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Meal occasion, overweight, obesity and central obesity in children and adults: A cross-sectional study based on a nationally representative survey. Colombia, 2015.

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Key words: Meals, Overweight, Obesity, Abdominal Obesity, Diet Surveys

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ABSTRACT

Objective To establish the effect of the number of meals/day on overweight, obesity and central obesity.

Design Cross-sectional, nationally representative surveys.

Setting Colombia.

Participants 6,985 children aged 5 to 17 years and 7,846 adults aged 18 to 64 years.

Main outcomes and measures Overweight was declared in children according to World Health Organization, between Z>1 and Z≤2 in body mass index (BMI) for age and in adults between BMI≥25 and BMI<30 [kg/m^2]. Obesity in children as Z>2 and in adults as BMI≥30. Central obesity in children was established according to the International Diabetes Federation. In adults, men≥90 cm and women≥80 cm. The number of meals/day was estimated with a Food Frequency Questionnaire. Meals/day were grouped into three categories: [Reference≤3, 4 and 5+]. Crude and adjusted Prevalence Ratios (PR) and their 95% confidence interval PR (95% CI) were calculated. The adjustment included usual energy intake/day and physical activity.

Results 26.5% eat three or fewer meals/day, 27.5% eat four and 46.0% eat five or more. Obesity was 6.7% and 13.1% and, central obesity was 4.0% and 44.8%, in children and adults, respectively. The adjusted PR for obesity in children was 1.14 (0.62, 2.07) for four meals/day and 0.95 (0.57, 1.59) for five or more meals/day. In adults it was 0.61 (0.42, 0.88) for four and 0.51 (0.36, 0.72) for five or more meals/day. For adult central obesity 0.70 (0.54, 0.92) for five or more meals/day.

Conclusions Increasing the number of meals/day is a potential strategy to control overweight, obesity and central obesity.

Strengths and limitations of this study

- The analyzed data came from a national survey (ENSIN-2015), which used rigorous and universally accepted methods.
- It used in the estimated risk adjustment the usual energy intake/day and the fulfillment of physical activity goals.
- The direction and strength of the association between the number of meals/day and overweight, obesity and central obesity in adults is similar to that reported in previous studies, which confers external validity to the findings.
- The data are cross-sectional data coming from an observational study; therefore, it is not possible to establish causal relationships.
- There may still be residual or unmeasured confusion, particularly in the case of children.

INTRODUCTION

Overweight and obesity have been of interest for centuries. Currently, this interest is based on the World Health Organization (WHO) statement on the global obesity epidemic and the public health crisis associated with the resulting morbidity and mortality.[1-3] Nowadays, we accept body mass index [kg/m2] (BMI) and waist circumference as indirect indicators of overweight (S), obesity (O) and central obesity (CO).[4] Ow, Ob and CO begin at an early age, their prevalence increases with age, and strategies to control them are expensive and ineffective in the long term.[5]

Regardless of total energy intake and other potential confounders, the number of meals per day (meals/day) has been inversely associated with Ob in children and directly associated with Ob and CO in adults.[5-9] Results with null or contradictory associations have been attributed to lack of statistical power, lack of unification of the definitions used to state the number of meals/day and poor statistical adjustment by ignoring potential confounding variables or biases such as information bias.[5 8 10] The number of meals/day has an effect on metabolism and on the mechanisms involved in visceral and body fat deposition.[11 12] Ow, Ob, and CO are precursors of type 2 diabetes, insulin resistance, metabolic syndrome, cardiovascular disease, and are associated with overall mortality.[13] CO is the best predictor of cardiovascular disease and mortality.[14-16] Increasing the number of meals/day and the timing of meals may overshadow the effect of diet therapy on the control of metabolic syndrome in adults.[17] In Colombia, South America, based on the National Nutrition Surveys (ENSIN) it was established that the nutritional transition is in force with weight distribution shifting to the right at a rate of 1.0 kg / m^2 per decade.[18] In 2005 the prevalence of obesity in adults (BMI≥30 kg / m^2) was 13.9%, in 2010 16.4% and in 2015 18.7%.[19]

The obesity epidemic developed under a dietary pattern of three dense and two intermediate meals.[20] In Colombia, there is a growing interest in controlling Ow, Ob and metabolic markers through the number of meals due to the increase in chronic diseases associated with obesity.[12] The number of meals/day, among others, is associated with BMI, body composition, health markers such as lipid profile, postprandial insulin, lipid and glucose concentrations and with the sensation of hunger and satiety.[12]

Because the evidence on the relationship between the number of meals/day and Ow, Ob and CO in developing countries is limited, the aim of this study was to establish the effect of the number of meals on Ow, Ob and CO in apparently healthy Colombian children and adults.

METHODS

Population and sample studied

We conducted a cross-sectional study based on the latest National Survey of the Nutritional Situation in Colombia conducted in 2015 (ENSIN-2015).[19] Colombia is a developing country, located in the northwestern corner of South America, where two transitions are taking place concurrently, one nutritional and the other alimentary.[18 21] The ENSIN-2015 was conducted by the Colombian Institute of Family Welfare (ICBF) and the Ministry of Health. It surveyed 44,202 households in 4,739 clusters in 295 strata; these households represent 99% of the country's population. The methods, the populations studied, the scope and limitations of the ENSIN-2015 were already published.[19] Children between 5 and 17 years old and adults between 18 and 64 years old, excluding women and pregnant girls, were the target population of this analysis. Individuals answered among others, a Food Frequency Questionnaire (FFQ), a reminder of dietary consumption in the last twenty-four hours repeated in a subsample (24-hour-recall-24HR) and a sociodemographic survey. The ENSIN-2015 included 151,343 individuals, of whom 28,902 answered the FFQ. After excluding pregnant women (n=1,939), and individuals outside the age range or with incomplete information (n=12,132), the sample finally analyzed was 14,831; 6,985 children between 5 and 17 years old and 7,846 adults between 18 and 64 years old.

Patient and public involvement

No patient involved. This study was based on secondary, anonymized and publicly available data.

Data sources

All variables including FFQ and 24HR were obtained by direct interview by Dietitian Nutritionists and trained personnel.

Output variables. There were three binomial type (yes/no), Ow, Ob and CO or abdominal. Anthropometric measurements were obtained in all individuals with the use of calibrated standards, techniques and instruments. In the ENSIN-2015, height was measured with stadiometers (ShorrBoard) with sensitivity of 1 mm, weight was measured with SECA 874 scales with precision of 100 g and waist circumference, with tape measures with precision of 1 mm.[19]. Z scores for BMI in children between 5 and 17 years of age were stablished in accordance with the World Health Organization (WHO) growth standards.[22]In adults, BMI was established as (kg / m^2). Overweight was stated between Z>1 and Z≤2 in minors, and in adults between BMI≥25 and BMI<30. Obesity was stated in children as Z>2 and in adults as BMI≥30. Central obesity in children was established by sex and age using the cut-

off points equivalent to those for adults established by the International Diabetes Federation, ≥90 cm and ≥80 cm, in males and females, respectively.[23]

Main explanatory variable. It was the number of meals/day. Based on the FFQ, the number of meals/day was estimated by asking whether or not eight specific meals from a pre-established list (*before breakfast, breakfast, half-meals, lunch, mid-afternoon, dinner, after dinner and other*) were usually eaten. In children under 12 years of age, the caregiver or caretaker completed the FFQ together with the child. The FFQ response rate was 90.9%.

Covariates. Ten biological and sociodemographic variables including sex, age, and household size were those of interest. The ENSIN-2015 applied a repeated 24HR on a subsample, following the methodology developed in 1999 by the United States Department of Agriculture (USDA).[19 24 25] The 24HR had a response rate of 92%. Based on the 24HR, the usual energy consumed per day (kilocalories/day) was estimated. The distribution of kilocalorie/day intake was normalized and corrected for intra-person variability using the methods proposed by the University of Iowa and PC-Side software, v1.0. [26] In adolescents aged 6 to 17 years, compliance with physical activity recommendations was declared when they performed 60 or more minutes per day of moderate or vigorous physical activity, according to the Youth Risk Behavior Surveillance System[27] and in adults, compliance was declared when they performed at least 150 minutes per week of moderate-intensity aerobic physical activity, or 75 minutes per week of vigorous aerobic physical activity, according to the International Physical Activity Questionnaire (IPAQ) developed by the WHO.[28] The level of urbanization was established based on the concentration of the population in three categories; urban centers -more than one million inhabitants and large cities, small towns -between one hundred thousand inhabitants and less than one million inhabitants and with dispersed population -less than one hundred thousand inhabitants.[19] The food security status of the household was established through the Latin American and Caribbean Food Security Scale (ELCSA).[29] The level of wealth was established by analyzing a set of physical characteristics of the household, household assets and availability of services, according to the index wealth methodology designed for the International Demographic and Health Survey.[19 30] The level of schooling of the head of household was established based on the number of years of approved years of study. The geographic region is a variable that represents the territory and the structural, economic and cultural development conditions of the subjects. Colombia has five geographic regions,[19] Bogotá(the capital of the country) and the central region have the highest human development index. The Pacific and Amazon-Orinoquia regions are the poorest.[31]

Statistical analysis

The prevalence of Ow, Ob and CO and their 95% confidence intervals (CI) were estimated based on the binomial distribution. The dose-response effect was estimated with two tests for trends across ordered groups, an extension of the Wilcoxon rank-sum test and additionally with the Cochran-Armitage test.[32 33] The description of the proportion of Ow, Ob and CO across the covariate categories studied was performed by binomial regression. In addition, through binomial regression, crude and adjusted Prevalence Ratios (PR) with their CI were established for the main explanatory variable and some covariates associated in the bivariate analysis to Ow, Ob and CO. Adjustment of the PR included the following covariates, usual kilocalorie intake (*continuous*), age (*continuous*), sex, meeting physical activity goals (*binomial*), family size, education of the household head, level of household food security, and level of urbanicity. All analyses were performed incorporating the effect of sample design. The analysis was performed with Stata software, v14.1.[34]

Ethics approval and consent to participate. All analyses were carried out under the principles of the Helsinki Declaration.[35] The used databases are in the public domain. This research is classified as 'without risk' according to Resolution 8430 of 1993 of the Colombian Ministry of Health.[36] All participants gave informed consent to ICBF before being surveyed. Since this is a secondary analysis of population studies, with anonymized data, no authorization is required from the Health Research Ethics Committee of the XXXXXXX.

RESULTS

The age of the children (mean ± standard deviation) was 11.7 years ± 3.8, that of the adults 39.0 years ± 13.0. The 54.5% were boys and 40.7% were men. 26.5% of the general population had three or less meals/day, 27.5% four and 46.0% had five or more meals/day. In the general population the number of meals/day is associated with sex, females make 0.12 meals/day less than males, P=0.003, with the level of education of the household head in a direct relationship, $P<0.0001$ and with the level of food security in an inverse relationship, $P<0.0001$. For all other covariates there was no association with number of meals/day, $P>0.05$. In children the number of meals was not associated with Ow, Ob, or CO. In adults the dose-effect is evident, Ow, Ob, and CO decrease as the number of meals increases, in all three cases for trend, $P<0.0001$, The prevalence of CO versus that estimated with BMI is lower in children and higher in adults (table 1).

In children, two variables were inversely associated with both Ow and Ob, number of family members and food insecurity (table S1). The risk of overweight is lower in children with seven or more family members, adjusted PR 0.60 (CI: 0.39, 0.90) (table 2). In addition to the number of meals/day, family size, education of the head of household, region of the

Table 1 Number of meals per day and prevalence (95% CI) of overweight, obesity and central obesity in Colombian population, 5 to 64 years old (*Non-pregnant women*). Colombia, ENSIN, 2015.

[n_1: n_2: n_3: n_4: n_5: n_6] *	Children 5 to17 *y* % (95% CI)			Adults 18 to 64 *y* % (95% CI)		
Number of meals per day (Based on FFQ)	**Overweight** †	**Obesity** ‡	**Central obesity** §	**Overweight** †	**Obesity** ‡	**Central obesity** §
Total	18.5 (16.1, 21.1)	6.7 (5.2, 8.5)	4.0 (2.9, 5.5)	32.3 (30.0, 34.6)	13.1 (11.5, 15.0)	44.8 (42.3, 47.3)
Three or fewer	15.0 (11.7, 19.0)	5.2 (3.3, 8.1)	3.7 (2.5, 5.4)	37.8 (33.2, 42.6)	18.3 (15.1, 22.2)	48.9 (44.3, 53.5)
[1054: 1117: 1559: 1838: 1879: 1534]	[193]	[63]	[80]	[444]	[214]	[636]
Four	20.8 (16.0, 26.7)	7.3 (4.9, 10.8)	4.0 (2.8, 5.8)	36.8 (32.1, 41.8)	12.3 (9.7, 15.6)	49.1 (44.3, 53.9)
[1440: 1533: 1862: 2069: 1941: 1599]	[244]	[93]	[76]	[487]	[163]	[619]
Five or more	18.5 (16.1, 21.2)	6.8 (5.1, 9.0)	4.2 (2.7, 6.4)	26.7 (23.8, 29.8)	10.6 (8.4, 13.4)	38.6 (34.6, 42.7)
[4091: 4335: 3732: 3939: 3009: 2267]	[703]	[244]	[139]	[566]	[205]	[654]
P-value for trend	0.496	0.823	0.465	<0.0001	<0.0001	<0.0001
Cochran-Armitage trend test, *P-value*	0.568	0.832	0.484	<0.0001	<0.0001	<0.0001

* [$\mathbf{n_1}$: $\mathbf{n_2}$: for children 5 to 17 years old for overweight and obesity respectively, $\mathbf{n_3}$: $\mathbf{n_4}$: for adults 18 to 64 years old for overweight and obesity respectively, $\mathbf{n_5}$: $\mathbf{n_6}$: for central obesity for children and adult respectively]. † In children based on Z-score for BMI for age (WHO)[22], overweight between Z>1 and Z<=2. In Adults based on BMI (kg / m^2), between BMI>=25 and BMI<30. ‡ In children based on Z-score for BMI for age (WHO)[22], obesity Z>2. In Adults based on BMI (kg / m^2), BMI>=30. § Base on International Diabetes Federation[23]

Table 2 Prevalence ratios (PR) for number of meals per day, potential confounders and overweight and obesity in Colombian children, 5 to 17 years (*Non-pregnant women*). Colombia, ENSIN, 2015.

Explanatory variable	PR for meal frequency (95% CI)			
	Overweight *		Obesity *	
	Crude	Adjusted †	Crude	Adjusted †
Number of meals per day				
Three or fewer	1.0	1.0	1.0	1.0
Four	1.49 (1.00, 2.23)	1.29 (0.86, 1.91)	1.44 (0.84, 2.47)	1.14 (0.62, 2.07)
Five or more	1.28 (0.94, 1.76)	1.10 (0.79, 1.53)	1.34 (0.83, 2.14)	0.95 (0.57, 1.59)
Sex				
Males	1.0	1.0	1.0	1.0
Females	1.37 (1.01, 1.84)	1.43 (1.07, 1.92)	0.93 (0.57, 1.53)	0.97 (0.60, 1.58)
Household members				
1 to 4	1.0	1.0	1.0	1.0
5 to 6	0.88 (0.66, 1.17)	0.90 (0.67, 1.20)	0.30 (0.20, 0.45)	0.32 (0.21, 0.49)
7+	0.61 (0.41, 0.91)	0.60 (0.39, 0.90)	0.56 (0.33, 0.96)	0.75 (0.43, 1.29)
Education of head				
<5 (Primary or less)	1.0	1.0	1.0	1.0
5 to <11	1.15 (0.86, 1.55)	1.02 (0.75, 1.39)	1.64 (0.90, 3.03)	1.28 (0.70, 2.35)
11 to <16	1.21 (0.91, 1.63)	1.03 (0.77, 1.37)	2.01 (1.14, 3.57)	1.37 (0.83, 2.24)
≥16 (University)	1.10 (0.67, 1.86)	0.82 (0.47, 1.45)	2.63 (1.02, 6.80)	1.81 (0.76, 4.29)
Food insecurity in the home ‡				
No	1.0	1.0	1.0	1.0
Mild	0.72 (0.54, 0.97)	0.79 (0.59, 1.07)	0.74 (0.45, 1.24)	0.83 (0.49, 1.43)
Moderate	0.61 (0.42, 0.89)	0.70 (0.47, 1.04)	0.38 (0.24, 0.62)	0.46 (0.28, 0.76)
Severe	0.65 (0.42, 1.02)	0.78 (0.47, 1.30)	0.51 (0.26, 1.02)	0.71 (0.34, 1.49)
Urbanicity				
Big cities|	1.0	1.0	1.0	1.0
100.001 to 1.000.000 population	0.70 (0.47, 1.04)	0.71 (0.49, 1.02)	0.75 (0.42, 1.32)	0.92 (0.56, 1.51)
0 to 100.000 population	0.67 (0.46, 0.98)	0.66 (0.47, 0.93)	0.57 (0.33, 0.99)	0.65 (0.39, 1.09)
Disperse population	0.74 (0.50, 1.10)	0.80 (0.56, 1.14)	0.60 (0.30, 1.21)	0.72 (0.37, 1.41)

* Based on Z-score for BMI for age (WHO),[22] overweight between Z>1 and Z<=2, obesity Z>2. † Multiple binomial regression. In the adjustment of the prevalence ratios (PR), in addition to the covariates in the table, the usual intake of kilocalories/day (continuous), age (continuous) and physical activity compliance (binomial) were included. ‡ Estimated with ELCSA scale (FAO).[29]

country and compliance with physical activity recommendations were associated with Ow and/or Ob in adults (table 3). In adults, the risk of overweight and obesity is lower the higher the number of meals, those who eat three or less meals/day have 72.4% higher risk of overweight and 96.1% higher risk of obesity than those who eat five or more meals/day (table 4). In children sex and age were associated with CO, in adults in addition to the above, usual kilocalorie intake/day was associated (table S2). Adults with three or fewer meals/day had 42.9% higher risk of CO than those with five or more meals/day (table 5).

Table 3 Prevalence (95% CI) of overweight and obesity for the categories of explanatory covariates in adults 18 to 64 years old (*Non-pregnant women*). Colombia, ENSIN, 2015.

Variable		Overweight *			Obesity *	
	n	% (CI 95%)	*P-value* ‡	n	% (CI 95%)	*P-value* ‡
Usual intake (kcal/d) †: mean ± sd	7153	1953 ± 31	0.185	7846	2085 ± 78	0.167
Number of meals per day			<0.0001			0.001
Three or fewer	1559	37.8 (33.2, 42.6)		1838	18.3 (14.9, 22.2)	
Four	1862	36.8 (32.1, 41.8)		2069	12.3 (9.5, 15.6)	
Five or more	3132	26.7 (23.8, 20.9)		3939	10.6 (8.3, 13.4)	
Sex			0.435			0.527
Males	3357	31.2 (28.0, 34.6)		3673	13.7 (11.2, 16.7)	
Females	3796	33.1 (29.9, 36.6)		4173	12.6 (10.5, 15.1)	
Age group (y)			0.436			0.711
Young adult (18 to <26)	1533	30.6 (26.0, 35.6)		1669	13.8 (10.1, 18.5)	
Older adult (27 to <64)	5620	32.8 (30.2, 35.5)		6177	12.9 (11.1, 15.0)	
Compliance Physical activity			0.470			0.019
Yes	5019	32.2 (29.3, 35.3)		5543	14.6 (12.4, 17.1)	
No	1770	34.1 (30.1, 38.3)		1928	10.3 (8.0, 13.1)	
Household members			0.034			0.153
Four or fewer	3879	34.8 (31.6, 38.1)		4336	14.3 (12.0, 16.9)	
5 to 6	2174	27.2 (24.3, 30.3)		2338	10.8 (8.6, 13.5)	
7 or more	1100	31.0 (25.6, 37.0)		1172	12.0 (8.0, 17.6)	
Education of head			0.001			0.839
<5 (Primary or less)	2112	27.7 (24.6, 31.0)		2336	13.3 (10.7, 16.3)	
5 to <11	2426	29.9 (26.7, 33.3)		2650	13.2 (10.1, 17.0)	
11 to <16	2204	36.4 (32.2, 40.9)		2393	12.3 (9.6, 15.6)	
≥16 (University)	366	39.4 (29.9, 49.7)		418	15.9 (10.0, 24.1)	
Wealth index, quintiles §			0.737			0.547
Q1	3246	29.8 (27.1, 32.7)		3554	12.5 (10.5, 14.8)	
Q2	1695	35.1 (30.9, 39.4)		1854	14.4 (10.9, 18.7)	
Q3	1399	35.6 (30.3, 41.2)		1525	11.1 (8.1, 15.2)	
Q4	813	27.9 (21.9, 34.8)		913	15.9 (11.3, 21.9)	
Food insecurity in the home |			0.462			0.532
No	2395	33.9 (30.1, 37.9)		2660	14.9 (11.9, 18.5)	
Mild	2536	30.9 (27.8, 34.2)		2781	10.9 (9.0, 13.1)	
Moderate	1366	33.0 (27.9, 38.6)		1481	13.2 (9.6, 17.9)	
Severe	855	30.0 (21.7, 39.9)		923	13.5 (8.8, 20.3)	
Urbanicity			0.160			0.361
Big cities	735	36.2 (30.4, 42.5)		803	13.9 (9.7, 19.3)	
100.001 to 1.000.000 population	1836	31.0 (27.0, 35.2)		2043	14.3 (11.5, 17.8)	
0 to 100.000 population	2701	31.2 (28.3, 34.3)		2960	11.4 (9.2, 14.0)	
Disperse population	1881	30.1 (27.4, 34.6)		2040	12.3 (9.8, 15.3)	
Country region			0.008			0.121
Central	1675	29.9 (26.5, 33.6)		1856	13.8 (10.9, 17.3)	
Atlantic (North)	1448	28.1 (25.1, 31.3)		1602	14.6 (11.7, 18.2)	
Oriental	1424	31.8 (28.2, 35.5)		1564	13.6 (10.4, 17.5)	
Pacific (West)	891	36.9 (29.3, 45.3)		974	14.6 (9.6, 21.7)	
Bogotá	472	37.0 (29.7, 44.1)		495	8.1 (4.4, 14.5)	
Amazonia-Orinoquia	1243	37.8 (33.6, 42.1)		1355	13.3 (9.6, 18.2)	

n The analyzed sample may be less than 7153 or 7846 due to missing values. * Based on BMI (kg / m^2), overweight between BMI>=25 and BMI<30, obesity BMI>=30. † Based on 24-hour recall. 1 kcal/d = 4.18 kJ/d. Based on usual intake, incorporating intra-subject variability.[26] ‡ Test for linear trend for ordinal predictors. § The wealth index is a composite measure of a household's cumulative living standard. The wealth index is calculated using easy-to-collect data on a household's ownership of selected assets such as televisions and bicycles, materials used for housing construction, type of water supply and sanitation facilities. | Estimated with ELCSA scale (FAO).[29]

Table 4 Prevalence ratios (PR) for number of meals per day, potential confounders and overweight and obesity in Adults, 18 to 64 years (*Non-pregnant women*). Colombia, ENSIN, 2015.

Explanatory variable	PR for meal frequency (95% CI)			
	Overweight *		Obesity *	
	Crude	Adjusted †	Crude	Adjusted †
Number of meals per day				
Three or fewer	1.0	1.0	1.0	1.0
Four	0.96 (0.72, 1.23)	0.97 (0.72, 1.30)	0.62 (0.43, 0.90)	0.61 (0.42, 0.88)
Five or more	0.60 (0.47, 0.77)	0.58 (0.45, 0.76)	0.53 (0.38, 0.75)	0.51 (0.36, 0.72)
Sex				
Males	1.0	1.0	1.0	1.0
Females	1.09 (0.87, 1.37)	1.04 (0.82, 1.32)	0.91 (0.67, 1.23)	0.98 (0.73, 1.32)
Household members				
1 to 4	1.0	1.0	1.0	1.0
5 to 6	0.70 (0.57, 0.86)	0.76 (0.61, 0.94)	0.72 (0.52, 1.00)	0.75 (0.54, 1.02)
7+	0.84 (0.62, 1.14)	1.02 (0.74, 1.39)	0.81 (0.50, 1.33)	0.90 (0.52, 1.54)
Education of head				
<5 (Primary or less)	1.0	1.0	1.0	1.0
5 to <11	1.11 (0.88, 1.41)	1.08 (0.85, 1.40)	0.99 (0.68, 1.46)	0.96 (0.66, 1.41)
11 to <16	1.49 (1.16, 1.92)	1.51 (1.14, 2.01)	0.91 (0.63, 1.33)	0.84 (0.57, 1.24)
≥16 (University)	1.70 (1.01, 2.65)	1.68 (1.02, 2.76)	1.23 (0.69, 2.19)	1.06 (0.58, 1.95)
Food insecurity in the home ‡				
No	1.0	1.0	1.0	1.0
Mild	0.87 (0.70, 1.08)	0.92 (0.73, 1.17)	0.70 (0.50, 0.97)	0.67 (0.47, 0.96)
Moderate	0.96 (0.70, 1.31)	0.98 (0.72, 1.34)	0.87 (0.56, 1.36)	0.81 (0.49, 1.34)
Severe	0.84 (0.52, 1.34)	0.89 (0.54, 1.48)	0.89 (0.51, 1.56)	0.82 (0.44, 1.55)
Urbanicity				
Big cities|	1.0	1.0	1.0	1.0
100.001 to 1.000.000 population	0.79 (0.57, 1.09)	0.84 (0.60, 1.16)	1.04 (0.65, 1.67)	1.08 (0.66, 1.76)
0 to 100.000 population	0.80 (0.59, 1.07)	0.90 (0.67, 1.22)	0.80 (0.50, 1.27)	0.81 (0.49, 1.35)
Disperse population	0.79 (0.58, 1.07)	0.90 (0.65, 1.23)	0.87 (0.54, 1.40)	0.86 (0.51, 1.45)

* Based on BMI (kg / m^2), overweight between BMI>=25 and BMI<30, obesity BMI>=30. † Multiple binomial regression. In the adjustment of the prevalence ratios (PR), in addition to the covariates in the table, the usual intake of kilocalories/day (continuous), age (continuous) and physical activity compliance (binomial) were included. ‡ Estimated with ELCSA scale (FAO).[29]

Table 5 Prevalence ratios (PR) for number of meals per day, potential confounders and central obesity (*Abdominal obesity**) in Colombian population aged 5 to 64 years (*Non-pregnant women*). Colombia, ENSIN, 2015.

Explanatory variable	PR for meal frequency (95% CI)			
	Children 5 to17 *y*		Adults 18 to 64 *y*	
	Crude	Adjusted †	Crude	Adjusted †
Number of meals per day				
Three or fewer	1.0	1.0	1.0	1.0
Four	1.10 (0.71, 1.70)	1.03 (0.65, 1.61)	1.00 (0.78, 1.31)	1.08 (0.82, 1.43)
Five or more	1.15 (0.80, 1.67)	1.06 (0.72, 1.55)	0.66 (0.51, 0.84)	0.70 (0.54, 0.92)
Sex				
Males	1.0	1.0	1.0	1.0
Females	0.30 (0.20, 0.45)	0.29 (0.19, 0.43)	3.23 (2.62, 4.00)	3.34 (2.69, 4.14)
Household members				
1 to 4	1.0	1.0	1.0	1.0
5 to 6	1.06 (0.60, 1.88)	1.08 (0.58, 2.01)	0.80 (0.65, 1.00)	0,76 (0.61, 0.95)
7+	0.91 (0.49, 1.71)	0.91 (0.47, 1.73)	1.11 (0.83, 1.50)	1.06 (0.78, 1.44)

Education of head				
<5 (Primary or less)	1.0	1.0	1.0	1.0
5 to <11	0.59 (0.33, 1.06)	0.52 (0.26, 1.02)	0.94 (0.74, 1.19)	0.91 (0.71, 1.17)
11 to <16	0.92 (0.61, 1.39)	0.84 (0.53, 1.34)	1.06 (0.82, 1.36)	1.05 (0.80, 1.39)
≥16 (University)	0.77 (0.22, 2.68)	0.71 (0.19, 2.66)	0.95 (0.62, 1.47)	0.86 (0.51, 1.45)
Food insecurity in the home ‡				
No	1.0	1.0	1.0	1.0
Mild	0.95 (0.66, 1.37)	0.94 (0.66, 1.36)	0.80 (0.64, 1.01)	0.77 (0.60, 0.98)
Moderate	1.07 (0.68, 1.69)	1.14 (0.71, 1.83)	1.06 (0.80, 1.42)	0.99 (0.74, 1.33)
Severe	0.92 (0.53, 1.60)	1.03 (0.58, 1.84)	1.02 (0.67, 1.56)	0.95 (0.59, 1.52)

* Base on International Diabetes Federation.[23] † Multiple binomial regression. In the adjustment of the prevalence ratios (PR), in addition to the covariates in the table, the usual intake of kilocalories/day (continuous), age (continuous) and physical activity compliance (binomial) were included. ‡ Estimated with ELCSA scale (FAO).[29]

DISCUSSION

Based on cross-sectional data, we established that the number of meals/day was not associated with overweight, obesity, or central obesity in children. However, in adults, this relationship exists in an inverse manner regardless of energy intake/day, meeting physical activity goals, sex, age, and other potentially confounding sociodemographic and environmental variables.

Previous studies in children have shown conflicting results. In New Zealand, no association was found between BMI and the number of meals/day in children under two years of age[37] In Prague (Czechoslovakia) no differences were found in weight gain in children between 6 and 16 years of age exposed to an extreme number of meals/day (three versus seven).[38] In Lousiana (USA), no effect was found between each meal episode/day and obesity in 10-year-old children; OR 0.91 (CI: 0.72, 1.15).[39] In the same study, no relationship was found between the number of meals/day and overweight after two decades of follow-up.[40] In children in Bavaria (Germany) between 5 and 6 years of age, an inverse association was found, eating three meals/day or more constitutes protection against childhood obesity; adjusted odds ratio (OR) for four meals/day OR 0.73 (CI: 0.44, 1.21) and for five or more meals/day, OR 0.51 (CI: 0.29, 0.89).[5] A 10-year follow-up study in a cohort of 4-year-old children in Peru, a middle-income country like Colombia, found that those who ate fewer meals/day gained more BMI than those who ate five or more; for <4 meals/day, β=0.39 (CI: 0.17, 0.62).[41] In Puerto Rico, it was found that 12-year-old children who consumed a greater number of meals/day had lower weight and higher dietary quality.[42] A cohort study with a 10-year follow-up conducted in Bethesda (USA) showed that the BMI of girls aged 9 to 10 years at baseline was lower when they ate three or more meals/day, compared to those who ate <3 meals/day.[43] A meta-analysis reviewing fifty-seven studies conducted in high-income countries (one in Latin America and eight longitudinal) showed that a higher frequency of

children's meals with the family was associated with better nutritional conditions, including lower body weight.[7 41].

In adults, as in children, the relationship between the number of meals/day and Ow, Ob, and CO is contradictory.[8] However, it is suggested that direct association such as the one reported here prevails.[8] In American adults ≥20 years of age and with data based on the National Health and Nutrition Examination Survey (NHANES), an adjusted risk for obesity in men of OR 1.54 (CI: 1.23, 1.93) and for women of OR 1.45 (CI: 1.17, 1.81) was found for five or more meals/day versus ≤3. For central obesity in men OR 1.42 (CI: 1.15, 1.75) and OR 1.29 (CI: 1.05, 1.59) for women.[8] In Dodoma (Tanzania) formal sector workers who had more home-cooked meals/day in the workplace were at higher risk of CO, adjusted OR 2.32 (CI: 1.04, 4.19).[44] In British adults aged 19-64 years, a direct association was found between number of meals/day, BMI-based obesity and CO.[9] Adults from Puerto Rico aged 30 to 75 years, regardless of whether or not they skipped breakfast, had a higher risk of CO when they consumed between 1.5 and 3 meals/day, OR 2.75 (CI: 1.23, 6.15), or when they ate ≥3 meals/day, OR 2.88 (CI: 1.14, 7.31), than when they consumed ≤1.5 meals/day.[45]

Possible causes for finding contradictory results between the number of meals/day and Ow, Ob and CO, and also making it difficult to compare our results, both in children and adults, are: the lack of a unified criterion to establish the cut-off points for the number of meals in the different studies, although a cut-off of 3 meals/day is generally accepted, the different methods to establish the number of meals/day and the jargon used to refer to them.[10 46] Others are, the lack of control variables that leave residual confusion when trying to adjust in the mathematical models that explain this relationship, the lack of statistical power due to limited samples, and the differences in age ranges in the studies together with the different prevalence of Ow, Ob and CO between children and adults. The last presupposes that it is not the same to investigate the relationship between subjects with a wide age range or with specific ages. The underreporting of energy/day consumed among overweight or obese subjects and the lack of correction of dietary intake for intrasubject variability is well known, which surely extends to the reporting of the number of meals/day.[47-49]

Strengths and limitations of this study

This study has several strengths. The analyzed data came from a national survey (ENSIN-2015), that used rigorous and universally accepted methods. The sample sizes are large and confer sufficient power to the analysis. The direction and strength of the association between the number of meals/day and Ow, Ob and CO, is similar to that reported in previous studies, which confers external validity to the findings. For risk adjustment (RP), ten potential confounding variables were used, including usual

energy intake/day corrected for intrasubject variability and compliance with physical activity goals, variables not available simultaneously in many of the studies cited.

It also has some weaknesses. The data are cross-sectional coming from an observational study and, therefore, it is not possible to establish causal relationships. Despite having studied ten covariates as potential confounders, there may still be residual or unmeasured confounding, particularly in the case of children. The number of meals/day was established based on an FFQ, although it is unlikely that the estimate was differential with respect to the outcome.

In conclusion, further investigation of the effect of the number of meals/day and its effect on Ow, Ob, and CO in children and adults is warranted in the context of middle-income, high-poverty, food-insecure countries.[19] Increasing the number of meals/day is a potential strategy for the control of overweight, obesity, and central obesity.

DATA AVAILABILITY STATEMENT To access the ENSIN 2015 public database, you must register in the repository of the Ministry of Public Health: repositorio@minsalud.gov.co and make the request through the format available at: https://www.minsalud.gov.co/sites/rid/paginas/freesearchresultsf.aspx?k=Base%20de%20datos%20Encuesta%20Nacional%20de%20la%20Situaci%C3%B3n%20Nutricional%20ENSIN%202015.

COMPETING INTERESTS STATEMENT

None

ETHICAL APPROVAL The study was conducted according to the guidelines laid down in the Declaration of Helsinki. Consent for participation in the survey was obtained by the Colombian Institute of Family Welfare prior to enrolment. Ethics committee in health research of the Universidad Industrial de Santander determined that analyses of these anonymized data were exempt from review.

TRANSPARENCY DECLARATION The lead author affirms that this manuscript is an honest, accurate and transparent account of the study being reported. The reporting of this work is compliant with STROBE guidelines. The lead author affirms that no important aspects of the study have been omitted and that any discrepancies from the study as planned have been explained.

CONTRIBUTIONS Authors' contributions were as follows: C.H-F and O.F. H., designed the research. O.F.H led the statistical analysis. C.H-F, participated in the statistical analysis. C.H-F., and

O.F.H wrote the paper. O.F.H. had primary responsibility for the final content. All authors have read and approved the final version of the manuscript.

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Table S1 Prevalence (95% CI) of overweight and obesity for the categories of explanatory covariates in children 5 to 17 years old (*Non-pregnant women*). Colombia, ENSIN, 2015.

Variable	Overweight *			Obesity		
	n	% (CI 95%)	*P-value* ‡	n	% (CI 95%)	*P-value* ‡
Usual intake (kcal/d) †: mean ± ee	6585	2014 ± 76	0.983	6985	2015 ± 106	0.258
Number of meals per day			0.372			0.459
Three or fewer	1054	15.0 (11.7, 19.0)		1117	5.2 (3.3, 8.1)	
Four	1440	20.8 (16.0, 26.7)		1533	7.3 (4.9, 10.8)	
Five or more	4091	18.5 (16.1, 21.2)		4335	6.8 (5.1, 9.0)	
Sex			0.039			0.776
Males	3354	16.3 (14.1, 18.7)		3557	6.9 (5.0, 9.5)	
Females	3231	21.0 (17.2, 25.4)		3428	6.5 (4.6, 9.1)	
Age group (*y*)			0.434			0.062
Schoolchildren (5 to <13)	3187	19.5 (16.5, 20.0)		3395	8.1 (5.6, 11.5)	
Adolescents (13 to <18)	3398	17.6 (14.1, 21.7)		3590	5.5 (4.4, 6.7)	
Compliance Physical activity			0.656			0.157
Yes	4690	18.7 (16.0, 21.8)		4991	7.2 (5.5, 9.5)	
No	1410	17.7 (14.0, 22.1)		1484	5.4 (3.6, 7.9)	
Household members			0.021			0.001
Four or fewer	3182	20.2 (17.2, 23.6)		3433	9.5 (7.1, 12.6)	
5 to 6	2275	18.3 (14.7, 22.5)		2372	3.0 (2.1, 4.4)	
7 or more	1128	13.4 (9.9, 17.9)		1180	5.5 (3.7, 8.2)	
Education of head			0.296			0.014
<5 (Primary or less)	1941	16.8 (14.0, 20.0)		2018	4.1 (3.0, 5.6)	
5 to <11	2229	18.9 (15.2, 23.1)		2371	6.6 (4.1, 10.3)	
11 to <16	2044	19.7 (15.7, 24.4)		2188	7.9 (5.3, 11.6)	
≥16 (University)	329	18.2 (12.3, 26.1)		361	10.1 (4.4, 21.3)	
Wealth index, quintiles §			0.265			0.833
Q1	3414	18.6 (15.6, 21.9)		3627	6.7 (4.4, 10.2)	
Q2	1607	21.5 (16.5, 27.4)		1702	6.4 (4.6, 8.9)	
Q3	1058	14.5 (11.3, 18.3)		1110	6.4 (3.2, 12.2)	
Q4	506	17.6 (12.6, 24.0)		546	8.0 (5.5, 11.4)	
Food insecurity in the home |			0.024			0.006
No	2048	22.4 (18.3, 27.1)		2221	8.8 ({6.5, 12.0)	
Mild	2324	17.3 (14.5, 20.4)		2463	6.7 (4.3, 10.4)	
Moderate	1262	15.0 (11.8, 19.0)		1319	3.6 (2.5, 5.2)	
Severe	949	15.9 (11.3, 21.8)		980	4.7 (2.8, 8.0)	
Urbanicity			0.116			0.104
Big cities	1020	22.1 (16.9, 28.3)		1093	8.5 (5.6, 12.9)	
100.001 to 1.000.000 population	1414	16.5 (13.7, 19.8)		1503	6.5 (4.7, 8.9)	
0 to 100.000 population	2587	15.9 (13.7, 18.4)		2749	5.1 (3.8, 6.7)	
Disperse population	1564	17.3 (14.6, 20.5)		1640	5.3 (3.2, 8.7)	
Country region			0.122			0.835
Central	1657	17.7 (15.5, 20.1)		1764	8.1 (5.3, 12.0)	
Atlantic (North)	956	15.7 (12.2, 19.9)		999	4.6 (3.1, 6.8)	
Oriental	1064	15.9 (12.7, 19.8)		1121	4,8 (3.0, 7.7)	
Pacific (West)	926	21.3 (14.9, 29.4)		980	6.5 (4.3, 9.8)	
Bogotá	493	22.8 (15.0, 33.0)		523	9.2 (4.4, 18.0)	
Amazonia-Orinoquia	1489	18.1 (14.8, 21.8)		1598	6.4 (4.4, 9.3)	

n The analyzed sample may be less than 6585 or 6985 due to missing values. * Based on Z-score for BMI for age (WHO) [22], overweight between Z>1 and Z<=2, obesity Z>2. † Based on 24-hour recall. 1 kcal/d = 4.18 kJ/d. Based on usual intake, incorporating intra-subject variability.[26] ‡ Test for linear trend for ordinal predictors. § The wealth index is a composite measure of a household's cumulative living standard. The wealth index is calculated using easy-to-collect data on a household's ownership of selected assets such as televisions and bicycles, materials used for housing construction, type of water supply and sanitation facilities. | Estimated with ELCSA scale (FAO).[29]

Table S2 Prevalence (95% CI) of central obesity (*Abdominal obesity**) in Colombian population aged 5 to 64 years (Non-pregnant women). Colombia, ENSIN, 2015.

Variable	n	Children 5 to17 *y*		n	Adults 18 to 64 *y*	
		% (CI 95%)	*P-value* ‡		% (CI 95%)	*P-value* ‡
Usual intake (kcal/d) †: mean ± ee	6829	2035 ± 168	0.637	5400	1940 ± 36	0.023
Number of meals per day			0.458			0.001
Three or fewer	1879	3.7 (2.5, 5.4)		1534	48.9 (44.3, 53.5)	
Four	1941	4.0 (2.8, 5.8)		1599	49.1 (44.3, 53.9)	
Five or more	3009	4.2 (2.8, 6.4)		2267	38.6 (34.6, 42.7)	
Sex			<0.0001			<0.0001
Males	3574	5.8 (4.4, 7.5)		2502	29.4 (26.2, 32.8)	
Females	3255	1.8 (1.4, 2.4)		2898	57.4 (53.9, 60.7)	
Age group (y)			0.001			
Schoolchildren (5 to <13)	3047	5.6 (4.1, 7.7)				
Adolescents (13 to <18)	3782	2.7 (2.0, 3.6)				
Age group (y)						0.481
Young adult (18 to <27)				1144	43.0 (37.1, 49.0)	
Older adult (27 to <64)				4256	45.3 (42.6, 48.0)	
Compliance Physical activity			0.234			0.553
Yes	4935	3.6 (2.5, 5.4)		3858	45.0 (41.9, 48.0)	
No	1549	4.6 (3.1, 6.6)		1267	46.6 (42.0, 51.2)	
Household members			0.919			0.765
Four or fewer	3890	4.0 (2.6, 5.9)		3133	45.8 (42.5, 49.2)	
5 to 6	1964	4.2 (2.9, 5.9)		1513	40.4 (36.4, 44.5)	
7 or more	975	3.6 (1.5, 8.3)		754	48.5 (41.8, 55.3)	
Education of head			0.906			0.825
<5 (Primary or less)	1997	4.8 (2.7, 8.6)		1667	45.0 (40.9, 49.2)	
5 to <11	2366	2.9 (2.2, 3.9)		1811	43.4 (39.4, 47.6)	
11 to <16	2070	4.5 (2.8, 7.1)		1588	46.4 (41.6, 51.3)	
≥16 (University)	364	3.8 (1.6, 8.7)		303	43.8 (34.4, 53.6)	
Wealth index, quintiles §			0.205			0.726
Q1	3426	4.7 (2.8, 7.9)		2395	44.7 (41.0, 48.3)	
Q2	1666	3.9 (2.7, 5.8)		1271	46.1 (41.0, 51.4)	
Q3	1169	3.1 (1.6, 5.7)		1085	44.9 (39.2, 50.7)	
Q4	568	3.0 (1.7, 5.4)		649	43.0 (35.9, 50.3)	
Food insecurity in the home |			0.932			0.861
No	2380	4.0 (2.8, 5.8)		1837	46.3 (42.2, 50.6)	
Mild	2410	3.8 (2.5, 5.8)		1916	40.8 (37.2, 44.6)	
Moderate	1213	4.3 (2.7, 6.9)		1029	47.9 (42.0, 53.9)	
Severe	824	3.7 (2.1, 6.7)		618	46.8 (37.3, 56.6)	
Urbanicity			0.072			0.585
Big cities	1177	5.1 (3.2, 8.0)		534	42.5 (36.4, 48.9)	
100.001 to 1.000.000 population	1625	3.2 (2.0, 4.9)		1456	46.5 (41.9, 51.1)	
0 to 100.000 population	2445	3.2 (2.6, 4.3)		1983	44.4 (40.1, 48.7)	
Disperse population	1582	2.9 (1.9, 4.2)		1427	45.4 (41.7, 49.2)	
Country region			0.936			0.364
Central	1770	5.2 (3.0, 8.9)		1334	43.6 (39.0, 48.3)	
Atlantic (North)	1176	2.3 (1.5, 3.3)		1156	46.9 (42.0, 51.8)	
Oriental	1151	3.0 (1.9, 4.5)		1124	48.3 (43.6, 53.0)	
Pacific (West)	887	3.5 (2.1, 5.8)		657	45.1 (37.6, 52.8)	
Bogotá	522	4.9 (3.0, 8.0)		322	37.8 (30.4, 45.7)	
Amazonia-Orinoquia	1323	4.6 (1.8, 11.5)		807	52.7 (47.6, 57.6)	

n The analyzed sample may be less than 6829 or 5400 due to missing values. * Base on International Diabetes Federation (IDF)[23] † Based on 24-hour recall. 1 kcal/d = 4.18 kJ/d. Based on usual intake, incorporating intra-subject variability.[26] ‡ Test for linear trend for ordinal predictors. § The wealth index is a composite measure of a household's cumulative living standard. The wealth index is calculated using easy-to-collect data on a household's ownership of selected assets such as televisions and bicycles, materials used for housing construction, type of water supply and sanitation facilities. | Estimated with ELCSA scale (FAO).[29]

Meal occasion, overweight, obesity and central obesity in children and adults: A cross-sectional study based on a nationally representative survey. Colombia, 2015.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*5-7*
Bias	9	Describe any efforts to address potential sources of bias	4, 13
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6-7
		(*b*) Describe any methods used to examine subgroups and interactions	6-7
		(*c*) Explain how missing data were addressed	5
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	5-7
		(*e*) Describe any sensitivity analyses	-
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	4, 7, 9
		(b) Give reasons for non-participation at each stage	-
		(c) Consider use of a flow diagram	-
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	4, 7. 9
		(b) Indicate number of participants with missing data for each variable of interest	7-12
Outcome data	15*	Report numbers of outcome events or summary measures	7.12

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	7-12
		(*b*) Report category boundaries when continuous variables were categorized	5-7
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	-
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	-
Discussion			
Key results	18	Summarise key results with reference to study objectives	12-14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	12.14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Meal occasion, overweight, obesity and central obesity in children and adults: A cross-sectional study based on a nationally representative survey. Colombia, 2015.

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Running title: Meal frequency and obesity in Colombia.

Keywords: Meals, Overweight, Obesity, Abdominal Obesity, Diet Surveys

Wort count: 4036

ABSTRACT

Objective To establish the association of the number of meals/day with Overweight (Ow), obesity (Ob), and central obesity (CO).

Design Cross-sectional, nationally representative surveys.

Setting Colombia.

Participants 6,985 children aged 5 to 17 years and 7,846 adults aged 18 to 64 years.

Main outcomes and measures Overweight was declared in children, according to World Health Organization, between Z>1 and Z≤2 in Body Mass Index (BMI) for age and in adults between BMI≥25 and BMI<30 [kg/m2]. Obesity in children as Z>2 and adults as BMI≥30. CO in children was established by sex and age using the cut-off points equivalent to those of adults established by the International Diabetes Federation, ≥90 cm and ≥80 cm, in males and females, respectively. The number of meals/day was estimated with a Food Frequency Questionnaire. Meals/day were grouped into three categories: [Reference≤3, four, and 5+]. Crude and adjusted relative Prevalence Ratios (PR) and their 95% confidence interval (95% CI) were calculated. The adjustment included usual energy intake/day and physical activity.

Results *In children*: 18.5% had Ow, 6.7% Ob and 4.0 CO. The adjusted PR for five or more meals/day versus 3 or less meals/day were; for Ow, 1.10 (95% CI: 0.79, 1.55), for Ob, 0.95 (95% CI: 0.57, 1.59) and for CO, 1.06 (95% CI: 0.72, 1.55). *In adults*: 32.3% had Ow, 13.1% Ob and 44.8 CO. The adjusted PR for five or more meals/day versus 3 or less meals/day were; for Ow, 0.58 (95% CI: 0.45, 0.76), for Ob, 0.51 (95% CI: 0.36, 0.72) and for CO, 0.70 (95% CI: 0.54, 0.92).

Conclusions In children, meals/day was not associated with Ow, Ob, or CO. In adults, this relationship exists inversely regardless of energy intake/day, meeting physical activity goals, sex, age, and other potentially confounding sociodemographic and environmental variables.

Strengths and limitations of this study

- The analyzed data came from the National Survey of the Nutritional Situation, Colombia, 2015, which used rigorous and universally accepted methods.
- In establishing the relationship between the number of meals/day and excess weight, obesity, and central obesity, we considered confounding across ten variables, including usual energy intake/day and meeting physical activity goals, overcoming this limitation in other studies."
- The data are cross-sectional from an observational study; therefore, it is impossible to establish causal relationships.
- There may still be residual or unmeasured confusion, particularly in the case of children.
- Because of the potential of intervening in the number of meals to control overweight, obesity, and central obesity, prospective studies are needed, especially in children.

FUNDING This study did not receive specific financial support. Therefore, funding sources did not play any role in the study's design, conduct, or interpretation.

INTRODUCTION

Overweight and obesity have been of interest for centuries. This interest is based on the World Health Organization (WHO) statement on the global obesity epidemic and the public health crisis associated with the resulting morbidity and mortality.[1-3] Nowadays, we accept Body Mass Index [kg/m2] (BMI) and waist circumference as indirect indicators of overweight (Ow), obesity (Ob), and central obesity (CO).[4] Ow, Ob, and CO begin at an early age, their prevalence increases with age, and strategies to control them are expensive and ineffective in the long term.[5]

Ow and Ob are an excessive accumulation of fat, while CO is an excessive accumulation of visceral fat around the stomach and abdomen. CO can occur without excess weight or general obesity. Ow, Ob and CO are multifactorial diseases that occur because of a chronic positive energy balance when dietary energy intake exceeds energy expenditure.[6 7] Ow, Ob, and CO are associated with adverse health effects.[6 7] Ow, Ob, and CO are precursors of type 2 diabetes, insulin resistance, metabolic syndrome, and cardiovascular disease and are associated with overall mortality.[8] CO is the best predictor of metabolic syndrome, cardiovascular disease, and mortality. [9-11]

The epidemiology of obesity is well known. Obesity occurs and has increased at all ages regardless of ethnicity, geographic location, and socioeconomic status. In low and middle-income countries, it is more prevalent in women, middle-aged subjects, and those with higher socioeconomic status or well-being who live in urban environments, allowing them to have a higher level of education.[6 7] Reducing sedentary lifestyles, along with reducing the consumption of ultra-processed, energy-dense, sugar, and fatty foods, have been the focus of interventions for the control of Ow, Ob, and CO.[6 7]

Colombia is a developing country located in the northwestern corner of South America, where two transitions are taking place simultaneously; a nutritional one, where the overweight is now predominant instead of malnutrition, and an alimentary one, where the traditional diet is beginning to be abandoned, and a more Western-type diet is being incorporated.[12 23] In Colombia, in 2005, excess weight [Ow+Ob] in school children (5-12 *y*) was 14.4%, in 2010, it was 18.8%, and in 2015 it was 24.4%. In adolescents (13-17 *y*) in 2005 it was 12.5%, in 2010 15.5% and in 2015 17.9%. In adults (18-64 *y*), in 2005, it was 45.9%, in 2010, it was 51.2%, and in 2015 it was 56.5%.[14] In Colombia, based on the National Nutrition Surveys (ENSIN), it was established that the nutritional transition is in force, with weight distribution shifting to the right at a rate of 1.0 kg / m2 per decade.[12] In 2005, the prevalence of obesity in adults (BMI≥30 kg / m2) was 13.9%, in 2010, 16.4%, and in 2015, 18.7%.[14] The nutritional transition occurs more rapidly in the poorest and those living in urban areas. Moreover,

women are at a disadvantage.[12] The obesity epidemic developed under a dietary pattern of three dense and two intermediate meals.[15]

Regardless of the total energy intake and the possible confounding factors mentioned above, the number of meals per day (meals/day) has been inversely associated with Ob in children and directly associated with Ob and CO in adults.[5 16-19] Results with null or contradictory associations have been attributed to a lack of statistical power, lack of unification of the definitions used to state the number of meals/day, and poor statistical adjustment by ignoring potential confounding variables or biases such as information bias.[5 18 20] The number of meals/day affects metabolism and the mechanisms involved in visceral and body fat deposition.[21 22] Increasing the number of meals/day, and the timing of meals may overshadow the effect of diet therapy on the control of metabolic syndrome in adults.[23]

Epidemiological evidence has shown that decreasing the number of meals/day or "gorging" increases cardiovascular risk. This was explained in dietary studies: When increasing the number of meals or “nibbling”, triglyceride and serum cholesterol levels decrease while carbohydrate tolerance increases. Favorable changes in nitrogen metabolism and tissue enzyme levels have also been demonstrated with nibbling. Increasing the number of meals requires portion size control. Otherwise, energy intake would increase along with body weight.[24] The number of meals/day, among others, is associated with BMI, body composition, health markers such as lipid profile, postprandial insulin, lipid and glucose concentrations, and the sensation of hunger and satiety.[22]

In Colombia, there is a growing interest in controlling Ow, Ob, and metabolic markers through the number of meals due to the increase in chronic diseases associated with obesity.[22] However, given that evidence on the relationship between the number of meals/day and Ow, Ob, and CO in developing countries is limited, mainly because of the few studies that exist and also because the existing studies in developed countries do not adjust the results for dietary energy intake and meeting physical activity goals, the objective of this study was to establish the association between the number of meals and Ow, Ob and CO in apparently healthy Colombian children and adults.

METHODS

Population and sample studied

We conducted a cross-sectional study based on the latest National Survey of the Nutritional Situation in Colombia (Encuesta Nacional de la Situación Nutricional - ENSIN 2015, in Spanish) conducted in 2015 (ENSIN-2015).[14] The objective of ENSIN-2015 was: “*To analyze the food and nutritional situation of the Colombian population framed in the model of social determinants defined for the ENSIN 2015, as input for the formulation, monitoring, and reorientation of public policies for*

food and nutritional security for Colombia."[14] Three ENSINs have been carried out in Colombia: 2005, 2010, and 2015.[14] The ENSIN-2015 was conducted by the Colombian Institute of Family Welfare (ICBF) and the Ministry of Health. It surveyed 44,202 households in 4,739 clusters in 295 strata; these households represent 99% of the country's population. The methods, the populations studied, the scope and limitations of the ENSIN-2015 were already published.[14] Individuals answered among others, a Food Frequency Questionnaire (FFQ), a reminder of dietary consumption in the last twenty-four hours repeated in a subsample (24-hour-recall-24HR) and a sociodemographic survey. Children between 5 and 17 years old and adults between 18 and 64 years old, excluding pregnant girls and women, were the target population of this analysis. The ENSIN-2015 included 151,343 individuals, of whom 28,902 answered the FFQ (13% of the subjects responded to a second 24HR). After excluding pregnant girls and women (n=1,939) and individuals outside the age range <5 years old (6,891) or with incomplete information (n=5,241), the sample finally analyzed was 14,831; 6,985 children between 5 and 17 years old and 7,846 adults between 18 and 64 years old.

Patient and public involvement

No patient was involved.

Data sources

This study was based on secondary, anonymized, and publicly available data taken from the public databases of the ENSIN-2015. The FFQ and 24HR were obtained in the ENSIN-2015 by direct interviews with Nutritionists and trained personnel. In children under 12 years of age, the caregiver or caretaker completed the 24HR and FFQ together with the child. The 24HR had a response rate of 92%. The FFQ response rate was 90.9%.

Output variables.

There were three binomial types (yes/no), Ow, Ob, and CO or abdominal obesity.

Anthropometric measurements were obtained in all individuals with the use of calibrated standards, techniques, and instruments. In the ENSIN-2015, height was measured with stadiometers (ShorrBoard) with an accuracy of 1 mm, weight was measured with SECA 874 scales with a precision of 100 g, and waist circumference, with tape measures with an accuracy of 1 mm.[14] Z scores for BMI in children between 5 and 17 years of age were established following the growth norms (<5 years) and growth reference standards (5-17 years) of the World Health Organization (WHO).[25 26] In adults, BMI was established as (kg / m2). Overweight (Ow) was stated between Z>1 and Z≤2 in minors and adults between BMI≥25 and BMI<30. Obesity (Ob) was stated in children as Z>2 and in adults as BMI≥30.[25] Central obesity (CO) in children was established by sex and age using the cut-off points equivalent to

those for adults established by the International Diabetes Federation, ≥90 cm and ≥80 cm, in males and females, respectively.[27]

Main explanatory variable.

It was the number of meals/day. An FFQ measures the prevalence of consumption (yes/no) and the frequency of consumption in a given reference period.[28] Based on the FFQ, the number of meals was estimated by investigating whether eight specific meals from a pre-established list were usually made (*before breakfast, breakfast, mid-morning, lunch, mid-afternoon, dinner, after dinner, and another*) and the prevalence of realization (%) through a dichotomous response (yes/no) on the usual intake in the last week. The frequency of each type of meal was established based on five categories referring to the past week (*every day, between five and six days, between three and four days, between two and three days, and between one and two days*). After translating the previous response options to a continuous time variable, the frequency of each type of meal was expressed as times per day (times/day).

Covariates

Ten covariates were of interest for their potential confounding effect on the relationship between the number of meals/day and Ow, Ob, and CO; sex, age, usual intake (kilocalories/day), compliance with physical activity, household members, education of the head of the household, wealth index, food insecurity in the home, urbanicity and country region.

The ENSIN-2015 applied a repeated 24HR on a subsample, following the methodology developed in 1999 by the United States Department of Agriculture (USDA).[14 29 30] Textually:[31] "*A 24-hour dietary recall (24HR) is a structured interview intended to capture detailed information about all foods and beverages (and possibly, dietary supplements) consumed by the respondent in the past 24 hours, most commonly, from midnight to midnight the previous day. A key feature of the 24HR is that, when appropriate, the respondent is asked for more detailed information than first reported*".[28 31] The 24HR applied in the ENSIN-2015 used standardized geometric figures representing foods to estimate portion sizes.[14] Based on the 24HR, the usual energy consumed per day (kilocalories/day) was estimated. Usual intake is one of the main confounding variables when studying overweight and obesity.[28 31 32] To estimate usual intake, the distribution of kilocalories/day intake was normalized and corrected for intra-person variability using the methods proposed by the University of Iowa and PC-Side software, v1.0.[32]

In adolescents aged 6 to 17 years, compliance with physical activity recommendations was declared when they performed 60 or more minutes per day of moderate or vigorous physical activity, according to the Youth Risk Behavior Surveillance System.[33] In adults, compliance was declared when

they performed at least 150 minutes per week of moderate-intensity aerobic physical activity or 75 minutes per week of vigorous aerobic physical activity, according to the WHO's International Physical Activity Questionnaire (IPAQ).[34] The level of urbanization was established based on the concentration of the population in three categories; urban centers -more than one million inhabitants and large cities, small towns -between one hundred thousand inhabitants and less than one million inhabitants and dispersed population -less than one hundred thousand inhabitants.[14] The food security status of the household was established through the Latin American and Caribbean Food Security Scale (ELCSA).[35] The level of wealth was established by analyzing a set of physical characteristics of the household, household assets, and availability of services, according to the index wealth methodology designed for the International Demographic and Health Survey.[14 36] The level of schooling of the head of the household was established based on the number of years of approved years of study. The geographic region is a variable representing the territory and the subjects' structural, economic, and cultural development conditions. Colombia has five geographic regions,[14] Bogotá (the country's capital) and the central region have the highest human development index. The Pacific and Amazonia-Orinoquia regions are the poorest.[37]

Statistical analysis

The prevalence of Ow, Ob, and CO and their 95% confidence intervals (95% CI) were estimated based on the binomial distribution. The association between meals/day and Ow, Ob, or CO (dose-response) was estimated with two tests for trends between ordered groups, an extension of the Wilcoxon rank sum test and the Cochran-Armitage test.[38 39] The description of the proportion of Ow, Ob, and CO across the covariate categories studied was performed by binomial regression [Generalized Linear Models: family binomial]. Through binomial regression, crude and adjusted relative Prevalence Ratios (PR) -equivalent to relative Risk Ratios (RR), with their 95% CI were established for the main explanatory variable and some covariates associated in the bivariate analysis to Ow, Ob, and CO. Adjustment of the PR included the following covariates, usual kilocalorie intake (*continuous*), age (*continuous*), sex, meeting physical activity goals (*binomial*), family size, level of education of the household head, level of household food security, and level of urbanicity. All analyses were performed incorporating the effect of the sample design. The analysis was performed with Stata software, v14.1.[40]

Ethical aspects

All analyses were carried out under the principles of the Helsinki Declaration.[41] The used databases are in the public domain. This research is classified as 'without risk' according to Resolution 8430 of 1993 of the Colombian Ministry of Health.[42] All participants gave informed consent to ICBF before being surveyed. The children signed an informed assent form. In children under 12 years old,

the person responsible for their feeding was always present when answering the FFQ and the 24HR. Since this is a secondary analysis of population studies, with anonymized data, no authorization was required from the Health Research Ethics Committee of the Universidad Industrial de Santander (Colombia).

RESULTS

Subject characteristics

The age of the children (mean ± standard deviation) was 11.7 years ± 3.8, and 54.5% were boys. The Ow was 18.5%, the Ob was 6.7%, and the CO was 4.0%. 14.0% had 3 or less meals/day, 20.8% had 4 meals/day and 65.2% had 5 or more meals/day. Compliance with physical activity goals was 25.4%. The adults' ages were 39.0 years ± 13.0, and 40.7% were men. The Ow was 32.3%, the Ob was 13.1%, and the CO was 44.8%. 26.7% had 3 or less meals/day, 27.8% had 4 meals/day and 45.5% had 5 or more meals/day. Compliance with physical activity goals was 28.5%.

26.5% of the general population had three or fewer meals/day, 27.5% four, and 46.0% had five or more meals/day. 40.6% of households had food security, 23.9% of household heads had less than primary school, 33.5% up to complete secondary school, and 8.0% had a university education. The lowest wealth quartile (Q_1) was 37.6% of the population, in the highest quartile (Q_4) was 13.1%. 34.4% of the subjects lived in large cities and 20.3% in rural areas or with a dispersed population.

Number of meals/day and Ow, Ob, and CO

Table 1 presents the relationship between the number of meals and Ow, Ob and CO in children and adults. In children, the number of meals was not associated with Ow, Ob, or CO. In adults, the dose-effect is evident; Ow, Ob, and CO decrease as the number of meals increases, in all three cases for trend, $P<0.0001$ (table 1). Table 2 presents the relationship of the covariates of interest concerning Ow and Ob in children. In children, two variables were inversely associated with Ow and Ob, the number of family members and food insecurity (table 2). Table 3 presents the crude and adjusted relative PRs for Ow and Ob with the number of meals/day and some of the covariates of interest in children. The risk of Ow is lower with seven or more family members, with adjusted PR 0.60 (95% CI: 0.39, 0.90) (table 3).

Table 4 presents the relationship of the covariates of interest concerning Ow and Ob in adults. Adults who eat five or more meals/day are less overweight (26.7%) compared to those who eat three or fewer meals/day (37.8%). The same occurs with obese adults; those who eat five or more meals/day have less overweight (10.6%) than those who eat three or fewer meals/day (18.3%). The head of household's education is directly related to Ow, $P=0.001$ (table 4). Table 5 presented the crude and

Table 1 Number of meals per day and prevalence (95% CI) of overweight, obesity, and central obesity in Colombian population, 5 to 64 years old (*Non-pregnant women*). Colombia, ENSIN, 2015.

[n_1: n_2: n_3: n_4: n_5: n_6] *	Children 5 to17 *y* % (95% CI)			Adults 18 to 64 *y* % (95% CI)		
Number of meals per day (Based on FFQ)	**Overweight** †	**Obesity** ‡	**Central obesity** §	**Overweight** †	**Obesity** ‡	**Central obesity** §
Total	18.5 (16.1, 21.1)	6.7 (5.2, 8.5)	4.0 (2.9, 5.5)	32.3 (30.0, 34.6)	13.1 (11.5, 15.0)	44.8 (42.3, 47.3)
Three or fewer	15.0 (11.7, 19.0)	5.2 (3.3, 8.1)	3.7 (2.5, 5.4)	37.8 (33.2, 42.6)	18.3 (15.0, 22.2)	48.9 (44.3, 53.5)
[1054: 1117: 1559: 1838: 1879: 1534]	[193]	[63]	[80]	[444]	[222]	[636]
Four	20.8 (16.0, 26.7)	7.3 (4.9, 10.8)	4.0 (2.8, 5.8)	36.8 (32.1, 41.8)	12.3 (9.7, 15.6)	49.1 (44.3, 53.9)
[1440: 1533: 1862: 2069: 1941: 1599]	[244]	[93]	[76]	[487]	[170]	[619]
Five or more	18.5 (16.1, 21.2)	6.8 (5.1, 9.0)	4.2 (2.7, 6.4)	26.7 (23.8, 29.8)	10.6 (8.4, 13.4)	38.6 (34.6, 42.7)
[4091: 4335: 3732: 3939: 3009: 2267]	[703]	[244]	[139]	[566]	[183]	[654]
P-value for trend	0.496	0.823	0.465	<0.0001	<0.0001	<0.0001
Cochran-Armitage trend test, *P-value*	0.568	0.832	0.484	<0.0001	<0.0001	<0.0001

Table 2 Prevalence (95% CI) of overweight and obesity for the categories of explanatory covariates in children 5 to 17 years old (*Non-pregnant women*). Colombia, ENSIN, 2015.

Variable		Overweight *			Obesity *	
	n	% (95% CI)	*P-value* ‡	n	% (95% CI)	*P-value* ‡
Usual intake (kcal/d) †: mean ± ee	6585	2104 ± 76	0.983	6985	2015 ± 106	0.258
Number of meals per day			0.372			0.459
Three or fewer	1054	15.0 (11.7, 19.0)		1117	5.2 (3.3, 8.1)	
Four	1440	20.8 (16.0, 26.7)		1533	7.3 (4.9, 10.8)	
Five or more	4091	18.5 (16.1, 21.2)		4335	6.8 (5.1, 9.0)	
Sex			0.039			0.776
Males	3354	16.3 (14.1, 18.7)		3557	6.9 (5.0, 9.5)	
Females	3231	21.0 (17.2, 25.4)		3428	6.5 (4.6, 9.1)	
Age group (*y*)			0.434			0.062
Schoolchildren (5 to <13)	3187	19.5 (16.5, 20.0)		3395	8.1 (5.6, 11.5)	
Adolescents (13 to <18)	3398	17.6 (14.1, 21.7)		3590	5.5 (4.4, 6.7)	
Compliance Physical activity			0.656			0.157
Yes	4690	18.7 (16.0, 21.8)		4991	7.2 (5.5, 9.5)	
No	1410	17.7 (14.0, 22.1)		1484	5.4 (3.6, 7.9)	
Household members			0.021			0.001
Four or fewer	3182	20.2 (17.2, 23.6)		3433	9.5 (7.1, 12.6)	
5 to 6	2275	18.3 (14.7, 22.5)		2372	3.0 (2.1, 4.4)	
7 or more	1128	13.4 (9.9, 17.9)		1180	5.5 (3.7, 8.2)	
Education of head			0.296			0.014
<5 (Primary or less)	1941	16.8 (14.0, 20.0)		2018	4.1 (3.0, 5.6)	
5 to <11	2229	18.9 (15.2, 23.1)		2371	6.6 (4.1, 10.3)	
11 to <16	2044	19.7 (15.7, 24.4)		2188	7.9 (5.3, 11.6)	
≥16 (University)	329	18.2 (12.3, 26.1)		361	10.1 (4.4, 21.3)	
Wealth index, quintiles §			0.265			0.833
Q1	3414	18.6 (15.6, 21.9)		3627	6.7 (4.4, 10.2)	
Q2	1607	21.5 (16.5, 27.4)		1702	6.4 (4.6, 8.9)	
Q3	1058	14.5 (11.3, 18.3)		1110	6.4 (3.2, 12.2)	
Q4	506	17.6 (12.6, 24.0)		546	8.0 (5.5, 11.4)	
Food insecurity in the home |			0.024			0.006
No	2048	22.4 (18.3, 27.1)		2221	8.8 ({6.5, 12.0)	
Mild	2324	17.3 (14.5, 20.4)		2463	6.7 (4.3, 10.4)	
Moderate	1262	15.0 (11.8, 19.0)		1319	3.6 (2.5, 5.2)	
Severe	949	15.9 (11.3, 21.8)		980	4.7 (2.8, 8.0)	
Urbanicity			0.116			0.104
Big cities	1020	22.1 (16.9, 28.3)		1093	8.5 (5.6, 12.9)	
100.001 to 1.000.000 population	1414	16.5 (13.7, 19.8)		1503	6.5 (4.7, 8.9)	
0 to 100.000 population	2587	15.9 (13.7, 18.4)		2749	5.1 (3.8, 6.7)	
Disperse population	1564	17.3 (14.6, 20.5)		1640	5.3 (3.2, 8.7)	
Country region			0.122			0.835
Central	1657	17.7 (15.5, 20.1)		1764	8.1 (5.3, 12.0)	
Atlantic (North)	956	15.7 (12.2, 19.9)		999	4.6 (3.1, 6.8)	
Oriental	1064	15.9 (12.7, 19.8)		1121	4,8 (3.0, 7.7)	
Pacific (West)	926	21.3 (14.9, 29.4)		980	6.5 (4.3, 9.8)	
Bogotá	493	22.8 (15.0, 33.0)		523	9.2 (4.4, 18.0)	
Amazonia-Orinoquia	1489	18.1 (14.8, 21.8)		1598	6.4 (4.4, 9.3)	

Table 3 Prevalence ratios (PR) for number of meals per day, potential confounders, and overweight and obesity in Colombian children, 5 to 17 years (*Non-pregnant women*). Colombia, ENSIN, 2015.

Explanatory variable	PR for meal frequency (95% CI)			
	Overweight *		Obesity *	
	Crude	Adjusted †	Crude	Adjusted †
Number of meals per day				
Three or fewer	1.0	1.0	1.0	1.0
Four	1.49 (1.00, 2.23)	1.29 (0.86, 1.91)	1.44 (0.84, 2.47)	1.14 (0.62, 2.07)
Five or more	1.28 (0.94, 1.76)	1.10 (0.79, 1.53)	1.34 (0.83, 2.14)	0.95 (0.57, 1.59)
Sex				
Males	1.0	1.0	1.0	1.0
Females	1.37 (1.01, 1.84)	1.43 (1.07, 1.92)	0.93 (0.57, 1.53)	0.97 (0.60, 1.58)
Household members				
1 to 4	1.0	1.0	1.0	1.0
5 to 6	0.88 (0.66, 1.17)	0.90 (0.67, 1.20)	0.30 (0.20, 0.45)	0.32 (0.21, 0.49)
7+	0.61 (0.41, 0.91)	0.60 (0.39, 0.90)	0.56 (0.33, 0.96)	0.75 (0.43, 1.29)
Education of head				
<5 (Primary or less)	1.0	1.0	1.0	1.0
5 to <11	1.15 (0.86, 1.55)	1.02 (0.75, 1.39)	1.64 (0.90, 3.03)	1.28 (0.70, 2.35)
11 to <16	1.21 (0.91, 1.63)	1.03 (0.77, 1.37)	2.01 (1.14, 3.57)	1.37 (0.83, 2.24)
≥16 (University)	1.10 (0.67, 1.86)	0.82 (0.47, 1.45)	2.63 (1.02, 6.80)	1.81 (0.76, 4.29)
Food insecurity in the home ‡				
No	1.0	1.0	1.0	1.0
Mild	0.72 (0.54, 0.97)	0.79 (0.59, 1.07)	0.74 (0.45, 1.24)	0.83 (0.49, 1.43)
Moderate	0.61 (0.42, 0.89)	0.70 (0.47, 1.04)	0.38 (0.24, 0.62)	0.46 (0.28, 0.76)
Severe	0.65 (0.42, 1.02)	0.78 (0.47, 1.30)	0.51 (0.26, 1.02)	0.71 (0.34, 1.49)
Urbanicity				
Big cities|	1.0	1.0	1.0	1.0
100.001 to 1.000.000 population	0.70 (0.47, 1.04)	0.71 (0.49, 1.02)	0.75 (0.42, 1.32)	0.92 (0.56, 1.51)
0 to 100.000 population	0.67 (0.46, 0.98)	0.66 (0.47, 0.93)	0.57 (0.33, 0.99)	0.65 (0.39, 1.09)
Disperse population	0.74 (0.50, 1.10)	0.80 (0.56, 1.14)	0.60 (0.30, 1.21)	0.72 (0.37, 1.41)

adjusted PRs for Ow and Ob concerning the number of meals/day and some of the covariates of interest in adults. The risk of Ow is lower in adults who eat five or more meals/day, adjusted PR 0.58 (95% CI 95%: 0.45, 0.76). The same occurs with the risk of obesity, which is lower when eating four or five meals/day versus three or fewer meals/day: adjusted PR 0.61 (95% CI 95%: 0.42, 0.88) and adjusted PR 0.51 (95% CI 95%: 0.36, 0.72), respectively (table 5). Table 6 presents the crude and adjusted relative PRs for CO with the number of meals/day and other covariates of interest. In children, no relationship was found between the number of meals/day and CO. However, in adults, the risk of CO is lower when eating five or more meals/day versus eating three or fewer meals/day, adjusted PR 0.70 (95% CI: 0.54, 0.92) (table 6). Table 1S (*online supplementary material*) presents the prevalence of CO for the categories of the variables of interest in both children and adults.

Table 4 Prevalence (95% CI) of overweight and obesity for the categories of explanatory covariates in adults 18 to 64 years old (*Non-pregnant women*). Colombia, ENSIN, 2015.

Variable		Overweight * [1497]			Obesity * [693]	
	n	% (95% CI)	*P-value* ‡	n	% (95% CI)	*P-value* ‡
Usual intake (kcal/d) †: mean ± sd	7153	1953 ± 31	0.185	7846	2085 ± 78	0.167
Number of meals per day			<0.0001			0.001
Three or fewer	1559	37.8 (33.2, 42.6)		1838	18.3 (14.9, 22.2)	
Four	1862	36.8 (32.1, 41.8)		2069	12.3 (9.5, 15.6)	
Five or more	3132	26.7 (23.8, 20.9)		3939	10.6 (8.3, 13.4)	
Sex			0.435			0.527
Males	3357	31.2 (28.0, 34.6)		3673	13.7 (11.2, 16.7)	
Females	3796	33.1 (29.9, 36.6)		4173	12.6 (10.5, 15.1)	
Age group (y)			0.436			0.711
Young adult (18 to <26)	1533	30.6 (26.0, 35.6)		1669	13.8 (10.1, 18.5)	
Older adult (27 to <64)	5620	32.8 (30.2, 35.5)		6177	12.9 (11.1, 15.0)	
Compliance Physical activity			0.470			0.019
Yes	5019	32.2 (29.3, 35.3)		5543	14.6 (12.4, 17.1)	
No	1770	34.1 (30.1, 38.3)		1928	10.3 (8.0, 13.1)	
Household members			0.034			0.153
Four or fewer	3879	34.8 (31.6, 38.1)		4336	14.3 (12.0, 16.9)	
5 to 6	2174	27.2 (24.3, 30.3)		2338	10.8 (8.6, 13.5)	
7 or more	1100	31.0 (25.6, 37.0)		1172	12.0 (8.0, 17.6)	
Education of head			0.001			0.839
<5 (Primary or less)	2112	27.7 (24.6, 31.0)		2336	13.3 (10.7, 16.3)	
5 to <11	2426	29.9 (26.7, 33.3)		2650	13.2 (10.1, 17.0)	
11 to <16	2204	36.4 (32.2, 40.9)		2393	12.3 (9.6, 15.6)	
≥16 (University)	366	39.4 (29.9, 49.7)		418	15.9 (10.0, 24.1)	
Wealth index, quintiles §			0.737			0.547
Q1	3246	29.8 (27.1, 32.7)		3554	12.5 (10.5, 14.8)	
Q2	1695	35.1 (30.9, 39.4)		1854	14.4 (10.9, 18.7)	
Q3	1399	35.6 (30.3, 41.2)		1525	11.1 (8.1, 15.2)	
Q4	813	27.9 (21.9, 34.8)		913	15.9 (11.3, 21.9)	
Food insecurity in the home |			0.462			0.532
No	2395	33.9 (30.1, 37.9)		2660	14.9 (11.9, 18.5)	
Mild	2536	30.9 (27.8, 34.2)		2781	10.9 (9.0, 13.1)	
Moderate	1366	33.0 (27.9, 38.6)		1481	13.2 (9.6, 17.9)	
Severe	855	30.0 (21.7, 39.9)		923	13.5 (8.8, 20.3)	
Urbanicity			0.160			0.361
Big cities	735	36.2 (30.4, 42.5)		803	13.9 (9.7, 19.3)	
100.001 to 1.000.000 population	1836	31.0 (27.0, 35.2)		2043	14.3 (11.5, 17.8)	
0 to 100.000 population	2701	31.2 (28.3, 34.3)		2960	11.4 (9.2, 14.0)	
Disperse population	1881	30.1 (27.4, 34.6)		2040	12.3 (9.8, 15.3)	
Country region			0.008			0.121
Central	1675	29.9 (26.5, 33.6)		1856	13.8 (10.9, 17.3)	
Atlantic (North)	1448	28.1 (25.1, 31.3)		1602	14.6 (11.7, 18.2)	
Oriental	1424	31.8 (28.2, 35.5)		1564	13.6 (10.4, 17.5)	
Pacific (West)	891	36.9 (29.3, 45.3)		974	14.6 (9.6, 21.7)	
Bogotá	472	37.0 (29.7, 44.1)		495	8.1 (4.4, 14.5)	
Amazonia-Orinoquia	1243	37.8 (33.6, 42.1)		1355	13.3 (9.6, 18.2)	

Table 5 Prevalence ratios (PR) for the number of meals per day, potential confounders, and overweight and obesity in Adults, 18 to 64 years (*Non-pregnant women*). Colombia, ENSIN, 2015.

Explanatory variable	PR for meal frequency (95% CI)			
	Overweight *		Obesity *	
	Crude	Adjusted †	Crude	Adjusted †
Number of meals per day				
Three or fewer	1.0	1.0	1.0	1.0
Four	0.96 (0.72, 1.23)	0.97 (0.72, 1.30)	0.62 (0.43, 0.90)	0.61 (0.42, 0.88)
Five or more	0.60 (0.47, 0.77)	0.58 (0.45, 0.76)	0.53 (0.38, 0.75)	0.51 (0.36, 0.72)
Sex				
Males	1.0	1.0	1.0	1.0
Females	1.09 (0.87, 1.37)	1.04 (0.82, 1.32)	0.91 (0.67, 1.23)	0.98 (0.73, 1.32)
Household members				
1 to 4	1.0	1.0	1.0	1.0
5 to 6	0.70 (0.57, 0.86)	0.76 (0.61, 0.94)	0.72 (0.52, 1.00)	0.75 (0.54, 1.02)
7+	0.84 (0.62, 1.14)	1.02 (0.74, 1.39)	0.81 (0.50, 1.33)	0.90 (0.52, 1.54)
Education of head				
<5 (Primary or less)	1.0	1.0	1.0	1.0
5 to <11	1.11 (0.88, 1.41)	1.08 (0.85, 1.40)	0.99 (0.68, 1.46)	0.96 (0.66, 1.41)
11 to <16	1.49 (1.16, 1.92)	1.51 (1.14, 2.01)	0.91 (0.63, 1.33)	0.84 (0.57, 1.24)
≥16 (University)	1.70 (1.01, 2.65)	1.68 (1.02, 2.76)	1.23 (0.69, 2.19)	1.06 (0.58, 1.95)
Food insecurity in the home ‡				
No	1.0	1.0	1.0	1.0
Mild	0.87 (0.70, 1.08)	0.92 (0.73, 1.17)	0.70 (0.50, 0.97)	0.67 (0.47, 0.96)
Moderate	0.96 (0.70, 1.31)	0.98 (0.72, 1.34)	0.87 (0.56, 1.36)	0.81 (0.49, 1.34)
Severe	0.84 (0.52, 1.34)	0.89 (0.54, 1.48)	0.89 (0.51, 1.56)	0.82 (0.44, 1.55)
Urbanicity				
Big cities|	1.0	1.0	1.0	1.0
100.001 to 1.000.000 population	0.79 (0.57, 1.09)	0.84 (0.60, 1.16)	1.04 (0.65, 1.67)	1.08 (0.66, 1.76)
0 to 100.000 population	0.80 (0.59, 1.07)	0.90 (0.67, 1.22)	0.80 (0.50, 1.27)	0.81 (0.49, 1.35)
Disperse population	0.79 (0.58, 1.07)	0.90 (0.65, 1.23)	0.87 (0.54, 1.40)	0.86 (0.51, 1.45)

Table 6 Prevalence ratios (PR) for the number of meals per day, potential confounders, and central obesity (*Abdominal obesity**) in the Colombian population aged 5 to 64 years (*Non-pregnant women*). Colombia, ENSIN, 2015.

Explanatory variable	PR for meal frequency (95% CI)			
	Children 5 to17 *y*		Adults 18 to 64 *y*	
	Crude	Adjusted †	Crude	Adjusted †
Number of meals per day				
Three or fewer	1.0	1.0	1.0	1.0
Four	1.10 (0.71, 1.70)	1.03 (0.65, 1.61)	1.00 (0.78, 1.31)	1.08 (0.82, 1.43)
Five or more	1.15 (0.80, 1.67)	1.06 (0.72, 1.55)	0.66 (0.51, 0.84)	0.70 (0.54, 0.92)
Sex				
Males	1.0	1.0	1.0	1.0
Females	0.30 (0.20, 0.45)	0.29 (0.19, 0.43)	3.23 (2.62, 4.00)	3.34 (2.69, 4.14)
Household members				
1 to 4	1.0	1.0	1.0	1.0
5 to 6	1.06 (0.60, 1.88)	1.08 (0.58, 2.01)	0.80 (0.65, 1.00)	0,76 (0.61, 0.95)
7+	0.91 (0.49, 1.71)	0.91 (0.47, 1.73)	1.11 (0.83, 1.50)	1.06 (0.78, 1.44)
Education of head				
<5 (Primary or less)	1.0	1.0	1.0	1.0
5 to <11	0.59 (0.33, 1.06)	0.52 (0.26, 1.02)	0.94 (0.74, 1.19)	0.91 (0.71, 1.17)
11 to <16	0.92 (0.61, 1.39)	0.84 (0.53, 1.34)	1.06 (0.82, 1.36)	1.05 (0.80, 1.39)
≥16 (University)	0.77 (0.22, 2.68)	0.71 (0.19, 2.66)	0.95 (0.62, 1.47)	0.86 (0.51, 1.45)
Food insecurity in the home ‡				
No	1.0	1.0	1.0	1.0
Mild	0.95 (0.66, 1.37)	0.94 (0.66, 1.36)	0.80 (0.64, 1.01)	0.77 (0.60, 0.98)
Moderate	1.07 (0.68, 1.69)	1.14 (0.71, 1.83)	1.06 (0.80, 1.42)	0.99 (0.74, 1.33)
Severe	0.92 (0.53, 1.60)	1.03 (0.58, 1.84)	1.02 (0.67, 1.56)	0.95 (0.59, 1.52)

DISCUSSION

Based on cross-sectional data, we established that the number of meals/day was not associated with overweight, obesity, or central obesity in children. However, in adults, this relationship exists inversely regardless of energy intake/day, meeting physical activity goals, sex, age, and other potentially confounding sociodemographic and environmental variables.

Previous studies on children have shown conflicting results. In New Zealand, no association was found between BMI and the number of meals/day in children under two years of age.[43] In Prague (Czech Republic), no differences were found in weight gain in children between 6 and 16 years of age exposed to excessive meals/day (three versus seven).[44] In Lousiana (USA), no effect was found between each meal episode/day and obesity in 10-year-old children; OR 0.91 (95% CI: 0.72, 1.15).[45] In the same study, no relationship was found between the number of meals/day and overweight after two decades of follow-up.[46] In children in Bavaria (Germany) between 5 and 6 years of age, an inverse association was found, eating three meals/day or more protects against childhood obesity; adjusted odds ratio (OR) for four meals/day OR 0.73 (95% CI: 0.44, 1.21) and five or more meals/day, OR 0.51 (95% CI: 0.29, 0.89).[5] A 10-year follow-up study in a cohort of 4-year-old children in Peru, a middle-income country like Colombia, found that those who ate fewer meals/day gained more BMI than those

who ate five or more; for <4 meals/day, β=0.39 (95% CI: 0.17, 0.62).[47] In Puerto Rico, it was found that 12-year-old children who consumed a more significant number of meals/day had lower weight and higher dietary quality.[48] A cohort study with a 10-year follow-up conducted in Bethesda (USA) showed that the BMI of girls aged 9 to 10 years at baseline was lower when they ate three or more meals/day, compared to those who ate <3 meals/day.[49] A meta-analysis reviewing fifty-seven studies conducted in high-income countries (one in Latin America and eight longitudinal) showed that a higher frequency of children's meals with the family was associated with better nutritional conditions, including lower body weight.[17 47]

In American adults ≥20 years of age and with data based on the National Health and Nutrition Examination Survey (NHANES), an adjusted risk for obesity in men of OR 1.54 (95% CI: 1.23, 1.93) and women of OR 1.45 (95% CI: 1.17, 1.81) was found for five or more meals/day versus ≤3. For central obesity in men OR 1.42 (95% CI: 1.15, 1.75) and OR 1.29 (95% CI: 1.05, 1.59) for women.[16] In Dodoma (Tanzania), formal sector workers with more home-cooked meals/day were at higher risk of CO, adjusted OR 2.32 (95% CI: 1.04, 4.19).[50] In British adults aged 19-64 years, a direct association was found between the number of meals/day, BMI-based obesity, and CO.[19] Adults from Puerto Rico aged 30 to 75 years, regardless of whether or not they skipped breakfast, had a higher risk of CO when they consumed between 1.5 and 3 meals/day, OR 2.75 (95% CI: 1.23, 6.15), or when they ate ≥3 meals/day, OR 2.88 (95% CI: 1.14, 7.31), than when they consumed ≤1.5 meals/day.[51]

In adults, as in children, the relationship between the number of meals/day and Ow, Ob, and CO is contradictory.[18] However, it is suggested that direct association such as the one reported here prevails.[18] Our results can be explained as a hypothesis: In Colombian children, we did not find an association between the number of meals/day and Ow, Ob, or CO, because it is necessary for the "effect" of the number of meals to accumulate over time for the association with Ow, OB, or CO to be visible. The only study in a country comparable to our level of development and prevalences of Ow, Ob, and Co was performed on Peruvian children.[47] This Peruvian study required ten years of follow-up to observe the interest association. Complementarily, the required time has already passed in adults, so the "effect" is evident and translates into the observed association. It should also be noted that in Colombia, extreme economic inequalities[37] do not necessarily translate into extreme prevalences of Ow, Ob, and CO in the categories of well-being index or socioeconomic status, which may cause dilution of the association in children. In adults, the numbers of Ow, Ob, and CO are as high as in developed countries. Therefore, the results are not different from those achieved in these countries despite our level of development.

Other possible causes for finding contradictory results between the number of meals/day and Ow, Ob, and CO, and also making it difficult to compare our results, both in children and adults, are the different methods to establish the number of meals/day and the jargon used to refer to them. Furthermore, the lack of a unified criterion to establish the cut-off points for the number of meals in the different studies. However, a cut-off of three meals/day is generally accepted.[20 52] Others are the lack of control variables that leave residual confusion when trying to adjust the mathematical models that explain this relationship, the lack of statistical power due to limited samples, and the differences in age ranges in the studies, together with the different prevalence of Ow, Ob, and CO between children and adults. The last presupposes that it is not the same to investigate the relationship between subjects with a wide age range or specific ages. The underreporting of energy/day consumed among the overweight or obese subjects and the lack of correction of dietary intake for intrasubject variability is well known, which indeed extends to the reporting of the number of meals/day.[53-55]

Strengths and limitations of this study

This study has several strengths. First, the analyzed data came from a national survey (ENSIN-2015) that used rigorous and universally accepted methods. Second, the large sample sizes confer sufficient power to the analysis. Third, the direction and strength of the association between the number of meals/day and Ow, Ob, and CO, is similar to that reported in previous studies, which confers external validity to the findings. Finally, ten potential confounding variables were used for risk adjustment (RP), including usual energy intake/day corrected for intrasubject variability and compliance with physical activity goals. These variables were not available simultaneously in many of the studies cited.

It also has some weaknesses. First, the data are cross-sectional from an observational study; therefore, it is impossible to establish causal relationships. Despite having studied ten covariates as potential confounders, there may still be residual or unmeasured confounders in ENSIN-2015 (Loss of employment of the head of the household or any of its members, medical diagnoses, dietary changes based on empirical practices not guided by health professionals, time of year when the subject was surveyed). Finally, the number of meals/day was established based on an FFQ, although it is unlikely that the estimate was differential concerning the outcome.

In conclusion, further investigation of the effect of the number of meals/day and its effect on Ow, Ob, and CO in children and adults is needed in the context of middle-income, high-poverty, food-insecure countries.[14 37] Increasing the number of meals/day is a potential strategy for the control of overweight, obesity, and central obesity.

DATA AVAILABILITY STATEMENT To access the ENSIN 2015 public database, you must register in the repository of the Ministry of Public Health: repositorio@minsalud.gov.co and make the request through the format available at: https://www.minsalud.gov.co/sites/rid/paginas/freesearchresultsf.aspx?k=Base%20de%20datos%20Encuesta%20Nacional%20de%20la%20Situaci%C3%B3n%20Nutricional%20ENSIN%202015.

COMPETING INTERESTS STATEMENT

None

ETHICAL APPROVAL The study was conducted according to the guidelines in the Declaration of Helsinki. The Colombian Institute of Family Welfare obtained informed consent for the survey before enrolment. The ethics committee in health research of the Universidad Industrial de Santander determined that analyses of these anonymized data were exempt from review.

TRANSPARENCY DECLARATION The lead author affirms that this manuscript is an honest, accurate, and transparent account of the reported study. The reporting of this work is compliant with STROBE guidelines. The lead author affirms that no important study aspects have been omitted. Any discrepancies from the study as planned have been explained.

CONTRIBUTIONS Authors' contributions were as follows: C.H-F and O.F. H, designed the research. O.F.H led the statistical analysis. C.H-F, participated in the statistical analysis. C.H-F, and O.F.H wrote the paper. O.F.H. had primary responsibility for the final content. All authors have read and approved the final version of the manuscript.

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Footnotes for table 1

* [$\mathbf{n_1}$: $\mathbf{n_2}$: for children 5 to 17 years old for overweight and obesity respectively, $\mathbf{n_3}$: $\mathbf{n_4}$: for adults 18 to 64 years old for overweight and obesity respectively, $\mathbf{n_5}$: $\mathbf{n_6}$: for central obesity for children and adults respectively].

† In children based on Z-score for BMI for age (WHO)[26], overweight between Z>1 and Z<=2. In Adults based on BMI (kg / m^2), between BMI>=25 and BMI<30.

‡ In children based on Z-score for BMI for age (WHO)[26], obesity Z>2. In Adults based on BMI (kg / m^2), BMI>=30.

§ Based on International Diabetes Federation[27]

Footnotes for table 2

n The analyzed sample may be less than 6585 or 6985 due to missing values.

* Based on Z-score for BMI (WHO)[26], overweight between Z>1 and Z<=2, obesity Z>2.

† Based on 24-hour recall. 1 kcal/d = 4.18 kJ/d. Based on usual intake, incorporating intra-subject variability[32].

‡ Test for linear trend for ordinal predictors.

§ The wealth index is a composite measure of a household's cumulative living standard. The wealth index is calculated using easy-to-collect data on a household's ownership of selected assets such as televisions and bicycles, materials used for housing construction, type of water supply, and sanitation facilities.

| Estimated with ELCSA scale (FAO)[35]

Footnotes for table 3

* Based on Z-score for BMI for age (WHO),[26] overweight between Z>1 and Z<=2, obesity Z>2.

† Multiple binomial regression. In the adjustment of the prevalence ratios (PR), in addition to the covariates in the table, the usual intake of kilocalories/day (continuous), age (continuous) and physical activity compliance (binomial) were included.

‡ Estimated with ELCSA scale (FAO).[35]

Footnotes for table 4

n The analyzed sample may be less than 7153 or 7846 due to missing values.

* Based on BMI (kg / m^2), overweight between BMI>=25 and BMI<30, obesity BMI>=30.

† Based on 24-hour recall. 1 kcal/d = 4.18 kJ/d. Based on usual intake, incorporating intra-subject variability.[32]

‡ Test for linear trend for ordinal predictors.

§ The wealth index is a composite measure of a household's cumulative living standard. The wealth index is calculated using easy-to-collect data on a household's ownership of selected assets such as televisions and bicycles, materials used for housing construction, type of water supply, and sanitation facilities.

| Estimated with ELCSA scale (FAO).[35]

Footnotes for table 5

* Based on BMI (kg / m^2), overweight between BMI>=25 and BMI<30, obesity BMI>=30.

† Multiple binomial regression. In the adjustment of the prevalence ratios (PR), in addition to the covariates in the table, the usual intake of kilocalories/day (continuous), age (continuous), and physical activity compliance (binomial) were included.

‡ Estimated with ELCSA scale (FAO).[35]

Footnotes for table 6

* Based on International Diabetes Federation.[27]

† Multiple binomial regression. In the adjustment of the prevalence ratios (PR), in addition to the covariates in the table, the usual intake of kilocalories/day (continuous), age (continuous), and physical activity compliance (binomial) were included.

‡ Estimated with ELCSA scale (FAO).[35]

Meal occasion, overweight, obesity and central obesity in children and adults: A cross-sectional study based on a nationally representative survey. Colombia, 2015.

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Online Supplementary Material

Table 1S Prevalence (95% CI) of central obesity (*Abdominal obesity**) in Colombian population aged 5 to 64 years (Non-pregnant women). Colombia, ENSIN, 2015.

Variable	n	Children 5 to17 *y*		n	Adults 18 to 64 *y*	
		% (95% CI)	*P-value* ‡		% (95% CI)	*P-value* ‡
Usual intake (kcal/d) †: mean ± ee	6829	2035 ± 168	0.637	5400	1940 ± 36	0.023
Number of meals per day			0.458			0.001
Three or fewer	1879	3.7 (2.5, 5.4)		1534	48.9 (44.3, 53.5)	
Four	1941	4.0 (2.8, 5.8)		1599	49.1 (44.3, 53.9)	
Five or more	3009	4.2 (2.8, 6.4)		2267	38.6 (34.6, 42.7)	
Sex			<0.0001			<0.0001
Males	3574	5.8 (4.4, 7.5)		2502	29.4 (26.2, 32.8)	
Females	3255	1.8 (1.4, 2.4)		2898	57.4 (53.9, 60.7)	
Age group (y)			0.001			
Schoolchildren (5 to <13)	3047	5.6 (4.1, 7.7)				
Adolescents (13 to <18)	3782	2.7 (2.0, 3.6)				
Age group (y)						0.481
Young adult (18 to <27)				1144	43.0 (37.1, 49.0)	
Older adult (27 to <64)				4256	45.3 (42.6, 48.0)	
Compliance Physical activity			0.234			0.553
Yes	4935	3.6 (2.5, 5.4)		3858	45.0 (41.9, 48.0)	
No	1549	4.6 (3.1, 6.6)		1267	46.6 (42.0, 51.2)	
Household members			0.919			0.765
Four or fewer	3890	4.0 (2.6, 5.9)		3133	45.8 (42.5, 49.2)	
5 to 6	1964	4.2 (2.9, 5.9)		1513	40.4 (36.4, 44.5)	
7 or more	975	3.6 (1.5, 8.3)		754	48.5 (41.8, 55.3)	
Education of head			0.906			0.825
<5 (Primary or less)	1997	4.8 (2.7, 8.6)		1667	45.0 (40.9, 49.2)	
5 to <11	2366	2.9 (2.2, 3.9)		1811	43.4 (39.4, 47.6)	
11 to <16	2070	4.5 (2.8, 7.1)		1588	46.4 (41.6, 51.3)	
≥16 (University)	364	3.8 (1.6, 8.7)		303	43.8 (34.4, 53.6)	
Wealth index, quintiles §			0.205			0.726
Q1	3426	4.7 (2.8, 7.9)		2395	44.7 (41.0, 48.3)	
Q2	1666	3.9 (2.7, 5.8)		1271	46.1 (41.0, 51.4)	
Q3	1169	3.1 (1.6, 5.7)		1085	44.9 (39.2, 50.7)	
Q4	568	3.0 (1.7, 5.4)		649	43.0 (35.9, 50.3)	
Food insecurity in the home |			0.932			0.861
No	2380	4.0 (2.8, 5.8)		1837	46.3 (42.2, 50.6)	
Mild	2410	3.8 (2.5, 5.8)		1916	40.8 (37.2, 44.6)	
Moderate	1213	4.3 (2.7, 6.9)		1029	47.9 (42.0, 53.9)	
Severe	824	3.7 (2.1, 6.7)		618	46.8 (37.3, 56.6)	
Urbanicity			0.072			0.585
Big cities	1177	5.1 (3.2, 8.0)		534	42.5 (36.4, 48.9)	
100.001 to 1.000.000 population	1625	3.2 (2.0, 4.9)		1456	46.5 (41.9, 51.1)	
0 to 100.000 population	2445	3.2 (2.6, 4.3)		1983	44.4 (40.1, 48.7)	
Disperse population	1582	2.9 (1.9, 4.2)		1427	45.4 (41.7, 49.2)	
Country region			0.936			0.364
Central	1770	5.2 (3.0, 8.9)		1334	43.6 (39.0, 48.3)	
Atlantic (North)	1176	2.3 (1.5, 3.3)		1156	46.9 (42.0, 51.8)	
Oriental	1151	3.0 (1.9, 4.5)		1124	48.3 (43.6, 53.0)	
Pacific (West)	887	3.5 (2.1, 5.8)		657	45.1 (37.6, 52.8)	
Bogotá	522	4.9 (3.0, 8.0)		322	37.8 (30.4, 45.7)	
Amazonia-Orinoquia	1323	4.6 (1.8, 11.5)		807	52.7 (47.6, 57.6)	

n The analyzed sample may be less than 6829 or 5400 due to missing values. * Base on International Diabetes Federation (IDF)[27] † Based on 24-hour recall. 1 kcal/d = 4.18 kJ/d. Based on usual intake, incorporating intra-subject variability.[32] ‡ Test for linear trend for ordinal predictors. § The wealth index is a composite measure of a household's cumulative living standard. The wealth index is calculated using easy-to-collect data on a household's ownership of selected assets such as televisions and bicycles, materials used for housing construction, type of water supply, and sanitation facilities. | Estimated with ELCSA scale (FAO).[35]

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6-9
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-9
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6-9
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-9
Bias	9	Describe any efforts to address potential sources of bias	6-9
Study size	10	Explain how the study size was arrived at	6-9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	9
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	9
		(*e*) Describe any sensitivity analyses	9
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10-16
		(b) Give reasons for non-participation at each stage	10-16
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10-16

		(b) Indicate number of participants with missing data for each variable of interest	10-16
Outcome data	15*	Report numbers of outcome events or summary measures	10-16
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-16
		(*b*) Report category boundaries when continuous variables were categorized	10-16
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	10-16
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10-16
Discussion			
Key results	18	Summarise key results with reference to study objectives	16-18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16.18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16.18
Generalisability	21	Discuss the generalisability (external validity) of the study results	16-18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	4

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Meal occasion, overweight, obesity and central obesity in children and adults: A cross-sectional study based on a nationally representative survey. Colombia, 2015.

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Running title: Meal frequency and obesity in Colombia.

Keywords: Meals, Overweight, Obesity, Abdominal Obesity, Diet Surveys

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ABSTRACT

Objective To establish the association of the number of meals/day with overweight (Ow), obesity (Ob), and central obesity (CO).

Design Cross-sectional, nationally representative surveys.

Setting Colombia.

Participants A total of 6,985 children aged 5 to 17 years and 7,846 adults aged 18 to 64 years were included.

Main outcomes and measures According to the World Health Organization, overweight was defined in children as a body mass index (BMI)-for-age Z-score between >1 and ≤2 and in adults as a BMI between ≥25 and <30 [kg/m^2]. Obesity was defined as a Z-score >2 in children and as a BMI ≥30 in adults. CO in children was established by sex and age using cut-off points equivalent to those of adults established by the International Diabetes Federation: ≥90 cm and ≥80 cm, in males and females, respectively. The number of meals/day was estimated with a Food Frequency Questionnaire. Meals/day were grouped into three categories: [Reference ≤3, four, and 5+ meals/day]. Crude and adjusted relative prevalence ratios (PRs) and their 95% confidence intervals (95% CIs) were calculated. The adjustments included usual energy intake/day and physical activity.

Results *In children*, 18.5% had Ow, 6.7% had Ob and 4.0% had CO. The adjusted PR for five or more meals/day versus 3 or fewer meals/day were 1.10 (95% CI: 0.79, 1.55) for Ow, 0.95 (95% CI: 0.57, 1.59) for Ob and 1.06 (95% CI: 0.72, 1.55) for CO. *In adults*, 32.3% had Ow, 13.1% had Ob and 44.8% had CO. The adjusted PR for five or more meals/day versus 3 or fewer meals/day were 0.58 (95% CI: 0.45, 0.76) for Ow, 0.51 (95% CI: 0.36, 0.72) for Ob and 0.70 (95% CI: 0.54, 0.92) for CO.

Conclusions In children, meals/day were not associated with Ow, Ob, or CO. In adults, this inverse relationship exists regardless of energy intake/day, whether physical activity goals are met, sex, age, and other potentially confounding sociodemographic and environmental variables.

Strengths and limitations of this study

- The analysed data came from the National Survey of the Nutritional Situation, Colombia, 2015, which used rigorous and universally accepted methods.
- In establishing the relationship between the number of meals/day and excess weight, obesity, and central obesity, we considered confounding across ten variables, including usual energy intake/day and whether physical activity goals were met, overcoming this limitation in other studies.
- The data were cross-sectional data from an observational study; therefore, it was impossible to establish causal relationships.
- There may still be residual or unmeasured confounding, particularly in the case of children.
- Because of the potential of intervening in the number of meals to control overweight, obesity, and central obesity, prospective studies are needed, especially with children.

FUNDING This study did not receive specific financial support. Therefore, funding sources did not play any role in the study's design, conduct, or interpretation.

INTRODUCTION

Overweight and obesity have been of interest for centuries. This interest is based on the World Health Organization (WHO) statement on the global obesity epidemic and the public health crisis associated with the resulting morbidity and mortality.[1-3] Currently, we accept body mass index [kg/m^2] (BMI) and waist circumference as indirect indicators of overweight (Ow), obesity (Ob), and central obesity (CO).[4] Ow, Ob, and CO begin at an early age, their prevalence increases with age, and strategies to control them are expensive and ineffective in the long term.[5]

Ow and Ob are excessive accumulations of fat, while CO is an excessive accumulation of visceral fat around the stomach and abdomen. CO can occur without excess weight or general obesity. Ow, Ob and CO are multifactorial diseases that occur because of a chronic positive energy balance when dietary energy intake exceeds energy expenditure.[6 7] Ow, Ob, and CO are associated with adverse health effects.[6 7] Ow, Ob, and CO are precursors of type 2 diabetes, insulin resistance, metabolic syndrome, and cardiovascular disease and are associated with overall mortality.[8] CO is the best predictor of metabolic syndrome, cardiovascular disease, and mortality. [9-11]

The epidemiology of obesity is well known. Obesity occurs regardless of ethnicity, geographic location, and socioeconomic status and has increased in people of all ages. In low- and middle-income countries, it is more prevalent in women, middle-aged subjects, and individuals with higher socioeconomic status or well-being who live in urban environments, allowing them to have a higher level of education.[6 7] Reducing sedentary lifestyles, along with reducing the consumption of ultra-processed, energy-dense, sugary, and fatty foods, have been the focus of interventions for the control of Ow, Ob, and CO.[6 7]

Colombia is a developing country located in the northwestern corner of South America, where two transitions are taking place simultaneously: a nutritional transition, where overweight is now predominant instead of malnutrition, and an alimentary transition, where the traditional diet is beginning to be abandoned and a more Western-type diet is being incorporated.[12 23] In Colombia, the rate of excess weight [Ow+Ob] in school children (5-12 *y*) was 14.4% in 2005, 18.8% in 2010, and 24.4% in 2015; in adolescents (13-17 *y*), it was 12.5% in 2005, 15.5% in 2010 and 17.9% in 2015; and in adults (18-64 *y*), it was 45.9% in 2005, 51.2% in 2010, and 56.5% in 2015.[14] In Colombia, based on the National Nutrition Surveys (ENSIN), it was established that the nutritional transition is in force, with the weight distribution shifting to the right at a rate of 1.0 kg/m^2 per decade.[12] The prevalence of obesity in adults (BMI ≥30 kg/m^2) was 13.9% in 2005, 16.4% in 2010, and 18.7% in 2015.[14] The nutritional transition is occurring more rapidly in the poorest individuals and those living in urban

areas. Moreover, women are at a disadvantage.[12] The obesity epidemic developed under a dietary pattern of three dense and two intermediate meals per day.[15 16]

Regardless of the total energy intake and the possible confounding factors mentioned above, the number of meals per day (meals/day) has been inversely associated with Ob in children and directly associated with Ob and CO in adults.[5 17-20] Results with null or contradictory associations have been attributed to a lack of statistical power, a lack of unification of the definitions used to state the number of meals/day, and poor statistical adjustment by ignoring potential confounding variables or biases such as information bias.[5 19 21] The number of meals/day affects metabolism and the mechanisms involved in visceral and body fat deposition.[22 23] Increasing the number of meals/day and the timing of meals may overshadow the effect of diet therapy on the control of metabolic syndrome in adults.[24]

Epidemiological evidence has shown that decreasing the number of meals/day or "gorging" increases cardiovascular risk. This was explained in dietary studies: When increasing the number of meals or “nibbling”, triglyceride and serum cholesterol levels decrease while carbohydrate tolerance increases. Favourable changes in nitrogen metabolism and tissue enzyme levels have also been demonstrated with “nibbling”. Increasing the number of meals requires portion size control; otherwise, energy intake would increase along with body weight.[25] The number of meals/day is associated with BMI, body composition, health markers such as lipid profiles, postprandial insulin, lipid and glucose concentrations, and the sensation of hunger and satiety.[23]

In Colombia, there is a growing interest in controlling Ow, Ob, and metabolic markers through the number of meals due to the increase in chronic diseases associated with obesity.[23] However, given that evidence on the relationship between the number of meals/day and Ow, Ob, and CO in developing countries is limited, mainly because of the few existing studies and because the existing studies in developed countries did not adjust the results for dietary energy intake and whether physical activity goals were met, the objective of this study was to establish the association between the number of meals and Ow, Ob and CO in apparently healthy Colombian children and adults.

METHODS

Population and sample studied

We conducted a cross-sectional study based on the latest National Survey of the Nutritional Situation in Colombia (Encuesta Nacional de la Situación Nutricional - ENSIN 2015, in Spanish) that was conducted in 2015 (ENSIN-2015).[14] The objective of ENSIN-2015 was “*To analyse the food and nutritional situation of the Colombian population framed in the model of social determinants defined for the ENSIN 2015, as input for the formulation, monitoring, and reorientation of public policies for*

food and nutritional security for Colombia."[14] ENSINs were carried out in Colombia in 2005, 2010, and 2015.[14] The ENSIN-2015 was conducted by the Colombian Institute of Family Welfare (ICBF) and the Ministry of Health. It surveyed 44,202 households in 4,739 clusters in 295 strata; these households represented 99% of the country's population. The methods, the studied populations, and the scope and limitations of the ENSIN-2015 have already been published.[14] Individuals answered, among others, a Food Frequency Questionnaire (FFQ), a recall of dietary consumption in the last twenty-four hours that was repeated in a subsample (24-hour-recall, 24HR) and a sociodemographic survey. Children between 5 and 17 years old and adults between 18 and 64 years old, excluding girls and women who were pregnant, were the target population of this analysis. The ENSIN-2015 included 151,343 individuals, of whom 28,902 answered the FFQ (13% of the subjects responded to a second 24HR). After excluding girls and women who were pregnant (n=1,939) and individuals aged <5 years old (6,891) or with incomplete information (n=5,241), a total of 14,831 individuals were included in the final sample: 6,985 children between 5 and 17 years old and 7,846 adults between 18 and 64 years old.

Patient and public involvement

No patients were involved.

Data sources

This study was based on secondary, anonymized, and publicly available data taken from the public databases of the ENSIN-2015. The FFQ and 24HR were obtained in the ENSIN-2015 by direct interviews with nutritionists and trained personnel. In children under 12 years of age, the caregiver or caretaker completed the 24HR and FFQ together with the child. The 24HR had a response rate of 92%. The FFQ response rate was 90.9%.

Output variables

There were three binomial types (yes/no): Ow, Ob, and CO or abdominal obesity.

Anthropometric measurements were obtained in all individuals with the use of calibrated standards, techniques, and instruments. In the ENSIN-2015, height was measured with stadiometers (ShorrBoard) with an accuracy of 1 mm, weight was measured with SECA 874 scales with a precision of 100 g, and waist circumference was measured with tape measures with an accuracy of 1 mm.[14] Z-scores for BMI in children between 5 and 17 years of age were established following the growth norms (<5 years) and growth reference standards (5-17 years) of the World Health Organization (WHO).[26 27] In adults, BMI was established as kg/m^2. Overweight (Ow) was defined as a Z-score between >1 and ≤2 in minors and as a BMI between ≥25 and <30 in adults. Obesity (Ob) was defined as a Z-score >2 in children and as a BMI ≥30 in adults.[26] Central obesity (CO) in children was established by sex and age

using cut-off points equivalent to those for adults established by the International Diabetes Federation: ≥90 cm and ≥80 cm, in males and females, respectively.[28]

Main explanatory variable

The main explanatory variable was the number of meals/day. An FFQ measures the prevalence of consumption (yes/no) and the frequency of consumption in a given reference period.[29] Based on the FFQ, the number of meals was estimated by investigating whether eight specific meals from a preestablished list were usually made (*before breakfast, breakfast, mid-morning, lunch, mid-afternoon, dinner, after dinner, and another*) and the prevalence of realization (%) through a dichotomous response (yes/no) regarding the usual intake in the last week. The frequency of each type of meal was established based on five categories referring to the past week (*every day, between five and six days, between three and four days, between two and three days, and between one and two days*). After translating the previous response options to a continuous time variable, the frequency of each type of meal was expressed as times per day (times/day).

Covariates

Ten covariates were considered for their potential confounding effect on the relationship between the number of meals/day and Ow, Ob, and CO: sex, age, usual intake (kilocalories/day), compliance with physical activity recommendations, the number of household members, education level of the head of the household, the wealth index, food insecurity in the home, urbanicity and country region.

The ENSIN-2015 applied a repeated 24HR with a subsample, following the methodology developed by the United States Department of Agriculture (USDA) in 1999.[14 30 31] Textually: [32] "*A 24-hour dietary recall (24HR) is a structured interview intended to capture detailed information about all foods and beverages (and possibly, dietary supplements) consumed by a respondent in the past 24 hours, most commonly, from midnight to midnight the previous day. A key feature of the 24HR is that, when appropriate, the respondent is asked for more detailed information than first reported*".[29 32] The 24HR applied in the ENSIN-2015 used standardized geometric figures representing foods to estimate portion sizes.[14] Based on the 24HR, the usual energy consumed per day (kilocalories/day) was estimated. Usual intake is one of the main confounding variables when studying overweight and obesity.[29 32 33] To estimate usual intake, the distribution of kilocalorie intake/day was normalized and corrected for intraperson variability using the methods proposed by the University of Iowa and PC-Side software, v1.0.[33]

In adolescents aged 6 to 17 years, compliance with physical activity recommendations was declared when they performed 60 or more minutes of moderate or vigorous physical activity per day,

according to the Youth Risk Behavior Surveillance System.[34] In adults, compliance was declared when they performed at least 150 minutes of moderate-intensity aerobic physical activity per week or 75 minutes of vigorous aerobic physical activity per week, according to the WHO's International Physical Activity Questionnaire (IPAQ).[35] The level of urbanization was established based on the concentration of the population in three categories; urban centers: with more than one million inhabitants and large cities; small towns: between one hundred thousand inhabitants and less than one million inhabitants; and dispersed populations: less than one hundred thousand inhabitants.[14] The food security status of the household was established through the Latin American and Caribbean Food Security Scale (ELCSA).[36] The level of wealth was established by analysing a set of physical characteristics of the household, household assets, and the availability of services, according to the index wealth methodology designed for the International Demographic and Health Survey.[14 37] The level of schooling of the head of the household was established based on the number of years of approved years of study. Geographic region is a variable representing the territory and the subjects' structural, economic, and cultural development conditions. Colombia has five geographic regions,[14] with Bogotá (the country's capital) and the central region having the highest human development index. The Pacific and Amazonia-Orinoquia regions are the poorest regions.[38]

Statistical analysis

The prevalence of Ow, Ob, and CO and the 95% confidence intervals (95% CIs) were estimated based on the binomial distribution. The association between meals/day and Ow, Ob, or CO (dose–response) was estimated with two tests for trends between ordered groups, an extension of the Wilcoxon rank sum test and the Cochran-Armitage test.[39 40] The description of the proportion of Ow, Ob, and CO across the covariate categories studied was performed by binomial regression [Generalized Linear Models: family binomial]. Through binomial regression, crude and adjusted relative Prevalence Ratios (PRs), equivalent to relative Risk Ratios (RRs), with their 95% CIs were established for the main explanatory variable and some covariates in the bivariate analysis associated with Ow, Ob, and CO. Adjustment of the PR included the following covariates: usual kilocalorie intake (*continuous*), age (*continuous*), sex, whether physical activity goals were met (*binomial*), family size, level of education of the household head, level of household food security, and level of urbanicity. All analyses were performed incorporating the effect of the sample design. The analysis was performed with Stata software, v14.1.[41]

Ethical aspects

All analyses were carried out under the principles of the Helsinki Declaration.[42] The databases used are in the public domain. This research was classified as 'without risk' according to Resolution

8430 of 1993 of the Colombian Ministry of Health.[43] All participants gave informed consent to the ICBF before being surveyed. The children signed an informed assent form. In children under 12 years old, the person responsible for feeding them was always present when answering the FFQ and 24HR. Since this was a secondary analysis of population studies, with anonymized data, no authorization was required from the Health Research Ethics Committee of the Universidad Industrial de Santander (Colombia).

RESULTS

Subject characteristics

The average age of the children (mean ± standard deviation) was 11.7 ± 3.8 years, and 54.5% were boys. The rate of Ow was 18.5%, that of Ob was 6.7%, and that of CO was 4.0%. A total of 14.0% had 3 or fewer meals/day, 20.8% had 4 meals/day and 65.2% had 5 or more meals/day. The rate of compliance with physical activity goals was 25.4%. The average age of the adults was 39.0 ± 13.0 years, and 40.7% were men. The rate of Ow was 32.3%, that of Ob was 13.1%, and that of CO was 44.8%. A total of 26.7% had 3 or fewer meals/day, 27.8% had 4 meals/day and 45.5% had 5 or more meals/day. The rate of compliance with physical activity goals was 28.5%.

A total of 26.5% of the general population had three or fewer meals/day, 27.5% had four meals/day, and 46.0% had five or more meals/day. A total of 40.6% of the households had food security. A total of 23.9% of the household heads had less than a primary school education, 33.5% had completed secondary school, and 8.0% had a university education. A total of 37.6% of the population was in the lowest wealth quartile (Q_1), and 13.1% was in the highest quartile (Q_4). A total of 34.4% of the subjects lived in large cities, and 20.3% lived in rural areas or areas with a dispersed population.

Number of meals/day and Ow, Ob, and CO

Table 1 presents the relationship between the number of meals and Ow, Ob and CO in children and adults. In children, the number of meals was not associated with Ow, Ob, or CO. In adults, the dose-effect was evident; Ow, Ob, and CO decreased as the number of meals increased in all three cases (for trend, $P<0.0001$) (Table 1). Table 2 presents the relationship of the covariates of interest concerning Ow and Ob in children. In children, two variables were inversely associated with Ow and Ob risk: the number of family members and food insecurity (Table 2). Table 3 presents the crude and adjusted relative PRs for Ow and Ob with the number of meals/day and some of the covariates of interest in children. The risk of Ow was lower in children with seven or more family members, with an adjusted PR of 0.60 (95% CI: 0.39, 0.90) (Table 3).

Table 4 presents the relationship of the covariates of interest concerning Ow and Ob in adults. Adults who ate five or more meals/day were less overweight (26.7%) compared to those who ate three or fewer meals/day (37.8%). The same was observed with obese adults: those who ate five or more meals/day were less overweight (10.6%) than those who ate three or fewer meals/day (18.3%). The head of household's education level was directly related to Ow (P=0.001) (Table 4). Table 5 presents the crude and

Table 1 Number of meals per day and prevalence (95% CI) of overweight, obesity, and central obesity in the Colombian population, 5 to 64 years old (*nonpregnant women*). Colombia, ENSIN, 2015.

[n_1: n_2: n_3: n_4: n_5: n_6] *	Children 5 to17 *y* % (95% CI)			Adults 18 to 64 *y* % (95% CI)		
Number of meals per day (Based on FFQ)	**Overweight** †	**Obesity** ‡	**Central obesity** §	**Overweight** †	**Obesity** ‡	**Central obesity** §
Total	18.5 (16.1, 21.1)	6.7 (5.2, 8.5)	4.0 (2.9, 5.5)	32.3 (30.0, 34.6)	13.1 (11.5, 15.0)	44.8 (42.3, 47.3)
Three or fewer	15.0 (11.7, 19.0)	5.2 (3.3, 8.1)	3.7 (2.5, 5.4)	37.8 (33.2, 42.6)	18.3 (15.0, 22.2)	48.9 (44.3, 53.5)
[1054: 1117: 1559: 1838: 1879: 1534]	[193]	[63]	[80]	[444]	[222]	[636]
Four	20.8 (16.0, 26.7)	7.3 (4.9, 10.8)	4.0 (2.8, 5.8)	36.8 (32.1, 41.8)	12.3 (9.8, 15.6)	49.1 (44.3, 53.9)
[1440: 1533: 1862: 2069: 1941: 1599]	[244]	[93]	[76]	[487]	[163]	[619]
Five or more	18.5 (16.1, 21.2)	6.8 (5.1, 9.0)	4.2 (2.7, 6.4)	26.7 (23.8, 29.8)	10.6 (8.4, 13.4)	38.6 (34.6, 42.7)
[4091: 4335: 3732: 3939: 3009: 2267]	[703]	[244]	[139]	[566]	[183]	[654]
P-value for trend	0.496	0.823	0.465	<0.0001	<0.0001	<0.0001
Cochran-Armitage trend test, *P-value*	0.568	0.832	0.484	<0.0001	<0.0001	<0.0001

Table 2 Prevalence (95% CI) of overweight and obesity for the categories of explanatory covariates in children 5 to 17 years old (*nonpregnant women*). Colombia, ENSIN, 2015.

Variable	Overweight *			Obesity *		
	n	% (95% CI)	*P-value* ‡	n	% (95% CI)	*P-value* ‡
Usual intake (kcal/d) †: mean ± ee	6585	2104 ± 76	0.983	6985	2015 ± 106	0.258
Number of meals per day			0.372			0.459
Three or fewer	1054	15.0 (11.7, 19.0)		1117	5.2 (3.3, 8.1)	
Four	1440	20.8 (16.0, 26.7)		1533	7.3 (4.9, 10.8)	
Five or more	4091	18.5 (16.1, 21.2)		4335	6.8 (5.1, 9.0)	
Sex			0.039			0.776
Males	3354	16.3 (14.1, 18.7)		3557	6.9 (5.0, 9.5)	
Females	3231	21.0 (17.2, 25.4)		3428	6.5 (4.6, 9.1)	
Age group (*y*)			0.434			0.062
Schoolchildren (5 to <13)	3187	19.5 (16.5, 20.0)		3395	8.1 (5.6, 11.5)	
Adolescents (13 to <18)	3398	17.6 (14.1, 21.7)		3590	5.5 (4.4, 6.7)	
Compliance Physical activity			0.656			0.157
Yes	4690	18.7 (16.0, 21.8)		4991	7.2 (5.5, 9.5)	
No	1410	17.7 (14.0, 22.1)		1484	5.4 (3.6, 7.9)	
Household members			0.021			0.001
Four or fewer	3182	20.2 (17.2, 23.6)		3433	9.5 (7.1, 12.6)	
5 to 6	2275	18.3 (14.7, 22.5)		2372	3.0 (2.1, 4.4)	
7 or more	1128	13.4 (9.9, 17.9)		1180	5.5 (3.7, 8.2)	
Education of head			0.296			0.014
<5 (Primary or less)	1941	16.8 (14.0, 20.0)		2018	4.1 (3.0, 5.6)	
5 to <11	2229	18.9 (15.2, 23.1)		2371	6.6 (4.1, 10.3)	
11 to <16	2044	19.7 (15.7, 24.4)		2188	7.9 (5.3, 11.6)	
≥16 (University)	329	18.2 (12.3, 26.1)		361	10.1 (4.4, 21.3)	
Wealth index, quintiles §			0.265			0.833
Q1	3414	18.6 (15.6, 21.9)		3627	6.7 (4.4, 10.2)	
Q2	1607	21.5 (16.5, 27.4)		1702	6.4 (4.6, 8.9)	
Q3	1058	14.5 (11.3, 18.3)		1110	6.4 (3.2, 12.2)	
Q4	506	17.6 (12.6, 24.0)		546	8.0 (5.5, 11.4)	
Food insecurity in the home |			0.024			0.006
No	2048	22.4 (18.3, 27.1)		2221	8.8 ({6.5, 12.0)	
Mild	2324	17.3 (14.5, 20.4)		2463	6.7 (4.3, 10.4)	
Moderate	1262	15.0 (11.8, 19.0)		1319	3.6 (2.5, 5.2)	
Severe	949	15.9 (11.3, 21.8)		980	4.7 (2.8, 8.0)	
Urbanicity			0.116			0.104
Big cities	1020	22.1 (16.9, 28.3)		1093	8.5 (5.6, 12.9)	
100.001 to 1.000.000 population	1414	16.5 (13.7, 19.8)		1503	6.5 (4.7, 8.9)	
0 to 100.000 population	2587	15.9 (13.7, 18.4)		2749	5.1 (3.8, 6.7)	
Disperse population	1564	17.3 (14.6, 20.5)		1640	5.3 (3.2, 8.7)	
Country region			0.122			0.835
Central	1657	17.7 (15.5, 20.1)		1764	8.1 (5.3, 12.0)	
Atlantic (North)	956	15.7 (12.2, 19.9)		999	4.6 (3.1, 6.8)	
Oriental	1064	15.9 (12.7, 19.8)		1121	4,8 (3.0, 7.7)	
Pacific (West)	926	21.3 (14.9, 29.4)		980	6.5 (4.3, 9.8)	
Bogotá	493	22.8 (15.0, 33.0)		523	9.2 (4.4, 18.0)	
Amazonia-Orinoquia	1489	18.1 (14.8, 21.8)		1598	6.4 (4.4, 9.3)	

Table 3 Prevalence ratios (PR) for number of meals per day, potential confounders, and overweight and obesity in Colombian children, 5 to 17 years (*nonpregnant women*). Colombia, ENSIN, 2015.

Explanatory variable	PR for meal frequency (95% CI)			
	Overweight *		Obesity *	
	Crude	Adjusted †	Crude	Adjusted †
Number of meals per day				
Three or fewer	1.0	1.0	1.0	1.0
Four	1.49 (1.00, 2.23)	1.29 (0.86, 1.91)	1.44 (0.84, 2.47)	1.14 (0.62, 2.07)
Five or more	1.28 (0.94, 1.76)	1.10 (0.79, 1.53)	1.34 (0.83, 2.14)	0.95 (0.57, 1.59)
Sex				
Males	1.0	1.0	1.0	1.0
Females	1.37 (1.01, 1.84)	1.43 (1.07, 1.92)	0.93 (0.57, 1.53)	0.97 (0.60, 1.58)
Household members				
1 to 4	1.0	1.0	1.0	1.0
5 to 6	0.88 (0.66, 1.17)	0.90 (0.67, 1.20)	0.30 (0.20, 0.45)	0.32 (0.21, 0.49)
7+	0.61 (0.41, 0.91)	0.60 (0.39, 0.90)	0.56 (0.33, 0.96)	0.75 (0.43, 1.29)
Education of head				
<5 (Primary or less)	1.0	1.0	1.0	1.0
5 to <11	1.15 (0.86, 1.55)	1.02 (0.75, 1.39)	1.64 (0.90, 3.03)	1.28 (0.70, 2.35)
11 to <16	1.21 (0.91, 1.63)	1.03 (0.77, 1.37)	2.01 (1.14, 3.57)	1.37 (0.83, 2.24)
≥16 (University)	1.10 (0.67, 1.86)	0.82 (0.47, 1.45)	2.63 (1.02, 6.80)	1.81 (0.76, 4.29)
Food insecurity in the home ‡				
No	1.0	1.0	1.0	1.0
Mild	0.72 (0.54, 0.97)	0.79 (0.59, 1.07)	0.74 (0.45, 1.24)	0.83 (0.49, 1.43)
Moderate	0.61 (0.42, 0.89)	0.70 (0.47, 1.04)	0.38 (0.24, 0.62)	0.46 (0.28, 0.76)
Severe	0.65 (0.42, 1.02)	0.78 (0.47, 1.30)	0.51 (0.26, 1.02)	0.71 (0.34, 1.49)
Urbanicity				
Big cities|	1.0	1.0	1.0	1.0
100.001 to 1.000.000 population	0.70 (0.47, 1.04)	0.71 (0.49, 1.02)	0.75 (0.42, 1.32)	0.92 (0.56, 1.51)
0 to 100.000 population	0.67 (0.46, 0.98)	0.66 (0.47, 0.93)	0.57 (0.33, 0.99)	0.65 (0.39, 1.09)
Disperse population	0.74 (0.50, 1.10)	0.80 (0.56, 1.14)	0.60 (0.30, 1.21)	0.72 (0.37, 1.41)

adjusted PRs for Ow and Ob concerning the number of meals/day and some of the covariates of interest in adults. The risk of Ow was lower in adults who ate five or more meals/day, with an adjusted PR of 0.58 (95% CI 95%: 0.45, 0.76). The same was observed for the risk of obesity, which was lower when participants ate four or five meals/day versus three or fewer meals/day, with adjusted PRs of 0.61 (95% CI 95%: 0.42, 0.88) and 0.51 (95% CI 95%: 0.36, 0.72), respectively (Table 5). Table 6 presents the crude and adjusted relative PRs for CO with the number of meals/day and other covariates of interest. In children, no relationship was found between the number of meals/day and CO risk. However, in adults, the risk of CO was lower when participants ate five or more meals/day versus three or fewer meals/day, with an adjusted PR of 0.70 (95% CI: 0.54, 0.92) (Table 6). Table 1S (*online supplementary material*) presents the prevalence of CO for the categories of the variables of interest in both children and adults.

Table 4 Prevalence (95% CI) of overweight and obesity for the categories of explanatory covariates in adults 18 to 64 years old (*nonpregnant women*). Colombia, ENSIN, 2015.

Variable		Overweight * [1497]			Obesity * [693]	
	n	% (95% CI)	*P-value* ‡	n	% (95% CI)	*P-value* ‡
Usual intake (kcal/d) †: mean ± sd	7153	1953 ± 31	0.185	7846	2085 ± 78	0.167
Number of meals per day			<0.0001			0.001
Three or fewer	1559	37.8 (33.2, 42.6)		1838	18.3 (14.9, 22.2)	
Four	1862	36.8 (32.1, 41.8)		2069	12.3 (9.5, 15.6)	
Five or more	3132	26.7 (23.8, 20.9)		3939	10.6 (8.3, 13.4)	
Sex			0.435			0.527
Males	3357	31.2 (28.0, 34.6)		3673	13.7 (11.2, 16.7)	
Females	3796	33.1 (29.9, 36.6)		4173	12.6 (10.5, 15.1)	
Age group (y)			0.436			0.711
Young adult (18 to <26)	1533	30.6 (26.0, 35.6)		1669	13.8 (10.1, 18.5)	
Older adult (27 to <64)	5620	32.8 (30.2, 35.5)		6177	12.9 (11.1, 15.0)	
Compliance Physical activity			0.470			0.019
Yes	5019	32.2 (29.3, 35.3)		5543	14.6 (12.4, 17.1)	
No	1770	34.1 (30.1, 38.3)		1928	10.3 (8.0, 13.1)	
Household members			0.034			0.153
Four or fewer	3879	34.8 (31.6, 38.1)		4336	14.3 (12.0, 16.9)	
5 to 6	2174	27.2 (24.3, 30.3)		2338	10.8 (8.6, 13.5)	
7 or more	1100	31.0 (25.6, 37.0)		1172	12.0 (8.0, 17.6)	
Education of head			0.001			0.839
<5 (Primary or less)	2112	27.7 (24.6, 31.0)		2336	13.3 (10.7, 16.3)	
5 to <11	2426	29.9 (26.7, 33.3)		2650	13.2 (10.1, 17.0)	
11 to <16	2204	36.4 (32.2, 40.9)		2393	12.3 (9.6, 15.6)	
≥16 (University)	366	39.4 (29.9, 49.7)		418	15.9 (10.0, 24.1)	
Wealth index, quintiles §			0.737			0.547
Q1	3246	29.8 (27.1, 32.7)		3554	12.5 (10.5, 14.8)	
Q2	1695	35.1 (30.9, 39.4)		1854	14.4 (10.9, 18.7)	
Q3	1399	35.6 (30.3, 41.2)		1525	11.1 (8.1, 15.2)	
Q4	813	27.9 (21.9, 34.8)		913	15.9 (11.3, 21.9)	
Food insecurity in the home |			0.462			0.532
No	2395	33.9 (30.1, 37.9)		2660	14.9 (11.9, 18.5)	
Mild	2536	30.9 (27.8, 34.2)		2781	10.9 (9.0, 13.1)	
Moderate	1366	33.0 (27.9, 38.6)		1481	13.2 (9.6, 17.9)	
Severe	855	30.0 (21.7, 39.9)		923	13.5 (8.8, 20.3)	
Urbanicity			0.160			0.361
Big cities	735	36.2 (30.4, 42.5)		803	13.9 (9.7, 19.3)	
100.001 to 1.000.000 population	1836	31.0 (27.0, 35.2)		2043	14.3 (11.5, 17.8)	
0 to 100.000 population	2701	31.2 (28.3, 34.3)		2960	11.4 (9.2, 14.0)	
Disperse population	1881	30.1 (27.4, 34.6)		2040	12.3 (9.8, 15.3)	
Country region			0.008			0.121
Central	1675	29.9 (26.5, 33.6)		1856	13.8 (10.9, 17.3)	
Atlantic (North)	1448	28.1 (25.1, 31.3)		1602	14.6 (11.7, 18.2)	
Oriental	1424	31.8 (28.2, 35.5)		1564	13.6 (10.4, 17.5)	
Pacific (West)	891	36.9 (29.3, 45.3)		974	14.6 (9.6, 21.7)	
Bogotá	472	37.0 (29.7, 44.1)		495	8.1 (4.4, 14.5)	
Amazonia-Orinoquia	1243	37.8 (33.6, 42.1)		1355	13.3 (9.6, 18.2)	

Table 5 Prevalence ratios (PR) for the number of meals per day, potential confounders, and overweight and obesity in adults aged 18 to 64 years (*nonpregnant women*). Colombia, ENSIN, 2015.

Explanatory variable	PR for meal frequency (95% CI)			
	Overweight *		Obesity *	
	Crude	Adjusted †	Crude	Adjusted †
Number of meals per day				
Three or fewer	1.0	1.0	1.0	1.0
Four	0.96 (0.72, 1.23)	0.97 (0.72, 1.30)	0.62 (0.43, 0.90)	0.61 (0.42, 0.88)
Five or more	0.60 (0.47, 0.77)	0.58 (0.45, 0.76)	0.53 (0.38, 0.75)	0.51 (0.36, 0.72)
Sex				
Males	1.0	1.0	1.0	1.0
Females	1.09 (0.87, 1.37)	1.04 (0.82, 1.32)	0.91 (0.67, 1.23)	0.98 (0.73, 1.32)
Household members				
1 to 4	1.0	1.0	1.0	1.0
5 to 6	0.70 (0.57, 0.86)	0.76 (0.61, 0.94)	0.72 (0.52, 1.00)	0.75 (0.54, 1.02)
7+	0.84 (0.62, 1.14)	1.02 (0.74, 1.39)	0.81 (0.50, 1.33)	0.90 (0.52, 1.54)
Education of head				
<5 (Primary or less)	1.0	1.0	1.0	1.0
5 to <11	1.11 (0.88, 1.41)	1.08 (0.85, 1.40)	0.99 (0.68, 1.46)	0.96 (0.66, 1.41)
11 to <16	1.49 (1.16, 1.92)	1.51 (1.14, 2.01)	0.91 (0.63, 1.33)	0.84 (0.57, 1.24)
≥16 (University)	1.70 (1.01, 2.65)	1.68 (1.02, 2.76)	1.23 (0.69, 2.19)	1.06 (0.58, 1.95)
Food insecurity in the home ‡				
No	1.0	1.0	1.0	1.0
Mild	0.87 (0.70, 1.08)	0.92 (0.73, 1.17)	0.70 (0.50, 0.97)	0.67 (0.47, 0.96)
Moderate	0.96 (0.70, 1.31)	0.98 (0.72, 1.34)	0.87 (0.56, 1.36)	0.81 (0.49, 1.34)
Severe	0.84 (0.52, 1.34)	0.89 (0.54, 1.48)	0.89 (0.51, 1.56)	0.82 (0.44, 1.55)
Urbanicity				
Big cities|	1.0	1.0	1.0	1.0
100.001 to 1.000.000 population	0.79 (0.57, 1.09)	0.84 (0.60, 1.16)	1.04 (0.65, 1.67)	1.08 (0.66, 1.76)
0 to 100.000 population	0.80 (0.59, 1.07)	0.90 (0.67, 1.22)	0.80 (0.50, 1.27)	0.81 (0.49, 1.35)
Disperse population	0.79 (0.58, 1.07)	0.90 (0.65, 1.23)	0.87 (0.54, 1.40)	0.86 (0.51, 1.45)

Table 6 Prevalence ratios (PR) for the number of meals per day, potential confounders, and central obesity (*Abdominal obesity**) in the Colombian population aged 5 to 64 years (*nonpregnant women*). Colombia, ENSIN, 2015.

Explanatory variable	PR for meal frequency (95% CI)			
	Children 5 to17 *y*		Adults 18 to 64 *y*	
	Crude	Adjusted †	Crude	Adjusted †
Number of meals per day				
Three or fewer	1.0	1.0	1.0	1.0
Four	1.10 (0.71, 1.70)	1.03 (0.65, 1.61)	1.00 (0.78, 1.31)	1.08 (0.82, 1.43)
Five or more	1.15 (0.80, 1.67)	1.06 (0.72, 1.55)	0.66 (0.51, 0.84)	0.70 (0.54, 0.92)
Sex				
Males	1.0	1.0	1.0	1.0
Females	0.30 (0.20, 0.45)	0.29 (0.19, 0.43)	3.23 (2.62, 4.00)	3.34 (2.69, 4.14)
Household members				
1 to 4	1.0	1.0	1.0	1.0
5 to 6	1.06 (0.60, 1.88)	1.08 (0.58, 2.01)	0.80 (0.65, 1.00)	0,76 (0.61, 0.95)
7+	0.91 (0.49, 1.71)	0.91 (0.47, 1.73)	1.11 (0.83, 1.50)	1.06 (0.78, 1.44)
Education of head				
<5 (Primary or less)	1.0	1.0	1.0	1.0
5 to <11	0.59 (0.33, 1.06)	0.52 (0.26, 1.02)	0.94 (0.74, 1.19)	0.91 (0.71, 1.17)
11 to <16	0.92 (0.61, 1.39)	0.84 (0.53, 1.34)	1.06 (0.82, 1.36)	1.05 (0.80, 1.39)
≥16 (University)	0.77 (0.22, 2.68)	0.71 (0.19, 2.66)	0.95 (0.62, 1.47)	0.86 (0.51, 1.45)
Food insecurity in the home ‡				
No	1.0	1.0	1.0	1.0
Mild	0.95 (0.66, 1.37)	0.94 (0.66, 1.36)	0.80 (0.64, 1.01)	0.77 (0.60, 0.98)
Moderate	1.07 (0.68, 1.69)	1.14 (0.71, 1.83)	1.06 (0.80, 1.42)	0.99 (0.74, 1.33)
Severe	0.92 (0.53, 1.60)	1.03 (0.58, 1.84)	1.02 (0.67, 1.56)	0.95 (0.59, 1.52)

DISCUSSION

Based on cross-sectional data, we established that the number of meals/day was not associated with overweight, obesity, or central obesity in children. However, in adults, this inverse relationship existed regardless of energy intake/day, whether physical activity goals were met, sex, age, and other potentially confounding sociodemographic and environmental variables.

Previous studies with children have shown conflicting results. In New Zealand, no association was found between BMI and the number of meals/day in children under two years of age.[44] In Prague (Czech Republic), no differences were found in weight gain in children between 6 and 16 years of age who were exposed to excessive meals/day (three versus seven meals/day).[45] In Louisiana (USA), no effect was found between each meal episode/day and obesity in 10-year-old children, with an OR of 0.91 (95% CI: 0.72, 1.15).[46] In the same study, no relationship was found between the number of meals/day and overweight after two decades of follow-up.[47] In children in Bavaria (Germany) between 5 and 6 years of age, an inverse association was found: eating three meals/day or more protected children against childhood obesity, with adjusted odds ratios (ORs) of 0.73 (95% CI: 0.44, 1.21) for four meals/day and 0.51 (95% CI: 0.29, 0.89) for five or more meals/day.[5] A 10-year follow-up study in a cohort of 4-year-old children in Peru, a middle-income country like Colombia, found that those

who ate fewer meals/day had higher BMIs than those who ate five or more meals/day (for <4 meals/day, β=0.39; 95% CI: 0.17, 0.62).[48] In Puerto Rico, it was found that 12-year-old children who consumed a more significant number of meals/day had a lower weight and higher dietary quality.[49] A cohort study with a 10-year follow-up conducted in Bethesda (USA) showed that the BMI of girls aged 9 to 10 years at baseline was lower when they ate three or more meals/day compared to those who ate <3 meals/day.[50] A meta-analysis reviewing fifty-seven studies conducted in high-income countries (one study in Latin America and eight longitudinal studies) showed that a higher frequency of meals with the family were associated with better nutritional conditions for children, including lower body weight.[18 49]

In American adults ≥20 years of age and with data based on the National Health and Nutrition Examination Survey (NHANES), adjusted ORs of 1.54 (95% CI: 1.23, 1.93) for obesity in men and 1.45 (95% CI: 1.17, 1.81) for obesity in women was found for five or more meals/day versus ≤3 meals/day. An OR of 1.42 (95% CI: 1.15, 1.75) was found for central obesity in men and an OR of 1.29 (95% CI: 1.05, 1.59) was found for women.[17] In Dodoma (Tanzania), formal sector workers who ate more home-cooked meals/day were at higher risk of CO, with an adjusted OR of 2.32 (95% CI: 1.04, 4.19).[51] In British adults aged 19-64 years, a direct association was found among the number of meals/day, BMI-based obesity, and CO.[20] Adults from Puerto Rico aged 30 to 75 years, regardless of whether they skipped breakfast, had a higher risk of CO when they consumed between 1.5 and 3 meals/day, (OR 2.75; 95% CI: 1.23, 6.15), or when they consumed ≥3 meals/day, (OR 2.88; 95% CI: 1.14, 7.31), than when they consumed ≤1.5 meals/day.[52]

In adults, as in children, the relationship between the number of meals/day and Ow, Ob, and CO is contradictory.[19] However, it is suggested that a direct association prevails, contrary to what is reported here.[19] Our results can be explained as a hypothesis: In Colombian children, we did not find an association between the number of meals/day and Ow, Ob, or CO because it is necessary for the "effect" of the number of meals to accumulate over time for the association with Ow, OB, or CO to be visible. The only study in a country comparable to our level of development and prevalence of Ow, Ob, and Co was performed on Peruvian children.[48] This Peruvian study required ten years of follow-up to observe the association of interest. Complementarily, the required time has already passed in adults, so the "effect" is evident and translates into the observed association. It should also be noted that in Colombia, extreme economic inequalities[38] do not necessarily translate into extreme prevalences of Ow, Ob, and CO in the categories of well-being index or socioeconomic status, which may cause dilution of the association in children. In adults, the numbers of Ow, Ob, and CO are as high as in

developed countries. Therefore, the results are not different from those achieved in these countries despite our level of development.

Other possible causes for the contradictory results between the number of meals/day and Ow, Ob, and CO, making it difficult to compare our results, both in children and adults, are the different methods to establish the number of meals/day and the terminology used to refer to them. Furthermore, there was a lack of a unified criterion to establish the cut-off points for the number of meals in the different studies. However, a cut-off of three meals/day is generally accepted.[21 53] Other causes are the lack of control variables that leave residual confounding when trying to adjust the mathematical models that explain this relationship, the lack of statistical power due to limited samples, and the differences in age ranges in the studies, together with the different prevalences of Ow, Ob, and CO between children and adults. The last possible cause presupposes that it is not the same to investigate the relationship between subjects with a wide age range or specific ages. The underreporting of energy intake/day consumed among overweight or obese subjects and the lack of correction of dietary intake for intrasubject variability is well known, which indeed extends to the reporting of the number of meals/day.[54-56]

Strengths and limitations of this study

This study has several strengths. First, the analyzed data came from a national survey (ENSIN-2015) that used rigorous and universally accepted methods. Second, the large sample sizes confer sufficient power to the analysis. Third, the direction and strength of the association between the number of meals/day and Ow, Ob, and CO is similar to that reported in previous studies, which confers external validity to the findings. Finally, ten potential confounding variables were used for risk adjustment (RP), including usual energy intake/day corrected for intrasubject variability and compliance with physical activity goals. These variables were not simultaneously available in many of the studies cited.

It also has some weaknesses. First, the data were cross-sectional data from an observational study; therefore, it is impossible to establish causal relationships. Despite having studied ten covariates as potential confounders, there may still be residual or unmeasured confounders in the ENSIN-2015 (e.g., loss of employment of the head of the household or any of its members, medical diagnoses, dietary changes based on empirical practices not guided by health professionals, time of year when the subject was surveyed). Finally, the number of meals/day was established based on an FFQ, although it is unlikely that the estimate was differential concerning the outcome.

In conclusion, further investigation of the effect of the number of meals/day and its effect on Ow, Ob, and CO in children and adults is needed in the context of middle-income, high-poverty, food-

insecure countries.[14 38] Increasing the number of meals/day is a potential strategy for the control of overweight, obesity, and central obesity.

DATA AVAILABILITY STATEMENT To access the ENSIN 2015 public database, you must register for the repository of the Ministry of Public Health (repositorio@minsalud.gov.co) and make the request through the format available at the following website: https://www.minsalud.gov.co/sites/rid/paginas/freesearchresultsf.aspx?k=Base%20de%20datos%20Encuesta%20Nacional%20de%20la%20Situaci%C3%B3n%20Nutricional%20ENSIN%202015.

COMPETING INTERESTS STATEMENT

None

ETHICAL APPROVAL The study was conducted according to the guidelines in the Declaration of Helsinki. The Colombian Institute of Family Welfare obtained informed consent for the survey before enrolment. The ethics committee in health research of the Universidad Industrial de Santander determined that analyses of these anonymized data were exempt from review.

TRANSPARENCY DECLARATION The lead author affirms that this manuscript is an honest, accurate, and transparent account of the reported study. The reporting of this work is compliant with STROBE guidelines. The lead author affirms that no important study aspects have been omitted. Any discrepancies from the study as planned have been explained.

CONTRIBUTIONS The authors' contributions were as follows: C. H-F and O.F. H designed the research. O.F.H led the statistical analysis. C. H-F participated in the statistical analysis. C. H-F, and O.F.H wrote the paper. O.F.H. had primary responsibility for the final content. All authors have read and approved the final version of the manuscript.

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Footnotes for Table 1

* [$\mathbf{n_1}$: $\mathbf{n_2}$: for children 5 to 17 years old for overweight and obesity respectively, $\mathbf{n_3}$: $\mathbf{n_4}$: for adults 18 to 64 years old for overweight and obesity respectively, $\mathbf{n_5}$: $\mathbf{n_6}$: for central obesity for children and adults respectively].

† In children based on Z-score for BMI for age (WHO)[27], overweight between Z>1 and Z<=2. In Adults based on BMI (kg/m^2), between BMI>=25 and BMI<30.

‡ In children based on Z-score for BMI for age (WHO)[27], obesity Z>2. In Adults based on BMI (kg / m^2), BMI>=30.

§ Based on International Diabetes Federation[28]

Footnotes for Table 2

n The analyzed sample may be less than 6585 or 6985 due to missing values.

* Based on Z-score for BMI (WHO)[27], overweight between Z>1 and Z<=2, obesity Z>2.

† Based on 24-hour recall. 1 kcal/d = 4.18 kJ/d. Based on usual intake, incorporating intra-subject variability[33].

‡ Test for linear trend for ordinal predictors.

§ The wealth index is a composite measure of a household's cumulative living standard. The wealth index is calculated using easy-to-collect data on a household's ownership of selected assets such as televisions and bicycles, materials used for housing construction, type of water supply, and sanitation facilities.

| Estimated with ELCSA scale (FAO)[36]

Footnotes for Table 3

* Based on Z-score for BMI for age (WHO),[27] overweight between Z>1 and Z<=2, obesity Z>2.

† Multiple binomial regression. In the adjustment of the prevalence ratios (PR), in addition to the covariates in the table, the usual intake of kilocalories/day (continuous), age (continuous) and physical activity compliance (binomial) were included.

‡ Estimated with ELCSA scale (FAO).[36]

Footnotes for Table 4

n The analyzed sample may be less than 7153 or 7846 due to missing values.

* Based on BMI (kg/m^2), overweight between BMI>=25 and BMI<30, obesity BMI>=30.

† Based on 24-hour recall. 1 kcal/d = 4.18 kJ/d. Based on usual intake, incorporating intra-subject variability.[33]

‡ Test for linear trend for ordinal predictors.

§ The wealth index is a composite measure of a household's cumulative living standard. The wealth index is calculated using easy-to-collect data on a household's ownership of selected assets such as televisions and bicycles, materials used for housing construction, type of water supply, and sanitation facilities.

| Estimated with ELCSA scale (FAO).[36]

Footnotes for Table 5

* Based on BMI (kg/m^2), overweight between BMI>=25 and BMI<30, obesity BMI>=30.

† Multiple binomial regression. In the adjustment of the prevalence ratios (PR), in addition to the covariates in the table, the usual intake of kilocalories/day (continuous), age (continuous), and physical activity compliance (binomial) were included.

‡ Estimated with ELCSA scale (FAO).[36]

Footnotes for Table 6

* Based on International Diabetes Federation.[28]

† Multiple binomial regression. In the adjustment of the prevalence ratios (PR), in addition to the covariates in the table, the usual intake of kilocalories/day (continuous), age (continuous), and physical activity compliance (binomial) were included.

‡ Estimated with ELCSA scale (FAO).[36]

Meal occasion, overweight, obesity and central obesity in children and adults: A cross-sectional study based on a nationally representative survey. Colombia, 2015.

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Online Supplementary Material

Table 1S Prevalence (95% CI) of central obesity (*Abdominal obesity**) in Colombian population aged 5 to 64 years (*nonpregnant women*). Colombia, ENSIN, 2015.

Variable	n	Children 5 to17 *y*		n	Adults 18 to 64 *y*	
		% (95% CI)	*P-value* ‡		% (95% CI)	*P-value* ‡
Usual intake (kcal/d) †: mean ± ee	6829	2035 ± 168	0.637	5400	1940 ± 36	0.023
Number of meals per day			0.458			0.001
Three or fewer	1879	3.7 (2.5, 5.4)		1534	48.9 (44.3, 53.5)	
Four	1941	4.0 (2.8, 5.8)		1599	49.1 (44.3, 53.9)	
Five or more	3009	4.2 (2.8, 6.4)		2267	38.6 (34.6, 42.7)	
Sex			<0.0001			<0.0001
Males	3574	5.8 (4.4, 7.5)		2502	29.4 (26.2, 32.8)	
Females	3255	1.8 (1.4, 2.4)		2898	57.4 (53.9, 60.7)	
Age group (y)			0.001			
Schoolchildren (5 to <13)	3047	5.6 (4.1, 7.7)				
Adolescents (13 to <18)	3782	2.7 (2.0, 3.6)				
Age group (y)						0.481
Young adult (18 to <27)				1144	43.0 (37.1, 49.0)	
Older adult (27 to <64)				4256	45.3 (42.6, 48.0)	
Compliance Physical activity			0.234			0.553
Yes	4935	3.6 (2.5, 5.4)		3858	45.0 (41.9, 48.0)	
No	1549	4.6 (3.1, 6.6)		1267	46.6 (42.0, 51.2)	
Household members			0.919			0.765
Four or fewer	3890	4.0 (2.6, 5.9)		3133	45.8 (42.5, 49.2)	
5 to 6	1964	4.2 (2.9, 5.9)		1513	40.4 (36.4, 44.5)	
7 or more	975	3.6 (1.5, 8.3)		754	48.5 (41.8, 55.3)	
Education of head			0.906			0.825
<5 (Primary or less)	1997	4.8 (2.7, 8.6)		1667	45.0 (40.9, 49.2)	
5 to <11	2366	2.9 (2.2, 3.9)		1811	43.4 (39.4, 47.6)	
11 to <16	2070	4.5 (2.8, 7.1)		1588	46.4 (41.6, 51.3)	
≥16 (University)	364	3.8 (1.6, 8.7)		303	43.8 (34.4, 53.6)	
Wealth index, quintiles §			0.205			0.726
Q1	3426	4.7 (2.8, 7.9)		2395	44.7 (41.0, 48.3)	
Q2	1666	3.9 (2.7, 5.8)		1271	46.1 (41.0, 51.4)	
Q3	1169	3.1 (1.6, 5.7)		1085	44.9 (39.2, 50.7)	
Q4	568	3.0 (1.7, 5.4)		649	43.0 (35.9, 50.3)	
Food insecurity in the home |			0.932			0.861
No	2380	4.0 (2.8, 5.8)		1837	46.3 (42.2, 50.6)	
Mild	2410	3.8 (2.5, 5.8)		1916	40.8 (37.2, 44.6)	
Moderate	1213	4.3 (2.7, 6.9)		1029	47.9 (42.0, 53.9)	
Severe	824	3.7 (2.1, 6.7)		618	46.8 (37.3, 56.6)	
Urbanicity			0.072			0.585
Big cities	1177	5.1 (3.2, 8.0)		534	42.5 (36.4, 48.9)	
100.001 to 1.000.000 population	1625	3.2 (2.0, 4.9)		1456	46.5 (41.9, 51.1)	
0 to 100.000 population	2445	3.2 (2.6, 4.3)		1983	44.4 (40.1, 48.7)	
Disperse population	1582	2.9 (1.9, 4.2)		1427	45.4 (41.7, 49.2)	
Country region			0.936			0.364
Central	1770	5.2 (3.0, 8.9)		1334	43.6 (39.0, 48.3)	
Atlantic (North)	1176	2.3 (1.5, 3.3)		1156	46.9 (42.0, 51.8)	
Oriental	1151	3.0 (1.9, 4.5)		1124	48.3 (43.6, 53.0)	
Pacific (West)	887	3.5 (2.1, 5.8)		657	45.1 (37.6, 52.8)	
Bogotá	522	4.9 (3.0, 8.0)		322	37.8 (30.4, 45.7)	
Amazonia-Orinoquia	1323	4.6 (1.8, 11.5)		807	52.7 (47.6, 57.6)	

n The analyzed sample may be less than 6829 or 5400 due to missing values. * Base on International Diabetes Federation (IDF)[28] † Based on 24-hour recall. 1 kcal/d = 4.18 kJ/d. Based on usual intake, incorporating intra-subject variability.[33] ‡ Test for linear trend for ordinal predictors. § The wealth index is a composite measure of a household's cumulative living standard. The wealth index is calculated using easy-to-collect data on a household's ownership of selected assets such as televisions and bicycles, materials used for housing construction, type of water supply, and sanitation facilities. | Estimated with ELCSA scale (FAO).[36]

Meal occasion, overweight, obesity and central obesity in children and adults: A cross-sectional study based on a nationally representative survey. Colombia, 2015.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5-6
Objectives	3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	4	Present key elements of study design early in the paper	6-9
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-9
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6-9
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-9
Bias	9	Describe any efforts to address potential sources of bias	6-9
Study size	10	Explain how the study size was arrived at	6-9
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	9
		(*c*) Explain how missing data were addressed	9
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	9
		(*e*) Describe any sensitivity analyses	9
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10-16
		(b) Give reasons for non-participation at each stage	10-16
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10-16

		(b) Indicate number of participants with missing data for each variable of interest	10-16
Outcome data	15*	Report numbers of outcome events or summary measures	10-16
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-16
		(*b*) Report category boundaries when continuous variables were categorized	10-16
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	10-16
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10-16
Discussion			
Key results	18	Summarise key results with reference to study objectives	16-18
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	16.18
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	16.18
Generalisability	21	Discuss the generalisability (external validity) of the study results	16-18
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	4

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.