to 36% reduction in consumption of calories, carbohydrates and added sugar. These reductions would align with current recommendations for age appropriate intake of carbohydrates and added sugars as well as caloric restriction for acute weight loss in adolescents and young adults with obesity.[8,11]

In addition, this age-aligned eating window should be accounted for when adolescents with obesity present for weight management treatment. As has been demonstrated in other chronic disease models conducted in paediatric populations, treatment regimens that harness normal activities of daily living are more effective and sustainable in this age group.[50–52]Successful dietary interventions often require a lifestyle redesign that supports sustained behaviour change and does not interfere with the adolescent's daily commitments and activities.[53,54]

The strengths of the present study include the use of data from a fairly homogenous, adolescent population and detailed food consumption data using an in-person 24-hours dietary recall conducted in duplicate or triplicate. There are several limitations to consider as well. First, as the sample was specific to Hispanic adolescents, there may be cultural components that could explain the eating windows identified and prevent generalization of the findings to other ethnic groups. Multiple studies have demonstrated that eating practices and perceptions differ across ethnic groups. Studies examining perceptions of eating in Hispanic American Child-parent dyads compared to non-Hispanic dyads have reported an increased emphasize on preparing traditional meals, consuming the entire portion served, preparing meals together as a family and a negative perception of eating alone.[55–57] These differences could impact not only perceptions of eating but also eating time periods and therefore further studies in more diverse cohorts are required. Secondly, dietary intakes were self-reported and subject to measurement error or social desirability bias. In addition, adolescents may not accurately recall all the food items consumed in different time windows which could lead to under or over reporting of consumption. Finally, sleep and wake times were not collected in this cohort which limits our ability to clearly demonstrate a shifting chronotype and how that change is associated with reported eating times.

5 | CONCLUSIONS

In summary, we found that Hispanic adolescents with obesity consume more than 65% of calories, carbohydrates and added sugars between 1100 and 1900. These findings reinforce that circadian eating patterns in this age group are consistent with an afternoon/evening chronotype profile and differ from patterns seen in early childhood. Therefore, an afternoon/evening TLE approach may be more feasible and socially acceptable as it aligns with the normal circadian pattern seen at this developmental stage. Future studies are needed to explore the effectiveness of a TLE based approach in adolescents and to examine the long-term outcomes of an afternoon/evening-based approach compared to TLE in this population.

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Abbreviations:

TRE	time restricted eating
LSC	low sugar carbohydrates
BMI	body mass index
zBMI	body mass index Z-score
%BMI$_{p95}$	percent over the 95th percentile
coef	coefficient
CI	confidence interval

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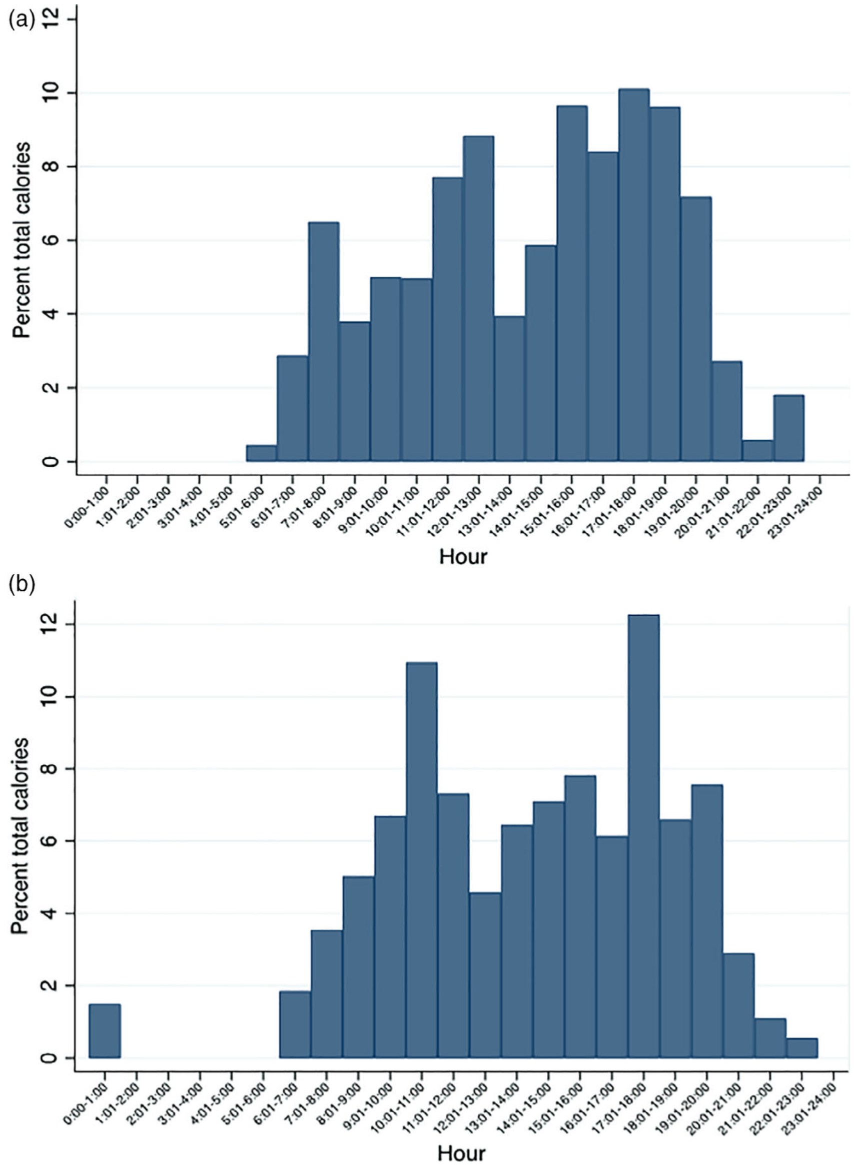

FIGURE 1.

Percent consumption of total calories (kcal/day) on (a) weekday and (b) weekend day

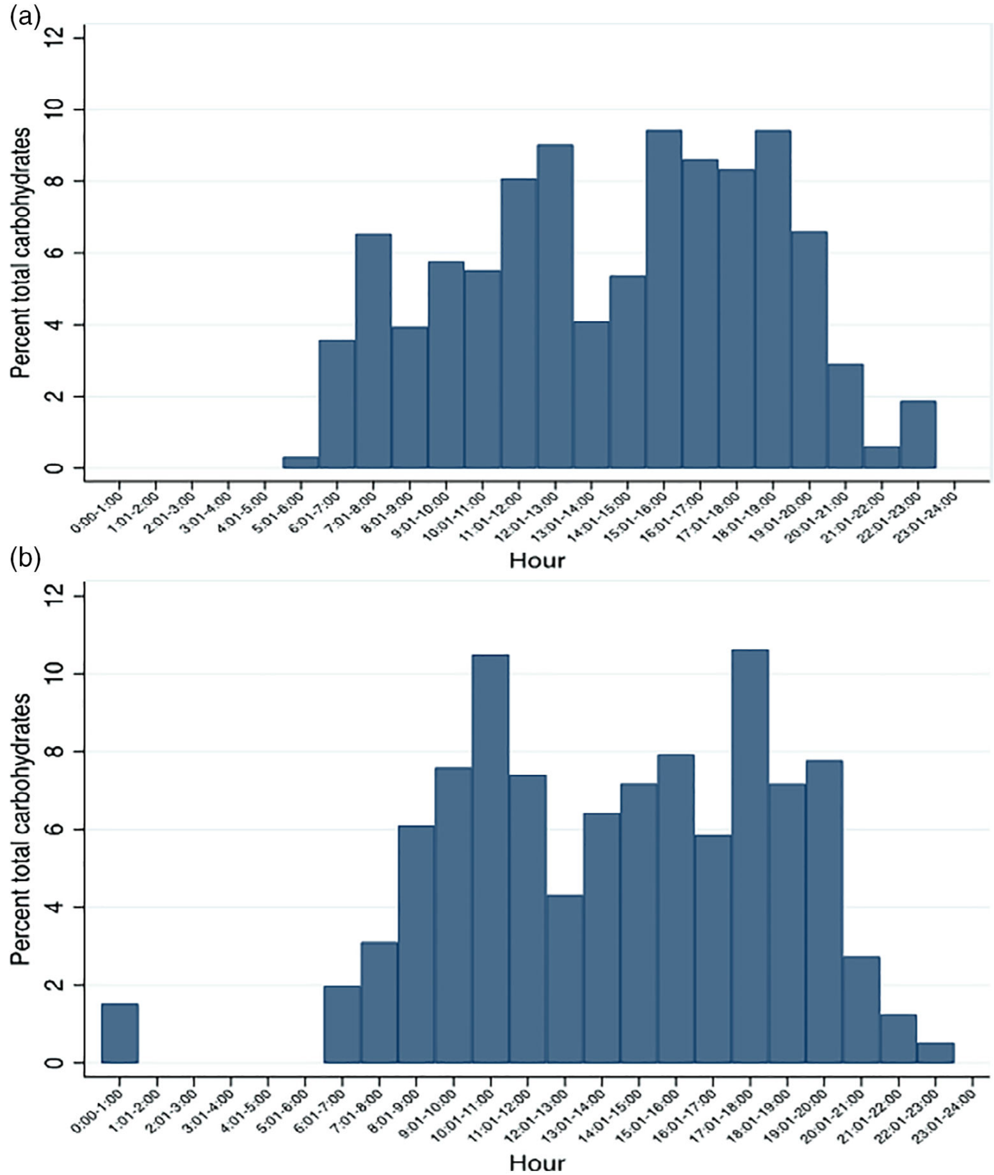

FIGURE 2.

Percent consumption of total carbohydrates (grams/day) on (a) weekday and (b) weekend day hourly collected from a 24-hours dietary recall

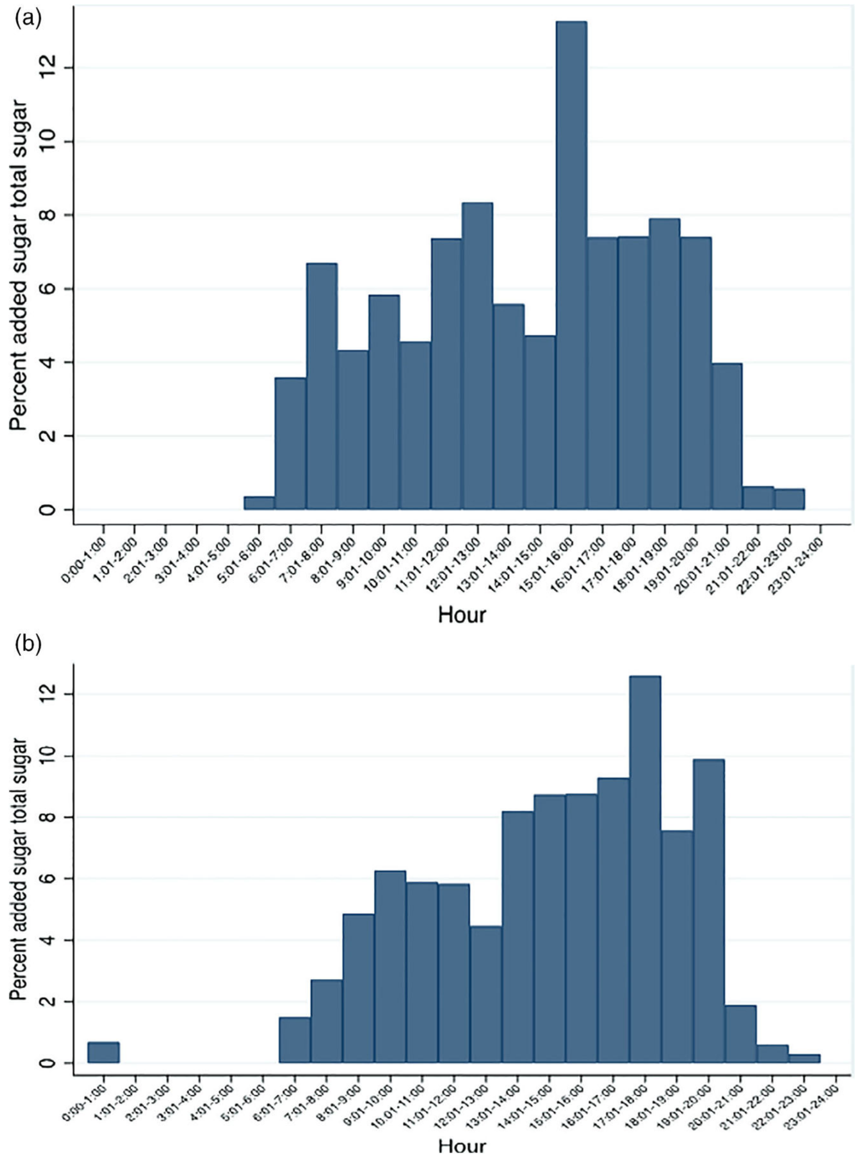

FIGURE 3.

Percent consumption of total added sugar (grams/day) on (a) weekday and (b) weekend day hourly collected from a 24-hours dietary recall

TABLE 1

Baseline demographic characteristics

Variable	Total (N = 101)
Age, years[a]	14.77 ± 2.12
Gender[b]	
Male	38 (48%)
Female	53 (52%)
Parent’s marital status[b]	
Single	15 (15%)
Married	49 (49%)
Divorced	6 (6%)
Separated	11 (11%)
Living together	19 (19%)
Civil union	1 (1%)
Mother’s education level[b]	
Less than eighth grade	30 (30%)
Finished eighth grade	14 (14%)
Some high school	6 (6%)
High school graduate/GED	24 (24%)
Some college or vocation school	13 (13%)
College graduate	7 (7%)
Graduate or professional training	1 (1%)
Missing	6 (6%)
Father’s education level[b]	
Less than eighth grade	26 (26%)
Finished eighth grade	17 (17%)
Some high school	14 (14%)
High school graduate/GED	14 (14%)
Some college or vocation school	7 (7%)
College graduate	2 (2%)
Graduate or professional training	-
Missing	21 (21%)
Household income[b]	
<$10 000	12 (12%)
$10 000–$20 000	18 (18%)
$20 000–$30 000	17 (17%)
$30 000–$40 000	8 (8%)
$40 000–$50 000	2 (2%)
>$50 000	4 (4%)
Missing	40 (40%)

Variable	**Total (*N* = 101)**
Public insurance	
No	49 (49%)
Yes	52 (52%)
Food stamps	
No	70 (69%)
Yes	31 (31%)
BMI[a]	34.19 ± 6.53
Severe obesity: Class II or III	22 (21%)
Weight (Kg)[a]	90.60 ± 19.83

[a]Arithmetic Mean ± SD.

[b]*n* (%).

TABLE 2

Percent consumption of total calories, carbohydrates and added sugars out of total daily caloric intake

	Weekday			Weekend		
	0300–1059	1100–1859	1900–0259	0300–1059	1100–1859	1900–0259
Calorie intake (%)						
Median (IQR)	24.3 (12.6, 34.3)	65.35 (51.9, 79.4)	11.35 (0, 26.2)	30.88 (19.8, 42.4)	58.28 (45.2, 75.4)	8.06 (0, 25.4)
Total carbohydrates (%)						
Median (IQR)	25.92 (17.0, 37.7)	65.26 (50.7, 77.9)	11.14 (0, 22.9)	33.33 (19.8, 44.3)	56.55 (42.9, 75.0)	8.19 (0, 31.3)
Added sugar (%)						
Median (IQR)	29.39 (2.6, 50.4)	59.09 (31.5, 92.2)	0 (0, 24.3)	14.92 (1.3, 46.7)	67.20 (34.3, 96.9)	0 (0, 30.5)