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Variation in dietary intake and body fatness by socioeconomic status among women in the context of Costa Rican nutrition transitions

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Abstract

The Nutrition Transition model posits that vegetable oils, animal source foods (ASFs) and caloric sweeteners contribute to increases in adiposity and hence body mass index (BMI). Body Mass Index is increasing more rapidly among Latin American populations of low- versus high-socioeconomic status (SES). In Latin America, few studies have evaluated dietary intake and adiposity at the individual level or how they vary by SES. The objectives of this study among Costa Rican women are to: (1) compare indicators of adiposity and dietary intake by SES and (2) evaluate the relationship between intake of foods high in vegetable oils, ASFs or caloric sweeteners and body fatness. This cross-sectional study included 128 low-, middle- and high-SES women. Anthropometry was used to assess BMI, body composition and body fat distribution. Dietary recalls (n=379) were used to assess dietary intake. Body fat percent was greater in low- versus high-SES women (31.5±3.9 vs. 28.2±4.7%). Skinfold measurements at four sites on the upper and lower body were greater in low- versus high-SES women. BMI did not vary in low- versus high-SES women. Intake frequency of foods high in vegetable oils was greater in low- and middle- (1.8 and 1.8 times/day, respectively) versus high- (1.1 times/day) SES women. For individual foods, intake frequency varied significantly by SES for high fat condiments, fried vegetables, dairy, sweetened coffee/tea and pastries and desserts. Intake frequency of Nutrition Transition food categories was not associated with percent body fat after adjustment for energy intake. Indicators of body composition provide additional information beyond BMI that are useful in understanding SES-adiposity associations in Latin America. Approaches to understanding diet and adiposity in Latin America that focus on vegetable oils, ASFs and caloric sweeteners should consider within-country variation in the pace of the Nutrition Transition, especially when explaining variation in adiposity by SES.

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The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

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Keywords

nutrition transition; socioeconomic status; Latin America

Introduction

The increased prevalence of adult obesity in middle income countries is well documented (Popkin *et al.*, 2012). Explanations are typically attributed to a single cause: the Nutrition Transition (Popkin *et al.*, 2012). This model posits that increases in obesity, as defined by body mass index (BMI)≥ 30.0 kg/m^2, are due to lifestyle changes that accompany economic development, and particularly to dietary increases in the consumption of vegetable oils, animal source foods (ASFs), and caloric sweeteners (Popkin, 2006). The evidence to support this model has been drawn primarily from national level data on food availability (Albala *et al.*, 2002; Kain *et al.*, 2003; Uauy and Monteiro, 2004; Cuevas *et al.*, 2009) and household food expenditures (Albala et al., 2002; Rivera *et al.*, 2002; Perez-Cueto *et al.*, 2006). Results from studies that evaluate dietary intake at the individual level in Latin America are inconsistent, but generally match at least some of the expectations of the Nutrition Transition model (Cunha *et al.*, 2010; Flores *et al.*, 2010; Dufour *et al.*, 2015).

In the literature on the Nutrition Transition, the most commonly evaluated outcomes are BMI and obesity prevalence at the national level (Vio *et al.*, 2008; Jeon *et al.*, 2015). The focus on BMI as an outcome measure limits understanding of the potential health effects because BMI is a measure of weight for height (i.e. kg/m^2) that does not distinguish between fat and lean tissue. It is therefore only a proxy for excess adiposity (Prentice and Jebb, 2001). Indeed, while some studies show a strong correlation between BMI and indicators of adiposity, such as overall fat mass and/or visceral fat mass (Bouchard, 2007), other studies show that the degree of adiposity (as percent body fat) at a given BMI can vary across individuals and populations (Okorodudu *et al.*, 2010) and is dependent on age, gender, and ethnicity (Gallagher *et al.*, 1996; Deurenberg *et al.*, 2002). It is clear, however, that excess adiposity elevates health risks even in individuals with BMIs in the normal range (Romero-Corral *et al.*, 2010). Hence, the focus on BMI as an outcome measure of the dietary changes accompanying the Nutrition Transition could be masking significant changes in adiposity among groups and obscuring the health risks. Further, focusing on national-level trends in BMI obscures potential socioeconomic differences that could be driven by variations in lifestyle or patterns of food intake resulting from transformations in local foods systems (Popkin, 2006; Popkin and Reardon, 2018). Indeed, there is evidence that obesity is rising faster among Latin American women from lower versus higher socioeconomic groups (Monteiro *et al.*, 2000; Boissonnet *et al.*, 2011; Olszowy *et al.*, 2012).

In the present study, measures of individual dietary intake and adiposity among Costa Rican women from three different socioeconomic (SES) groups provide insight into variation by SES in dietary intake and adiposity in the context of a nutrition transition. The focus is specifically on SES variation in adiposity and the consumption of foods in the categories highlighted in the Nutrition Transition model: vegetable oils, ASFs and caloric sweeteners. These are referred to as NT foods. The objectives of this study are to: (1) quantify variation by SES in finer tuned indicators of adiposity, and in the intake of NT foods; (2) assess the relationship between intake of NT foods and adiposity. The hypothesis is that both the intake of NT foods and adiposity will be greatest among low-SES women.

Methods

Setting

Costa Rica, along with many other Latin American countries, is in the later stages of the epidemiologic and nutrition transitions, which are characterized by increases in the prevalence of nutrition-related chronic diseases and changes in dietary intake and physical activity patterns (Popkin and Reardon, 2018). In Costa Rica, the prevalence of obesity and diabetes is similar to that of developed countries (Wong-McClure *et al.*, 2016; Bekelman *et al.*, 2017) due in part to an almost doubling of the combined prevalence of overweight/obesity among women of reproductive age between 1982 and 2008/2009 (Agüero, 2009). Changes in the prevalence of overweight/obesity have occurred in tandem with increasing consumption of foods and beverages high in fat, added sugars and salt (Rhee *et al.*, 2012; Cantor *et al.*, 2013; Monge-Rojas *et al.*, 2013; Heredia-Blonval *et al.*, 2014; Fisberg *et al.*, 2018).

Concurrent with these changes are changes in the national food supply. Over the last decade, there was a trend towards increasing availability of commonly used vegetable oils, such as soybean and palm; and ASFs, including poultry, cheese and eggs. In contrast, there was a trend over the same period towards decreasing availability of sugar, including sugar cane and refined sugar (Food and Agriculture Organization, 2017).Except for decreasing sugar availability, this nutrition profile in Costa Rica is consistent with Pattern 4 (Degenerative Diseases) of the Nutrition Transition (Popkin, 2006). Pattern 4 is characterized by changes in:

1. Diet (greater intake of fat, sugar, processed foods and lower intake of fiber),
2. Health status (increasing prevalence of chronic diseases, including obesity),
3. Economic conditions (rapid growth in income and increasing income disparities)
4. Technology use (increasing household and food processing technologies) (Popkin, 2006)

Whether this nutrition profile is uniform across Costa Rica or varies based on local conditions is unknown. One study by Colón-Ramos and colleagues found that Costa Rican women in higher versus lower SES tertiles favored cooking oils with less saturated fat (e.g. vegetable oils) (Colon-Ramos *et al.*, 2007). Lower levels of physical activity are also characteristic of Pattern 4 of the Nutrition Transition and may be an important contributor to rising obesity in Costa Rica. Among women in Latin America, physical activity levels are low and may vary by SES, although the direction of the SES-physical activity association is unclear (Poggio *et al.*, 2016; Aguilar-Farias *et al.*, 2018; Camargo *et al.*, 2018) and has not yet been evaluated in Costa Rican adults.

Administrative districts, known as cantons, in the capital province of Costa Rica were selected as the sites for this study based on the extreme variation in socioeconomic conditions between the cantons. Socioeconomic conditions of the cantons were characterized using the Human Development Index (HDI), a measure of social and economic development based on health, education and economic indicators (United Nations Development Program, 2013). In 2011, the poorer canton of *Alajuelita* had the lowest HDI score (0.596) in the country and the wealthier canton of *Escazú* had the fourth highest (0.924), on a spectrum of 0 to 1.0 where 1.0 indicates better conditions. The cantons of *Alajuelita* and *Escazú* were selected because of their similar levels of urbanicity and to provide a comparative perspective through recruitment of participants across the socioeconomic spectrum.

Study design

A random sample of 128 women were enrolled in this cross-sectional study. Data was collected between June 2014 and March 2015.All procedures were approved by the Scientific Ethics Committee at the University of Costa Rica (VI-4574–2014) and the Human Research Committee at the University of Colorado Boulder (13–0696). Written informed consent was obtained from all subjects.

Participants

Participants included non-pregnant, non-lactating women between 25 and 45 years of age, with one to four live births and Costa Rican citizenship. The study focused on women because obesity is higher in women than men in many Latin American cities (Schargrodsky *et al.*, 2008), including the greater San José metropolitan area (Ministerio de Salud, 2009), and because women play a prominent role in the procurement and preparation of food in Latin America. Pregnant and lactating women were excluded because their diet may not reflect their usual intake. Narrow ranges for age and parity were used because both were expected to differ by SES. Immigrants were excluded and participants were not recruited from indigenous communities because of the known association between ethnicity and anthropometric outcomes (Heymsfield *et al.*, 2016).

Sampling and recruitment

Participants were identified through random sampling in the two cantons. One hundred blocks in the two cantons were randomly selected for recruitment. Every house in the 100 blocks was visited in-person twice as part of the recruitment process, unless someone in the household consented to participate or all household members were found to be ineligible. A note describing the study which included contact information for investigators was left at all households where no one answered the door. The sample size was selected based on a power analysis to estimate the effects of SES on BMI, energy intake and protein intake. The power analysis was conducted in April 2013. The power calculation was based on previously published studies that compared BMI by SES among Latin American women (Dressler *et al.*, 2008; Olszowy *et al.*, 2012) and a pilot study in which preliminary data on dietary intake was collected among women residing in *Alajuelita* and *Escazú* (Bekelman *et al.*, 2013).

One thousand and twelve households were screened for eligible women, and 221women met the inclusion criteria. Of those, 140 provided informed consent. The proportion of eligible women who provided informed consent (63%) was similar in low- and high-SES neighborhoods, suggesting that any bias that may have been introduced through sampling was likely similar across SES groups. Twelve women (9%) who consented to participate in the study were excluded from data analysis because they declined to participate in the anthropometry, completed less than two dietary recalls, or reported dietary intake that did not reflect their usual intake. The final sample (n=128) included 45 low-SES women, 39 middle-SES women and 44 high-SES women. Ninety-six percent of women completed all three dietary recalls. Three hundred seventy nine recalls were included in the analysis for this study.

Socioeconomic status

Women were classified into one of three SES categories: low, middle or high using an index that was constructed based on a sociodemographic questionnaire and data on household conditions that was collected as part of in-person observations of the household. The assignment of women into SES categories was based on the following individual, household and neighborhood characteristics: (1) high school degree or higher, (2) employment in the formal sector (administrative, managerial, teaching, health care professional, customer service, sales), (3) household located on a paved street, (4) household with upgraded flooring (upgraded: polished wood, ceramic tile, carpet), (5) residence in the high-HDI canton. The five characteristics used to classify women by SES were drawn directly from the 2014 Costa Rican *Encuesta Nacional de Hogares* (National Household Census), which is administered by the National Institute of Statistics and Census (INEC) to assess household characteristics and poverty. Income was not included in the index because many individuals in this population are employed in the informal sector where there is wide month-to-month variation in income. Women who had two or less of the above characteristics were classified as low-SES. Women who had three were classified as middle-SES. Women who had four or more were classified as high-SES. This categorization strategy was determined *a priori* and was based on observations of household and neighborhood conditions from a pilot study conducted in 2013 in the study neighborhoods which indicated that many women had at least two characteristics (home on a paved road and upgraded flooring). Two out of the five characteristics were therefore considered to define the scale's first breaking point, three was set as the middle category, and four to five characteristics as the upper category.

Dietary intake

The methods used to measure dietary intake were reported previously (Bekelman *et al.*, 2017). Briefly, three non-sequential 24-hour dietary recalls were conducted in Spanish, following the methods described by Gibson (Gibson, 2005). First, participants were asked to provide a complete list of the foods and beverages they consumed on the preceding day. Second, participants were asked to describe where the food was obtained from. For foods prepared at home, participants provided recipes. For purchased food items, participants provided the name of the vendor or brand. Third, participants were asked to recall the food quantities. Fourth, the interviewer and the participant reviewed the entire recall. Intake from packaged foods was assessed by documenting nutritional information from the packaging label, when available.

Women were asked if the dietary intake they reported was their usual dietary intake and, if no, why not. Seven dietary recalls were dropped from the analysis because women reported unusual dietary intake due to sickness or fasting. Dietary recalls were conducted Tuesday through Saturday to recall weekday consumption. For each recall, a list of all food and beverage items was generated. Items were categorized into *a priori* categories consistent with the Nutrition Transition model: Vegetable Oils, Animal Source Foods, Added Sugars or Other. Within each category, the intake frequency, in times per day, of all foods was calculated. Within the vegetable oil group, foods were categorized as fried plant-based foods (e.g. French fries), packaged chips, or high fat condiments (e.g. margarine, mayonnaise). ASF intake was calculated as the intake frequency of all animal-derived products. Within the ASF group, foods were categorized as fresh (e.g. beef), canned or processed (e.g. canned sardines, processed lunch meat), eggs, or non-sweetened dairy (e.g. milk). Caloric sweetener intake was calculated as the intake frequency of foods with added sugars and a sweet taste. Within the caloric sweetener group, foods were categorized as high sugar cereals, pure sugar (e.g. honey), pastries and desserts, sweetened coffee or tea, *fresco* (a blended drink made with water, fresh fruit and sugar) or juice, sweetened dairy (e.g. flavored yogurt), commercial drinks (e.g. soft drinks), and traditional drinks (e.g. starch-thickened drinks).

Anthropometry

Standardized anthropometric procedures were used to assess weight, height, circumferences and skinfolds (Lohmann TG, 1988). Weight (kg) was measured to the nearest 0.2 kg in duplicate with a Seca digital scale that was calibrated weekly. Height (cm) was measured to the nearest 0.1 cm in duplicate with a Seca stadiometer. Skinfolds were measured in duplicate to the nearest 1 mm at six sites: triceps, biceps, subscapular, suprailiac, mid-thigh and medial calf on the right side of the body with a Lange skinfold caliper. A third skinfold measure was conducted if the first two measures differed by more than two millimeters. Circumferences at the mid-upper arm, waist, hip, mid-thigh, and calf circumferences were measured in duplicate to the nearest 0.1 cm with a flexible measuring tape. Waist circumference was measured at the narrowest part of the torso between the lowest rib and the iliac crest. Participants were barefoot and lightly clothed for all measurements. All measurements were conducted by the same investigator who was trained in anthropometric procedures.

Calculated variables and definitions

BMI was calculated as weight (kg) / squared height (m^2) and women were categorized based on World Health Organization guidelines: Underweight (< 18.5 kg/m^2), Normal Weight (18.5–24.9 kg/m^2), Overweight (25.0–29.9 kg/m^2), and Obese (≥ 30.0 kg/m^2) (WHO, 2015). Body composition was measured as percent body fat and lean tissue area in the extremities. Percent body fat was calculated from the sum of four skinfolds (triceps, subscapular, biceps, and suprailiac) using the equation by Siri, % body fat = (4.95/density – 4.50)(100) (Siri, 1956); density was calculated using the equation by Durnin and Rahaman, density = 1.1581 – 0.0720 (sum of 4 skinfolds) (Durnin and Rahaman, 1967). Lean tissue in the upper and lower extremities, upper arm muscle area (UAMA) and calf muscle area (CMA) were calculated with the equations: UAMA = (arm circumference – (triceps skinfold * π))^2 / 4π and CMA = (calf circumference – (calf skinfold * π))^2 / 4π) (Frisancho, 1974; Olszowy *et al.*, 2012).

Data analysis

Daily intake frequencies of each food and beverage for each participant were calculated as the number of times each food or beverage was consumed by the participant over the course of the study divided by the number of 24-hour dietary recalls the participant completed.

All variables were continuous, except for BMI category, SES, marital status and the criteria used to define SES, which were all categorical. Descriptive statistics were calculated for the full sample and by SES group. The normality of the distribution for each continuous variable was evaluated graphically with histograms and Q-Q plots and numerically for skewness and kurtosis and it was determined that log transformations were unnecessary. Chi square was used for the comparison of categorical variables. To compare means for continuous variables between the three SES groups, Analysis of Variance (ANOVA) with Scheffé's test was used for pairwise post-hoc SES comparisons (low- versus middle-SES, low- versus high-SES, middle- versus high-SES). To evaluate the relationship between SES and anthropometric outcomes (BMI, adiposity as indexed by percent body fat, UAMA and CMA) in the full sample, multivariate linear regression models were used with adjustment for age, parity, weight and height, except for the BMI model which did not include adjustments for body weight and height. Similarly, to evaluate the relationship between SES and the frequency of consumption of NT foods in the full sample, multivariate linear regression models were used with each of the NT foods' intake frequency as a dependent variable and SES, parity, age and BMI as co-variates. Lastly, to evaluate the relationship between intake frequency of NT foods and percent body fat in the full sample, multivariate linear regression models were used with percent body fat as the dependent variable, and intake frequency for each of the NT foods, SES, age, parity and total daily energy intake as covariates in the full sample. To further understand the relationship among the variables, an SES-NT food interaction term was included in the latter models. Statistical analyses were conducted with STATA statistical software version 13. Statistical significance was set at $\alpha = 0.05$.

Results

Demographic characteristics and SES criteria for the full sample and by SES are shown in Table 1. Mean age ($p = 0.914$), mean parity ($p = 0.068$), and the proportion of married women ($p = 0.272$) did not vary by SES. Anthropometric characteristics and SES comparisons are shown in Table 2. Mean BMI varied by SES, but post-hoc pairwise comparisons were not statistically significant. The prevalence of obesity, categorized as a BMI ≥ 30, varied by SES and was significantly greater in low- versus high-SES (42.2 versus 18.2%, respectively, $p = 0.033$) and middle- versus high-SES (46.2 and 18.2%, respectively, $p = 0.028$) women.

Measures of adiposity varied by SES (Figure 1). Skinfold measurements were greater in low-versus high-SES women at three sites on the limbs (triceps, $p = 0.001$; biceps, p =

0.004; medial calf, $p<0.001$) and one site on the torso (suprailiac, $p = 0.039$). Skinfolds were greater in low-versus middle-SES women at two sites on the limbs (triceps, $p = 0.022$and medial calf, $p = 0.001$). Overall adiposity as indexed by percent body fat varied by SES and was significantly greater in low- versus high-SES women ($p = 0.003$). Measures of lean tissue as indexed by UAMA were greater in middle- versus low-SES women (49.1±18.6 vs. 41.4±11.0, respectively, $p = 0.049$) and there was a similar, but non-significant, trend for CMA. Waist circumference did not vary by SES ($p=0.534$).

Multivariate analyses were also used to evaluate the relationship between SES and anthropometric outcomes (BMI, percent body fat and lean tissue measures) (Table 4). Compared to low-SES, high-SES was associated with significantly lower BMI ($\beta=-3.23$, SE ±1.4, $p=0.022$) and percent body fat ($\beta=-2.33$, SE±0.7, $p=0.002$). Compared to low-SES, middle-SES was associated with significantly lower percent body fat ($\beta=-2.05$, SE±0.70, $p=0.004$). In tandem with these adiposity results, there was greater lean tissue in both the upper arm ($\beta=5.94$, SE±2.3, $p=0.011$) and calf ($\beta=12.59$, SE±3.1, $p<0.001$) when comparing high- to low-SES women. Similarly, there was greater lean tissue in both the upper arm ($\beta=6.92$, SE±2.2, $p=0.002$) and calf ($\beta=8.09$, SE±2.9, $p=0.006$) when comparing middle- to low-SES.

Dietary intake frequencies of foods described in the Nutrition Transition model are shown in Table 3. Intake of foods high in vegetable oil was greater in low- and middle- versus high-SES women (1.8±0.87, 1.8±0.93, 1.1±0.78 times/day, respectively, $p <0.001$) (Figure 2). Intake frequency of fried vegetables and high-fat condiments was greater in middle- versus high-SES women.

Intake of ASFs did not vary by SES (Figure 2), except for intake of dairy products which was greater in high- (1.75±1.20 times/day) versus low-SES (1.18±0.94 times/day) women ($p =0.043$). However, variation in dairy intake did not reach statistical significance after a Bonferroni correction. Intake of foods high in caloric sweeteners did not vary by SES (Figure 2). However, within that category, intake of sweetened coffee and tea was greater in low- versus high-SES women (1.45±1.11 vs. 0.85±0.80 times/day, respectively, $p = 0.013$). In contrast, intake of pastries and desserts was greater in high- (0.54±0.38 times/day) versus low- (0.27±0.30 times/day) SES women ($p = 0.002$). Sweetened dairy intake varied by SES with a trend towards greater intake in high-SES women.

Multivariate analyses evaluating the relationship between SES and NT foods yielded only one statistically significant finding (Table 4). Compared to low-SES women, high-SES women had a significantly lower intake frequency for foods high in vegetable oils ($\beta = -0.63$, SE±0.2, $p=0.001$). SES was not significantly associated with intake frequency for ASFs or added sugar.

Multivariate analyses evaluating the relationship between NT foods and percent body fat in the full sample yielded no statistically significant findings after adjustment for SES, age, parity and total daily energy intake (vegetable oils: $\beta=-0.13$, SE=0.5, $p=0.776$; ASFs: $\beta=0.17$, SE=0.3, $p=0.536$; added sugars $\beta=-0.36$, SE=0.3, $p=0.255$).No evidence of an interaction between SES and intake of NT foods was found. When adding to the latter models, interaction terms between SES categories and intake of each of the three NT foods, middle- vs. low-SES interactions with vegetable oil (p=0.118), ASF (p=0.231) or added sugar (p=0.231) intake were not significant. Similarly, high- vs. low-SES interactions with vegetable oil (p=−0.072), ASF (p=0.354) or added sugar (p=0.627) intake were not significant.

Discussion

This study among urban Costa Rican women showed variation in several indicators of adiposity by SES, with a consistent trend towards greater adiposity among low- versus high-SES women. Despite this variation, two of the three NT foods (ASFs and foods high in caloric sweeteners) were consumed with similar frequency across SES groups. The third NT food category, vegetable oils, was consumed with greater frequency among women in the two lower SES groups. However, in the multivariate analyses, intake frequency of each NT food category was not associated with percent body fat.

This study provides evidence that body composition varied by SES; the best examples of which were greater body fat percent and skinfold measurements among low-SES women. These differences were masked by the similarities in BMI, but suggested by the higher prevalence of obesity in the low- and mid-SES groups. This finding of SES differences in obesity prevalence is consistent with two longitudinal studies in Latin America that document an increase in obesity prevalence among lower SES women, and no change or a reduction in obesity among higher SES women over the same period (Monteiro *et al.*, 2000; Olszowy *et al.*, 2012). The greater prevalence of obesity in the two lower SES groups suggests a similar trend may be unfolding in Costa Rica, but the burden of greater obesity has not completely shifted to the lowest socioeconomic group. This socioeconomic patterning provides insight into the Nutrition Transition in Costa Rica in two important ways. First, it suggests that high-SES women in Costa Rica may be moving into the final pattern of the Nutrition Transition (Pattern 5: Behavioral Change), in which the prevalence of obesity declines in response to individual behavior change (Popkin, 2006). Second, lower prevalence of obesity and adiposity among high- versus middle- or low-SES women suggests that women in different SES groups may be undergoing the Nutrition Transition at a different pace, with high-SES women furthest along in the transition.

The lack of variation in circumference measurements was surprising because the expectation was that at least some of the additional adipose tissue among low- versus high-SES women would be deposited on the upper arm, lower leg or abdomen, where circumferences were measured. Circumference measurements reflect the combined mass of both fat and lean tissue, so one possible explanation for the lack of variation is that low-SES women have greater adiposity, but less muscle mass than women in other SES groups. The finding that low-SES women have less muscle mass on the limbs even after adjustment for body weight, provides support for this explanation.

Less muscle mass among low-SES women may be due to the role of compromised early life nutrition in programming suboptimal lean body mass in adulthood (Kulkarni *et al.*, 2014). Another potential explanation for lower muscle mass among low-SES women would be a lower level of physical activity in leisure pursuits and/or occupation-related physical tasks. Unfortunately, data on physical activity is not available to assess this possibility. In other developing country populations, women from lower socioeconomic groups are more likely than wealthier women to participate in occupations that require manual labor (Stalsberg and Pedersen, 2018), and hence would be expected to have higher levels of lean tissue. This expectation is consistent with a study of Colombian women in which UMA was inversely correlated with SES (Olszowy et al., 2012). Objective assessments of physical activity and sedentary behavior among adult populations in Latin America would provide insight into differences in muscle mass by SES.

The lack of variation in waist circumference by SES is inconsistent with studies among urban women in other Latin American countries which document variation in waist circumference by SES (Dressler *et al.*, 2008; Boissonnet *et al.*, 2011; Olszowy *et al.*, 2012). The lack of variation is even more puzzling because skinfold thickness at the suprailiac site, which is located just distal to the navel, was greater among low- versus high-SES women. These findings highlight the importance of collecting a wide range of anthropometric measurements; the similarity in waist circumference across SES groups is masking observed differences in adiposity by SES.

Many foods assumed to be important contributors to obesity in the developing world were consumed infrequently in this sample. Packaged chips, high sugar cereals, and sweetened dairy products, like ice cream, were consumed once per week or less, on average, in all SES groups. These findings are consistent with the findings of Dufour *et al.* (2015) who documented infrequent intake of sweets and candies and savory snack foods among low-SES, urban Colombian women. Sugar sweetened beverages (SSBs) in the present study were consumed, on average, more than twice per day in all SES groups, suggesting that SSBs are a part of the usual intake in this population. Yet, fewer than a quarter of these SSBs were commercial drinks, like soft drinks, which have been widely touted as a threat to global health in the developing world (Popkin, 2012). The finding that the SSBs consumed in this population are primarily prepared at home, and with locally grown ingredients, are consistent with the findings of Rhee *et al.*(2012) in a large population-based study in Costa Rican adults and Dufour *et al.* (2015) in Colombian women. In terms of SES variation, Fisberg *et al.* (2018), who conducted a multicenter study in urban populations of eight Latin American countries, showed no SES variation in added sugar intake in Costa Rica, which is consistent with the findings here for overall intake frequency of foods high in caloric sweeteners. Taken together, these studies raise questions about the relative public health importance of SSBs introduced through the global economy compared to SSBs that are part of traditional Latin American cuisine. Nevertheless, globalization and free trade policies that link Costa Rica with global markets have led to an increase in the availability of commercially-produced foods linked to obesity, especially in areas with high levels of tourism (Cantor *et al.*, 2013; Himmelgreen *et al.*, 2014). Future studies should continue to track if and how these foods are integrated into the Costa Rican economy and diet.

The dietary intake findings from this sample provide limited evidence that foods highlighted in the Nutrition Transition model contribute to SES variation in adiposity. Only high fat condiments, such as margarine and mayonnaise, and sweetened coffee or tea were consumed more frequently among low- versus high-SES women. In fact, foods high in caloric sweeteners like dairy products and pastries and desserts were most frequently consumed by high-SES women. The findings reported here are consistent with data from Flores *et al.*, who showed that high-SES Mexican women were more likely to consume diets with more refined foods, and sweets than diets high in maize and beans, and found the reverse among low-SES women (Flores *et al.*, 2010).

The Nutrition Transition model describes broad-scale, national and global changes in diet and nutritional status, but numerous studies show variation in intake of NT foods within and across countries, suggesting that the pace of the Nutrition Transition may vary across populations. Here, intake of high fat condiments, foods high in vegetable oils, dairy products, sweetened coffee/tea and pastries and desserts varied by SES. Additional examples from Latin America, Africa and Asia include variation by SES, urban versus rural residence or sex in obesity and dietary practices associated with Pattern 4 of the Nutrition Transition (Arps, 2011; Bojorquez *et al.*, 2015; Amoateng *et al.*, 2017; Wang *et al.*, 2017; Cohen *et al.*, 2018). This variability indicates that approaches to understanding and preventing the adverse health effects of dietary change should consider within country variation in the pace of the Nutrition Transition.

In the current study, there was no association between intake frequency of NT foods and percent body fat. Further, the interaction analysis suggests that SES did not modify the association between intake of NT foods and percent body fat. In contrast, among adult populations in Mexico, intake of diets high in sweets, animal fats, and Westernized foods was positively associated with multiple indicators of adiposity (Flores *et al.*, 2010; Denova-Gutierrez *et al.*, 2011). The lack of statistically significant association between intake frequency of foods described in the Nutrition Transition model and adiposity among Costa Rican women may be due several factors. First, the sample size of 128 women may not have been large enough to detect statistically significant differences. Second, other lifestyle factors may play a more important role in adiposity among urban Costa Rican women, including intake of other types of foods, overall energy intake, or physical activity patterns.

The strengths of this study include the individual level data on dietary intake combined with a wide range of anthropometric indicators, many of which have not been previously reported by SES among urban Latin Americans. This study had several limitations. First, while skinfold measurements are superior to BMI in estimating adiposity, skinfolds are not as accurate or reproducible as other methods for assessing body fat, such as computerized imaging. Second, recall bias and intentional under- or over-reporting of food intake, which are common limitations of dietary recalls, may have influenced the accuracy of the dietary data. Third, the analysis did not account for food portion sizes. While intake frequency did not vary by SES, energy intake from foods described in the Nutrition Transition model may vary by SES if portion size varies by SES. Fourth, most women could not recall the details of cooking oil use, so the vegetable oil intake category does not include intake from oil used for cooking. Finally, the cross-sectional study design prohibits conclusions about the causal relationship between SES and intake of NT foods or anthropometric measurements.

In conclusion, adiposity was greater at four of six skinfold sites in low- versus high-SES women, a difference that was masked by their similar BMIs and circumference measurements. Additionally, the consumption of two categories of foods (ASF and caloric sweeteners) associated with increased obesity in the Nutrition Transition model was similar across SES groups, which raises questions about the importance of ASFs and foods high in caloric sweeteners in explaining the higher adiposity among low-SES women in the Costa Rican sample. In contrast, intake of the third category of foods (vegetable oils) was higher in the low-SES groups and hence consistent with the Nutrition Transition model. Thus, approaches to understanding adiposity in Latin America that focus on the role of vegetable oils, ASFs and caloric sweeteners should consider variation in dietary intake within countries, as the Nutrition Transition may not occur at the same pace across all demographic groups. While the etiology of SES differentials in adiposity is likely to be multi-factorial and arise from differences in dietary intake and physical activity, intake of foods high in vegetable oils merits further study. Efforts to address the rapid rise in obesity among Costa Rican women should acknowledge the role of both commercially-produced and traditional foods, and beverages high in sugar. Efforts to reduce socioeconomic disparities in obesity should consider the more frequent intake of foods high in vegetable oils and sweetened coffee and tea among women from lower versus higher socioeconomic groups. Dietary intake is affected by culture and local social and economic conditions and is therefore likely to vary across Latin American countries. Nevertheless, future research should identify regional trends in dietary intake, determine how dietary intake varies by SES, and further investigate the relationship between diet and adiposity. Expanding these analyses to different age groups, men and children will likely provide novel insights into within country variation in the pace of the Nutrition Transition.

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This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by the Scientific Ethics Committee at the University of Costa Rica (VI-4574–2014) and the Human Research Committee at the University of Colorado Boulder (13–0696). Written, free, informed consent was obtained from all study participants.

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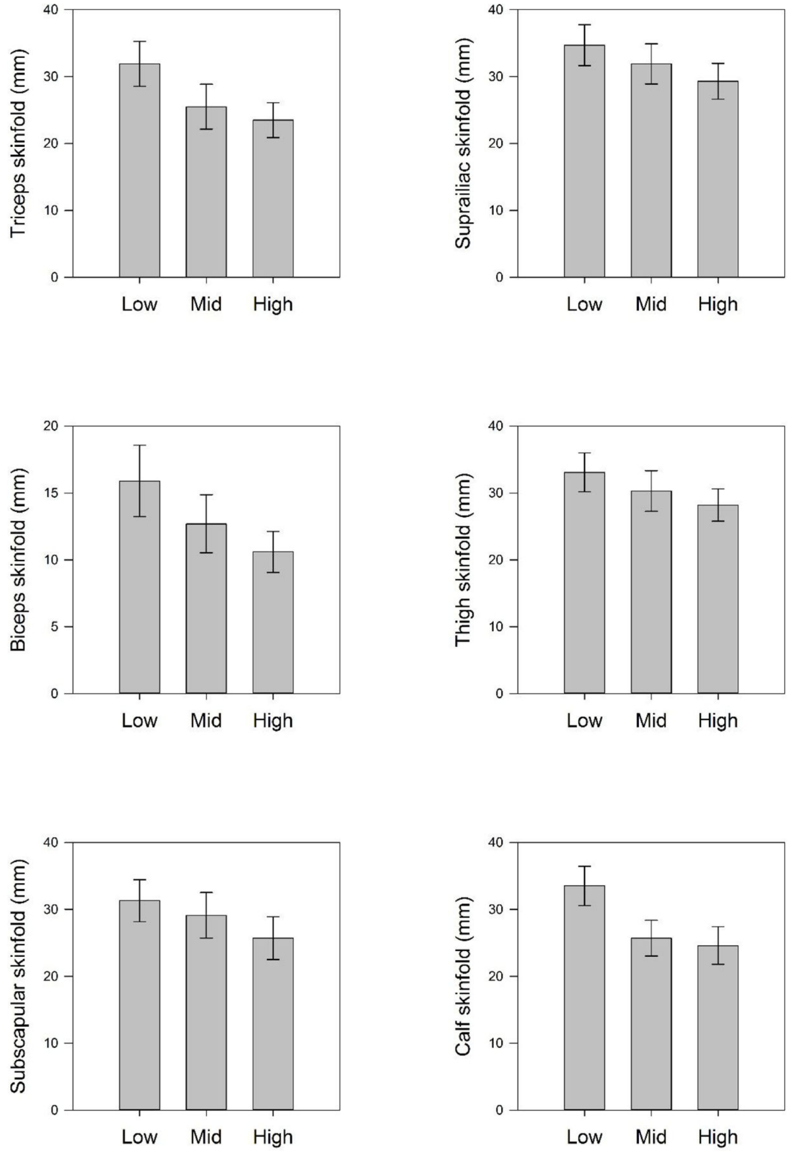

Figure 1.

Skinfold measurements at six sites (triceps, biceps, subscapular, suprailiac, mid-thigh, medial calf) by SES (low, middle, high). 95% confidence intervals are represented by error bars. Significant differences: low- versus high-SES (triceps, biceps, suprailiac, calf) and low- versus middle-SES (triceps and calf)

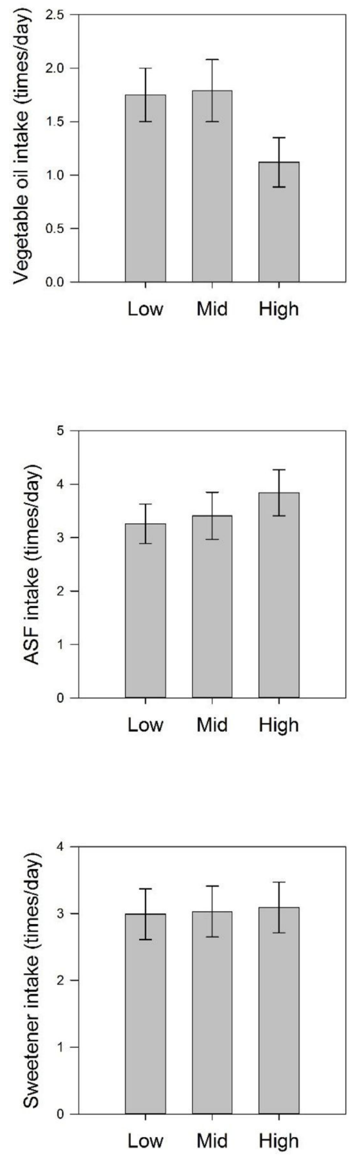

Figure 2.

Total intake frequency for NT foods (vegetable oil, animal source foods, caloric sweeteners). 95% confidence intervals are represented by error bars. Significant differences: low- versus high-SES and middle- versus high-SES (vegetable oil only).

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Table 1.

Demograpic characteristics in the full sample and by socioeconomic group

Category	Full sample (n=128)		Low-SES (n=45)		Middle-SES (n=39)		High-SES (n=44)	
	Mean or %	SD	Mean or %	SD	Mean or %	SD	Mean or %	SD
Age, years	36.8	5.6	36.7	6.4	37.1	5.0	36.6	5.3
Parity, births	2.2	1.0	2.4	1.1	2.2	0.9	1.9	0.8
Married, %	74.2		66.7		82.1		75.0	
SES criteria								
High school degree, %	35.9		0		15.4		90.9	
Works in formal sector, %	39.8		6.7		30.8		81.8	
Household on paved road, %	87.5		71.1		97.4		95.5	
Upgraded household flooring, %	71.1		33.3		87.2		95.5	
Household in a high-HDI neighborhood, %	53.1		4.4		69.2		88.6	

HDI, Human Development Index

SES, Socioeconomic Status

Table 2.

Anthropometric measurement and calculated anthropometric variables in the full sample and by socioeconomic group

Indicator	Full sample (n=128)		Low-SES (n=45)		Middle-SES (n=39)		High-SES (n=44)		P-value*	P-value † (Low vs. Mid)	P-value† (Low vs. High)	P-value † (Mid vs. High)
	Mean or %	**SD**	**Mean or %**	**SD**	**Mean or %**	**SD**	**Mean or %**	**SD**				
Weight, kg	71.7	16.4	72.8	17.7	73.3	17.3	69.1	14.2	0.439	--	--	--
Stature, m	157.0	6.1	156.0	4.6	155.0	5.3	159.7	6.1	**<0.001**	0.767	**0.011**	**0.002**
BMI, kg/m^2	29.1	6.5	29.9	7.0	30.4	6.7	27.1	5.4	**0.038**	0.942	0.117	0.066
BMI Category												
Underweight, %	0.78		2.2		0		0		0.401	--	--	--
Normal weight, %	26.6		20.0		20.5		38.6		0.082	--	--	--
Overweight, %	36.7		33.3		33.3		43.2		0.554	--	--	--
Obese, %	35.9		42.2		46.2		18.2		**0.010**	0.986	**0.033**	**0.028**
Circumferences, cm												
Arm	32.1	5.3	32.7	4.7	32.5	5.0	31.3	6.2	0.421	--	--	--
Calf	37.3	4.2	37.8	4.7	37.3	4.1	36.6	3.9	0.410	--	--	--
Hip	106.1	12.9	107.1	13.4	107.1	14.3	104.4	11.1	0.544	--	--	--
Waist	86.6	12.8	87.5	13.2	87.7	14.0	84.9	11.2	0.534	--	--	--
Skinfolds, mm												
Triceps	27.1	11.0	31.9	11.5	25.5	10.7	23.5	8.8	**0.001**	**0.022**	**0.001**	0.694
Biceps	13.1	7.6	15.9	9.1	12.7	6.9	10.6	5.2	**0.004**	0.155	**0.004**	0.410
Subscapular	28.7	10.9	31.3	10.8	29.1	10.8	25.7	10.8	0.053	--	--	--
Suprailiac	32.0	9.9	34.7	10.4	31.9	9.6	29.3	9.1	**0.038**	0.419	**0.039**	0.498
Mid-thigh	30.6	9.5	33.1	9.9	30.3	9.7	28.2	8.2	0.052	--	--	--
Medial calf	28.1	10.1	33.5	10.1	25.7	8.5	24.6	9.4	**<0.001**	**0.001**	**<0.001**	0.884
Calculated variables												
Body fat, %	29.8	4.4	31.5	3.9	29.7	4.4	28.2	4.7	**0.003**	0.165	**0.003**	0.336
Sum of 4 skinfolds, mm‡												
UAMA, cm^2	101.0	34.8	113.8	36.9	99.2	32.5	89.2	30.4	**0.003**	0.143	**0.003**	0.401
CMA, cm^2	44.5	14.4	41.4	11.0	49.1	18.6	43.5	12.2	**0.041**	**0.049**	0.798	0.197

BMI, Body Mass Index; UAMA, Upper Arm Muscle Area; CMA, Calf Muscle Area; SES, Socioeconomic Status

*P-values for BMI Category are from Chi-square, except 2-sided Fisher's Exact for Underweight; all other p-values are from Analysis of Variance for low vs. mid vs. high.

†P-values are from Scheffe's test. No post-hoc pairwise comparisons were conducted for BMI categories.

‡Sum of 4 skinfolds was calculated as the sum of triceps, subscapular, biceps, and suprailiac skinfolds.

Table 3.

Mean intake frequency in the full sample and by socioeconomic group

Indicator	Full sample (n=128)		Low-SES (n=45)		Middle-SES (n=39)		High-SES (n=44)		P-value*	P-value† (Low vs. Mid)	P-value† (Low vs. High)	P-value† (Mid vs. High)
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**				
Foods high in vegetable oil, times/day												
Total	1.55	0.91	1.75	0.87	1.79	0.93	1.12	0.78	**<0.001**	0.976	**0.003**	**0.002**
High fat condiments	1.23	0.77	1.46	0.79	1.36	0.76	0.89	0.64	**<0.001**	0.834	**0.002**	**0.016**
Fried vegetables	0.22	0.29	0.19	0.25	0.35	0.34	0.15	0.25	**0.004**	**0.040**	0.751	**0.006**
Packaged chips	0.09	0.20	0.10	0.20	0.08	0.15	0.08	0.24	0.890	--	--	--
Animal source foods, times/day												
Total	3.51	1.39	3.26	1.26	3.41	1.39	3.84	1.46	0.126	--	--	--
Dairy	1.44	1.08	1.18	0.94	1.40	1.02	1.75	1.20	**0.041**	0.626	**0.043**	0.336
Fresh ASFs	1.04	0.58	1.02	0.56	0.98	0.50	1.13	0.67	0.476	--	--	--
Canned or processed ASFs	0.62	0.49	0.64	0.48	0.63	0.53	0.60	0.48	0.924	--	--	--
Eggs	0.40	0.41	0.43	0.45	0.40	0.43	0.37	0.37	0.782	--	--	--
Foods high in caloric sweeteners, times/day												
Total	3.04	1.27	3.00	1.31	3.03	1.22	3.09	1.29	0.936	--	--	--
Sweetened coffee, tea***	1.20	0.96	1.45	1.11	1.30	0.85	0.85	0.80	**0.009**	0.780	**0.013**	0.094
Commercial drinks	0.52	0.54	0.54	0.63	0.61	0.58	0.42	0.37	0.278	--	--	--
Fresco or juice	0.51	0.56	0.44	0.58	0.39	0.49	0.67	0.59	0.054	--	--	--
Pastries and desserts	0.41	0.36	0.27	0.30	0.41	0.36	0.54	0.38	**0.002**	0.224	**0.002**	0.217
Pure sugar	0.15	0.27	0.09	0.22	0.16	0.34	0.20	0.25	0.117	--	--	--
Sweetened dairy	0.15	0.29	0.11	0.26	0.09	0.23	0.35	0.049		--	--	--
Traditional drinks	0.09	0.21	0.06	0.16	0.07	0.17	0.14	0.27	0.177	--	--	--
High sugar cereal	0.03	0.12	0.03	0.12	0.01	0.05	0.04	0.15	0.497	--	--	--

SES, Socioeconomic Status

*P-values are from Analysis of Variance for low versus mid versus high.

† P-values are from Scheffe's test.

‡ Not significant after Bonferroni correction

*** Intake only included in the analysis when a caloric sweetener was added to coffee or tea.

Table 4.

Multivariate linear regression models of the association between SES and anthropometric outcomes or intake frequency of NT foods among Costa Rican women

Variables*	Beta†	Standard Error	P-value
Body Mass Index (kg/m^2)			
Age	0.115	0.109	0.294
Parity	0.932	0.651	0.155
Middle-SES	0.291	1.406	0.836
High-SES	−3.23	1.388	**0.022**
Body fat (%)			
Age	0.181	0.056	**0.002**
Parity	0.163	0.327	0.618
Body weight	0.17	0.018	**<0.001**
Stature	0.093	0.052	0.079
Middle-SES	−2.054	0.699	**0.004**
High-SES	−2.333	0.738	**0.002**
Upper arm muscle area (cm^2)			
Age	0.3	0.176	0.091
Parity	0.234	1.019	0.819
Body weight	0.634	0.057	**<0.001**
Stature	0.424	0.163	**0.011**
Middle-SES	6.924	2.179	**0.002**
High-SES	5.94	2.3	**0.011**
Calf muscle area (cm^2)			
Age	0.073	0.234	0.975
Parity	0.185	1.357	0.892
Body weight	0.837	0.075	**<0.001**
Stature	0.528	0.217	**0.016**
Middle-SES	8.092	2.9	**0.006**
High-SES	12.593	3.061	**<0.001**
Foods high in vegetable oil (times/day)			
Age	0.019	0.015	0.202
Parity	0.024	0.088	0.788
Body Mass Index	0.005	0.012	0.682
Middle-SES	0.026	0.19	0.89
High-SES	−0.627	0.191	**0.001**
Animal Source Foods (times/day)			
Age	0.047	0.023	0.047
Parity	0.091	0.14	0.514

Variables*	**Beta†**	**Standard Error**	**P-value**
Body Mass Index	0.027	0.192	0.165
Middle-SES	0.129	0.299	0.667
High-SES	0.464	0.302	0.126
Foods high in caloric sweeteners (times/day)			
Age	0	0.021	0.986
Parity	0.331	0.128	**0.011**
Body Mass Index	0.017	0.017	0.332
Middle-SES	0.113	0.274	0.681
High-SES	0.205	0.276	0.46

SES, Socioeconomic Status

NT, Nutrition Transition

*All models included age and parity as covariates. Models for body fat, UAMA and CMA included body weight and stature as covariates. Models for intake frequency of NT foods included BMI as a covariate.

†Reference population: low-SES