BMJ Open

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

Oscar Fernando Herrán ,[1] Catalina Herrán-Fonseca [2]

To cite: Herrán OF, Herrán-Fonseca C. Meal occasion, overweight, obesity and central obesity in children and adults: a cross-sectional study based on a nationally representative survey. Colombia, 2015. *BMJ Open* 2022;**12**:e064832. doi:10.1136/bmjopen-2022-064832

► Prepublication history and additional supplemental material for this paper are available online. To view these files, please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2022-064832).

Received 16 May 2022
Accepted 05 September 2022

[1]Escuela de Nutrición y Dietética, Universidad Industrial de Santander, Bucaramanga, Santander, Colombia
[2]Programa Medicina, Facultad de Ciencias de la Salud, Universidad Autónoma de Bucaramanga, Bucaramanga, Santander, Colombia

Correspondence to
Professor Oscar Fernando Herrán; herran@uis.edu.co

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 6985 children aged 5–17 years and 7846 adults aged 18–64 years were included.

Main outcomes and measures According to the WHO, Ow 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). Ob 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 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, 4 and 5+ meals/day). Crude and adjusted relative prevalence ratios (PRs) and their 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 PRs for five or more meals/day versus three or fewer meals/day were 1.10 (95% CI 0.79 to 1.55) for Ow, 0.95 (95% CI 0.57 to 1.59) for Ob and 1.06 (95% CI 0.72 to 1.55) for CO. *In adults*, 32.3% had Ow, 13.1% had Ob and 44.8% had CO. The adjusted PRs for five or more meals/day versus three or fewer meals/day were 0.58 (95% CI 0.45 to 0.76) for Ow, 0.51 (95% CI 0.36 to 0.72) for Ob and 0.70 (95% CI 0.54 to 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 10 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.

INTRODUCTION

Overweight (Ow) and obesity (Ob) have been of interest for centuries. This interest is based on the WHO statement on the global Ob epidemic and the public health crisis associated with the resulting morbidity and mortality.[1–3] Currently, we accept body mass index (BMI, kg/m^2) and waist circumference as indirect indicators of Ow, 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 Ob. 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 Ob is well known. Ob occurs regardless of ethnicity, geographic location and socioeconomic status and has increased in people of all ages. In low-income 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 ultraprocessed, energy-dense, sugary and fatty foods, has 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 Ow 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 13] In Colombia, the rate of excess weight (Ow+Ob) in schoolchildren (5–12 years) was 14.4% in 2005, 18.8% in 2010 and 24.4% in 2015; in adolescents (13–17 years), it was 12.5% in 2005, 15.5% in 2010 and 17.9% in 2015; and in adults (18–64 years), it was 45.9% in 2005, 51.2% in 2010 and 56.5% in 2015.[14] In Colombia, based on the National Nutrition Survey (Encuesta Nacional de la Situación Nutricional, 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 Ob 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 Ob epidemic developed under a dietary pattern of three dense and two intermediate meals per day (meals/day).[15 16]

Regardless of the total energy intake and the possible confounding factors mentioned above, the number of 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 Ob.[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 (ENSIN 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] ENSIN was 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 4739 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 24 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=1939) and individuals aged <5 years old (6891) or with incomplete information (n=5241), a total of 14 831 individuals were included in the final sample: 6985 children between 5 and 17 years old and 7846 adults between 18 and 64 years old.

Patient and public involvement

No patients were involved.

Data sources

This study was based on secondary, anonymised 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 Ob.

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 WHO.[26 27] In adults, BMI was established as kg/m^2. Ow was defined as a Z-score between >1 and ≤2 in minors and as a BMI between ≥25 and <30 in adults. Ob was defined as a Z-score >2 in children and as a BMI ≥30 in adults.[26] 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 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 pre-established list were usually made (*before breakfast, breakfast, mid-morning, lunch, mid-afternoon, dinner, after dinner and another*) and the prevalence of realisation (%) 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 5 and 6 days, between 3 and 4 days, between 2 and 3 days and between 1 and 2 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 (kcal/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 US Department of Agriculture 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 standardised geometric figures representing foods to estimate portion sizes.[14] Based on the 24HR, the usual energy consumed per day (kcal/day) was estimated. Usual intake is one of the main confounding variables when studying Ow and Ob.[29 32 33] To estimate usual intake, the distribution of kilocalorie intake/day was normalised and corrected for intraperson variability using the methods proposed by the University of Iowa and PC-Side software V.1.0.[33]

In adolescents aged 6–17 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 min of moderate-intensity aerobic physical activity per week or 75 min of vigorous aerobic physical activity per week, according to the WHO's International Physical Activity Questionnaire.[35] The level of urbanisation was established based on the concentration of the population in three categories; urban centres: with more than 1 million inhabitants and large cities; small towns: between 100 000o inhabitants and less than 1 million inhabitants; and dispersed populations: less than 100 000 inhabitants.[14] The food security status of the household was established through the Latin American and Caribbean Food Security Scale.[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 wealth index 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]

Table 1 Number of meals/day and prevalence (95% CI) of overweight, obesity and central obesity in the Colombian population, 5–64 years old (*non-pregnant women*), Colombia, ENSIN, 2015

(n_1: n_2: n_3: n_4: n_5: n_6)* Number of meals/day (Based on FFQ)	Children 5–17 years % (95% CI)			Adults 18–64 years % (95% CI)		
	Overweight†	Obesity‡	Central obesity§	Overweight†	Obesity‡	Central obesity§
Total	18.5 (16.1 to 21.1)	6.7 (5.2 to 8.5)	4.0 (2.9 to 5.5)	32.3 (30.0 to 34.6)	13.1 (11.5 to 15.0)	44.8 (42.3 to 47.3)
Three or fewer (1054: 1117: 1559: 1838: 1879: 1534)	15.0 (11.7 to 19.0) (193)	5.2 (3.3 to 8.1) (63)	3.7 (2.5 to 5.4) (80)	37.8 (33.2 to 42.6) (444)	18.3 (14.9 to 22.2) (279)	48.9 (44.3 to 53.5) (636)
Four (1440: 1533: 1862: 2069: 1941: 1599)	20.8 (16.0 to 26.7) (244)	7.3 (4.9 to 10.8) (93)	4.0 (2.8 to 5.8) (76)	36.8 (32.1 to 41.8) (487)	12.3 (9.5 to 15.6) (207)	49.1 (44.3 to 53.9) (619)
Five or more (4091: 4335: 3732: 3939: 3009: 2267)	18.5 (16.1 to 21.2) (703)	6.8 (5.1 to 9.0) (244)	4.2 (2.7 to 6.4) (139)	26.7 (23.8 to 29.8) (566)	10.6 (8.3 to 13.4) (207)	38.6 (34.6 to 42.7) (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

*n_1: n_2: for children 5–17 years old for overweight and obesity, respectively, n_3: n_4: for adults 18–64 years old for overweight and obesity, respectively, n_5: 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]
BMI, body mass index; ENSIN, Encuesta Nacional de la Situación Nutricional; FFQ, Food Frequency Questionnaire.

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

		Overweight*			Obesity*	
Variable	**n**	**% (95% CI)**	**P value‡**	**n**	**% (95% CI)**	**P value‡**
Usual intake (kcal/day)†: mean±SD	6585	2104±76	0.983	6985	2015±106	0.258
Number of meals/day			0.372			0.459
3 or fewer	1054	15.0 (11.7 to 19.0)		1117	5.2 (3.3 to 8.1)	
4	1440	20.8 (16.0 to 26.7)		1533	7.3 (4.9 to 10.8)	
5 or more	4091	18.5 (16.1 to 21.2)		4335	6.8 (5.1 to 9.0)	
Sex			0.039			0.776
Males	3354	16.3 (14.1 to 18.7)		3557	6.9 (5.0 to 9.5)	
Females	3231	21.0 (17.2 to 25.4)		3428	6.5 (4.6 to 9.1)	
Age group (years)			0.434			0.062
Schoolchildren (5 to <13)	3187	19.5 (16.5 to 20.0)		3395	8.1 (5.6 to 11.5)	
Adolescents (13 to <18)	3398	17.6 (14.1 to 21.7)		3590	5.5 (4.4 to 6.7)	
Physical activity compliance			0.656			0.157
Yes	4690	18.7 (16.0 to 21.8)		4991	7.2 (5.5 to 9.5)	
No	1410	17.7 (14.0 to 22.1)		1484	5.4 (3.6 to 7.9)	
Household members			0.021			0.001
4 or fewer	3182	20.2 (17.2 to 23.6)		3433	9.5 (7.1 to 12.6)	
5–6	2275	18.3 (14.7 to 22.5)		2372	3.0 (2.1 to 4.4)	
7 or more	1128	13.4 (9.9 to 17.9)		1180	5.5 (3.7 to 8.2)	
Education of head			0.296			0.014
<5 (primary or less)	1941	16.8 (14.0 to 20.0)		2018	4.1 (3.0 to 5.6)	
5 to <11	2229	18.9 (15.2 to 23.1)		2371	6.6 (4.1 to 10.3)	
11 to <16	2044	19.7 (15.7 to 24.4)		2188	7.9 (5.3 to 11.6)	
≥16 (university)	329	18.2 (12.3 to 26.1)		361	10.1 (4.4 to 21.3)	
Wealth index, quintiles§			0.265			0.833
Q1	3414	18.6 (15.6 to 21.9)		3627	6.7 (4.4 to 10.2)	
Q2	1607	21.5 (16.5 to 27.4)		1702	6.4 (4.6 to 8.9)	
Q3	1058	14.5 (11.3 to 18.3)		1110	6.4 (3.2 to 12.2)	
Q4	506	17.6 (12.6 to 24.0)		546	8.0 (5.5 to 11.4)	
Food insecurity in the home¶			0.024			0.006
No	2048	22.4 (18.3 to 27.1)		2221	8.8 (6.5 to 12.0)	
Mild	2324	17.3 (14.5 to 20.4)		2463	6.7 (4.3 to 10.4)	
Moderate	1262	15.0 (11.8 to 19.0)		1319	3.6 (2.5 to 5.2)	
Severe	949	15.9 (11.3 to 21.8)		980	4.7 (2.8 to 8.0)	
Urbanicity			0.116			0.104
Big cities**	1020	22.1 (16.9 to 28.3)		1093	8.5 (5.6 to 12.9)	
100 001–1 000 000 population	1414	16.5 (13.7 to 19.8)		1503	6.5 (4.7 to 8.9)	
0–100 000 population	2587	15.9 (13.7 to 18.4)		2749	5.1 (3.8 to 6.7)	
Disperse population	1564	17.3 (14.6 to 20.5)		1640	5.3 (3.2 to 8.7)	
Country region			0.122			0.835
Central	1657	17.7 (15.5 to 20.1)		1764	8.1 (5.3 to 12.0)	
Atlantic (North)	956	15.7 (12.2 to 19.9)		999	4.6 (3.1 to 6.8)	
Oriental	1064	15.9 (12.7 to 19.8)		1121	4.8 (3.0 to 7.7)	
Pacific (West)	926	21.3 (14.9 to 29.4)		980	6.5 (4.3 to 9.8)	
Bogotá	493	22.8 (15.0 to 33.0)		523	9.2 (4.4 to 18.0)	
Amazonia-Orinoquia	1489	18.1 (14.8 to 21.8)		1598	6.4 (4.4 to 9.3)	

Continued

Table 2 Continued

Variable	n	Overweight* % (95% CI)	P value‡	n	Obesity* % (95% CI)	P value‡

n=the analysed 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/day=4.18 kJ/day. Based on usual intake, incorporating intrasubject 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 (Food and Agriculture Organization of the United Nations. FAO).[36]
**Bogotá, Barranquilla, Medellín, Cali.
BMI, body mass index; ELCSA, Latin American and Caribbean Food Security Scale; ENSIN, Encuesta Nacional de la Situación Nutricional.

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

	PR for meal frequency (95% CI)			
	Overweight*		Obesity*	
Explanatory variable	Crude	Adjusted†	Crude	Adjusted†
Number of meals/day				
3 or fewer	1	1	1	1
4	1.49 (1.00 to 2.23)	1.29 (0.86 to 1.91)	1.44 (0.84 to 2.47)	1.14 (0.62 to 2.07)
5 or more	1.28 (0.94 to 1.76)	1.10 (0.79 to 1.53)	1.34 (0.83 to 2.14)	0.95 (0.57 to 1.59)
Sex				
Males	1	1	1	1
Females	1.37 (1.01 to 1.84)	1.43 (1.07 to 1.92)	0.93 (0.57 to 1.53)	0.97 (0.60 to 1.58)
Household members				
1–4	1	1	1	1
5–6	0.88 (0.66 to 1.17)	0.90 (0.67 to 1.20)	0.30 (0.20 to 0.45)	0.32 (0.21 to 0.49)
7+	0.61 (0.41 to 0.91)	0.60 (0.39 to 0.90)	0.56 (0.33 to 0.96)	0.75 (0.43 to 1.29)
Education of head				
<5 (primary or less)	1	1	1	1
5 to <11	1.15 (0.86 to 1.55)	1.02 (0.75 to 1.39)	1.64 (0.90 to 3.03)	1.28 (0.70 to 2.35)
11 to <16	1.21 (0.91 to 1.63)	1.03 (0.77 to 1.37)	2.01 (1.14 to 3.57)	1.37 (0.83 to 2.24)
≥16 (university)	1.10 (0.67 to 1.86)	0.82 (0.47 to 1.45)	2.63 (1.02 to 6.80)	1.81 (0.76 to 4.29)
Food insecurity in the home‡				
No	1	1	1	1
Mild	0.72 (0.54 to 0.97)	0.79 (0.59 to 1.07)	0.74 (0.45 to 1.24)	0.83 (0.49 to 1.43)
Moderate	0.61 (0.42 to 0.89)	0.70 (0.47 to 1.04)	0.38 (0.24 to 0.62)	0.46 (0.28 to 0.76)
Severe	0.65 (0.42 to 1.02)	0.78 (0.47 to 1.30)	0.51 (0.26 to 1.02)	0.71 (0.34 to 1.49)
Urbanicity				
Big cities§	1	1	1	1
100 001–1 000 000 population	0.70 (0.47 to 1.04)	0.71 (0.49 to 1.02)	0.75 (0.42 to 1.32)	0.92 (0.56 to 1.51)
0–100 000 population	0.67 (0.46 to 0.98)	0.66 (0.47 to 0.93)	0.57 (0.33 to 0.99)	0.65 (0.39 to 1.09)
Disperse population	0.74 (0.50 to 1.10)	0.80 (0.56 to 1.14)	0.60 (0.30 to 1.21)	0.72 (0.37 to 1.41)

*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 PRs, in addition to the covariates in the table, the usual intake of kcal/day (continuous), age (continuous) and physical activity compliance (binomial) were included.
‡Estimated with ELCSA scale (Food and Agriculture Organization of the United Nations.FAO).[36]
§Bogotá, Barranquilla, Medellín, Cali.
BMI, body mass index; ELCSA, Encuesta Nacional de la Situación Nutricional; ENSN, Encuesta Nacional de la Situación Nutricional.

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

		Overweight* (1497)			Obesity* (693)	
Variable	**n**	**% (95% CI)**	**P value‡**	**n**	**% (95% CI)**	**P value‡**
Usual intake (kcal/day)†: mean±SD	7153	1953±31	0.185	7846	2085±78	0.167
Number of meals/day			<0.0001			0.001
3 or fewer	1559	37.8 (33.2 to 42.6)		1838	18.3 (14.9 to 22.2)	
4	1862	36.8 (32.1 to 41.8)		2069	12.3 (9.5 to 15.6)	
5 or more	3132	26.7 (23.8 to 20.9)		3939	10.6 (8.3 to 13.4)	
Sex			0.435			0.527
Males	3357	31.2 (28.0 to 34.6)		3673	13.7 (11.2 to 16.7)	
Females	3796	33.1 (29.9 to 36.6)		4173	12.6 (10.5 to 15.1)	
Age group (years)			0.436			0.711
Young adult (18 to <26)	1533	30.6 (26.0 to 35.6)		1669	13.8 (10.1 to 18.5)	
Older adult (27 to <64)	5620	32.8 (30.2 to 35.5)		6177	12.9 (11.1 to 15.0)	
Physical activity compliance			0.47			0.019
Yes	5019	32.2 (29.3 to 35.3)		5543	14.6 (12.4 to 17.1)	
No	1770	34.1 (30.1 to 38.3)		1928	10.3 (8.0 to 13.1)	
Household members			0.034			0.153
4 or fewer	3879	34.8 (31.6 to 38.1)		4336	14.3 (12.0 to 16.9)	
5–6	2174	27.2 (24.3 to 30.3)		2338	10.8 (8.6 to 13.5)	
7 or more	1100	31.0 (25.6 to 37.0)		1172	12.0 (8.0 to 17.6)	
Education of head			0.001			0.839
<5 (primary or less)	2112	27.7 (24.6 to 31.0)		2336	13.3 (10.7 to 16.3)	
5 to <11	2426	29.9 (26.7 to 33.3)		2650	13.2 (10.1 to 17.0)	
11 to <16	2204	36.4 (32.2 to 40.9)		2393	12.3 (9.6 to 15.6)	
≥16 (university)	366	39.4 (29.9 to 49.7)		418	15.9 (10.0 to 24.1)	
Wealth index, quintiles§			0.737			0.547
Q1	3246	29.8 (27.1 to 32.7)		3554	12.5 (10.5 to 14.8)	
Q2	1695	35.1 (30.9 to 39.4)		1854	14.4 (10.9 to 18.7)	
Q3	1399	35.6 (30.3 to 41.2)		1525	11.1 (8.1 to 15.2)	
Q4	813	27.9 (21.9 to 34.8)		913	15.9 (11.3 to 21.9)	
Food insecurity in the home¶			0.462			0.532
No	2395	33.9 (30.1 to 37.9)		2660	14.9 (11.9 to 18.5)	
Mild	2536	30.9 (27.8 to 34.2)		2781	10.9 (9.0 to 13.1)	
Moderate	1366	33.0 (27.9 to 38.6)		1481	13.2 (9.6 to 17.9)	
Severe	855	30.0 (21.7 to 39.9)		923	13.5 (8.8 to 20.3)	
Urbanicity			0.16			0.361
Big cities**	735	36.2 (30.4 to 42.5)		803	13.9 (9.7 to 19.3)	
100 001–1 000 000 population	1836	31.0 (27.0 to 35.2)		2043	14.3 (11.5 to 17.8)	
0–100 000 population	2701	31.2 (28.3 to 34.3)		2960	11.4 (9.2 to 14.0)	
Disperse population	1881	30.1 (27.4 to 34.6)		2040	12.3 (9.8 to 15.3)	

Continued

Table 4 Continued

Variable	n	Overweight* (1497) % (95% CI)	P value‡	n	Obesity* (693) % (95% CI)	P value‡
Country region			0.008			0.121
Central	1675	29.9 (26.5 to 33.6)		1856	13.8 (10.9 to 17.3)	
Atlantic (North)	1448	28.1 (25.1 to 31.3)		1602	14.6 (11.7 to 18.2)	
Oriental	1424	31.8 (28.2 to 35.5)		1564	13.6 (10.4 to 17.5)	
Pacific (West)	891	36.9 (29.3 to 45.3)		974	14.6 (9.6 to 21.7)	
Bogotá	472	37.0 (29.7 to 44.1)		495	8.1 (4.4 to 14.5)	
Amazonia-Orinoquia	1243	37.8 (33.6 to 42.1)		1355	13.3 (9.6 to 18.2)	

n=the analysed 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/day=4.18 kJ/day. Based on usual intake, incorporating intrasubject 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 (Food and Agriculture Organization of the United Nations. FAO).[36]
**Bogotá, Barranquilla, Medellín, Cali.
BMI, body mass index; ELCSA, Latin American and Caribbean Food Security Scale; ENSIN, Encuesta Nacional de la Situación Nutricional.

Statistical analysis

The prevalence of Ow, Ob and CO and the 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 (generalised linear models: family binomial). Through binomial regression, crude and adjusted relative prevalence ratios (PRs), equivalent to relative risk ratios, 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 V.14.1.[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 anonymised data, no authorisation 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±SD) 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 three or fewer meals/day, 20.8% had four meals/day and 65.2% had five 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 three or fewer meals/day, 27.8% had four meals/day and 45.5% had five 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 to 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 Ow (26.7%) compared with 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 Ow (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 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 0.45 to 0.76). The same was observed for the risk of Ob, which was lower when participants ate four or five meals/day vs

Table 5 Prevalence ratios (PR) for the number of meals/day, potential confounders and overweight and obesity in adults aged 18–64 years (*non-pregnant women*), Colombia, ENSIN, 2015

	PR for meal frequency (95% CI)			
	Overweight*		Obesity*	
Explanatory variable	Crude	Adjusted†	Crude	Adjusted†
Number of meals/day				
3 or fewer	1	1	1	1
4	0.96 (0.72 to 1.23)	0.97 (0.72 to 1.30)	0.62 (0.43 to 0.90)	0.61 (0.42 to 0.88)
5 or more	0.60 (0.47 to 0.77)	0.58 (0.45 to 0.76)	0.53 (0.38 to 0.75)	0.51 (0.36 to 0.72)
Sex				
Males	1	1	1	1
Females	1.09 (0.87 to 1.37)	1.04 (0.82 to 1.32)	0.91 (0.67 to 1.23)	0.98 (0.73 to 1.32)
Household members				
1–4	1	1	1	1
5–6	0.70 (0.57 to 0.86)	0.76 (0.61 to 0.94)	0.72 (0.52 to 1.00)	0.75 (0.54 to 1.02)
7+	0.84 (0.62 to 1.14)	1.02 (0.74 to 1.39)	0.81 (0.50 to 1.33)	0.90 (0.52 to 1.54)
Education of head				
<5 (primary or less)	1	1	1	1
5 to <11	1.11 (0.88 to 1.41)	1.08 (0.85 to 1.40)	0.99 (0.68 to 1.46)	0.96 (0.66 to 1.41)
11 to <16	1.49 (1.16 to 1.92)	1.51 (1.14 to 2.01)	0.91 (0.63 to 1.33)	0.84 (0.57 to 1.24)
≥16 (university)	1.70 (1.01 to 2.65)	1.68 (1.02 to 2.76)	1.23 (0.69 to 2.19)	1.06 (0.58 to 1.95)
Food insecurity in the home‡				
No	1	1	1	1
Mild	0.87 (0.70 to 1.08)	0.92 (0.73 to 1.17)	0.70 (0.50 to 0.97)	0.67 (0.47 to 0.96)
Moderate	0.96 (0.70 to 1.31)	0.98 (0.72 to 1.34)	0.87 (0.56 to 1.36)	0.81 (0.49 to 1.34)
Severe	0.84 (0.52 to 1.34)	0.89 (0.54 to 1.48)	0.89 (0.51 to 1.56)	0.82 (0.44 to 1.55)
Urbanicity				
Big cities§	1	1	1	1
100 001–1 000 000 population	0.79 (0.57 to 1.09)	0.84 (0.60 to 1.16)	1.04 (0.65 to 1.67)	1.08 (0.66 to 1.76)
0–100 000 population	0.80 (0.59 to 1.07)	0.90 (0.67 to 1.22)	0.80 (0.50 to 1.27)	0.81 (0.49 to 1.35)
Disperse population	0.79 (0.58 to 1.07)	0.90 (0.65 to 1.23)	0.87 (0.54 to 1.40)	0.86 (0.51 to 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 PRs, in addition to the covariates in the table, the usual intake of kcal/day (continuous), age (continuous) and physical activity compliance (binomial) were included.
‡Estimated with ELCSA scale (Food and Agriculture Organization of the United Nations. FAO).[36]
§Bogotá, Barranquilla, Medellín, Cali.
BMI, body mass index; ELCSA, Latin American and Caribbean Food Security Scale; ENSIN, Encuesta Nacional de la Situación Nutricional.

Table 6 Prevalence ratios (PR) for the number of meals/day, potential confounders and central obesity (*abdominal obesity**) in the Colombian population aged 5–64 years (*non-pregnant women*), Colombia, ENSIN, 2015

	PR for meal frequency (95% CI)			
	Children 5–17 years		Adults 18–64 years	
Explanatory variable	Crude	Adjusted†	Crude	Adjusted†
Number of meals/day				
3 or fewer	1	1	1	1
4	1.10 (0.71 to 1.70)	1.03 (0.65 to 1.61)	1.00 (0.78 to 1.31)	1.08 (0.82 to 1.43)
5 or more	1.15 (0.80 to 1.67)	1.06 (0.72 to 1.55)	0.66 (0.51 to 0.84)	0.70 (0.54 to 0.92)
Sex				
Males	1	1	1	1
Females	0.30 (0.20 to 0.45)	0.29 (0.19 to 0.43)	3.23 (2.62 to 4.00)	3.34 (2.69 to 4.14)
Household members				
1–4	1	1	1	1
5–6	1.06 (0.60 to 1.88)	1.08 (0.58 to 2.01)	0.80 (0.65 to 1.00)	0.76 (0.61 to 0.95)
7+	0.91 (0.49 to 1.71)	0.91 (0.47 to 1.73)	1.11 (0.83 to 1.50)	1.06 (0.78 to 1.44)
Education of head				
<5 (primary or less)	1	1	1	1
5 to <11	0.59 (0.33 to 1.06)	0.52 (0.26 to 1.02)	0.94 (0.74 to 1.19)	0.91 (0.71 to 1.17)
11 to <16	0.92 (0.61 to 1.39)	0.84 (0.53 to 1.34)	1.06 (0.82 to 1.36)	1.05 (0.80 to 1.39)
≥16 (university)	0.77 (0.22 to 2.68)	0.71 (0.19 to 2.66)	0.95 (0.62 to 1.47)	0.86 (0.51 to 1.45)
Food insecurity in the home‡				
No	1	1	1	1
Mild	0.95 (0.66 to 1.37)	0.94 (0.66 to 1.36)	0.80 (0.64 to 1.01)	0.77 (0.60 to 0.98)
Moderate	1.07 (0.68 to 1.69)	1.14 (0.71 to 1.83)	1.06 (0.80 to 1.42)	0.99 (0.74 to 1.33)
Severe	0.92 (0.53 to 1.60)	1.03 (0.58 to 1.84)	1.02 (0.67 to 1.56)	0.95 (0.59 to 1.52)

*Based on International Diabetes Federation.[28]
†Multiple binomial regression. In the adjustment of the PRs, in addition to the covariates in the table, the usual intake of kcal/day (continuous), age (continuous) and physical activity compliance (binomial) were included.
‡Estimated with ELCSA scale (Food and Agriculture Organization of the United Nations. FAO).[36]
ELCSA, Latin American and Caribbean Food Security Scale; ENSIN, Encuesta Nacional de la Situación Nutricional.

three or fewer meals/day, with adjusted PRs of 0.61 (95% CI 0.42 to 0.88) and 0.51 (95% CI 0.36 to 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 vs three or fewer meals/day, with an adjusted PR of 0.70 (95% CI 0.54 to 0.92) (table 6). Online supplemental table 1S presents the prevalence of CO for the categories of the variables of interest in both children and adults.

DISCUSSION

Based on cross-sectional data, we established that the number of meals/day was not associated with Ow, Ob or CO 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 2 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 vs seven meals/day).[45] In Louisiana (USA), no effect was found between each meal episode/day and Ob in 10-year-old children, with an OR of 0.91 (95% CI 0.72 to 1.15).[46] In the same study, no relationship was found between the number of meals/day and Ow after two decades of follow-up.[47] In children aged between 5 and 6 years in Bavaria (Germany), an inverse association was found: eating three meals/day or more protected children against childhood Ob, with adjusted ORs of 0.73 (95% CI 0.44 to 1.21) for four meals/day and 0.51 (95% CI 0.29 to 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 to 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 9–10 years at baseline was lower when they ate three or more meals/day compared with those who ate <3 meals/day.[50] A meta-analysis reviewing 57 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, adjusted ORs of 1.54 (95% CI 1.23 to 1.93) for Ob in men and 1.45 (95% CI 1.17 to 1.81) for Ob in women were found for five or more meals/day vs ≤3 meals/day. An OR of 1.42 (95% CI 1.15 to 1.75) was found for CO in men and an OR of 1.29 (95% CI 1.05 to 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 to 4.19).[51] In British adults aged 19–64 years, a direct association was found among the number of meals/day, BMI-based Ob and CO.[20] Adults from Puerto Rico aged 30–75 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 to 6.15), or when they consumed ≥3 meals/day (OR 2.88; 95% CI 1.14 to 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 10 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 under-reporting of energy intake/day consumed among Ow 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 analysed 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, 10 potential confounding variables were used for risk adjustment (Prevalence Ratio, PR), 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 10 covariates as potential confounders, there may still be residual or unmeasured confounders in the ENSIN-2015 (eg, 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 and food-insecure

countries.[14 38] Increasing the number of meals/day is a potential strategy for the control of Ow, Ob and CO.

Contributors CH-F and OFH designed the research. OFH led the statistical analysis. CH-F participated in the statistical analysis. CH-F and OFH wrote the paper. OFH had primary responsibility for the final content. All authors have read and approved the final version of the manuscript. OFH is the guarantor of the study.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants. Because this study was carried out with anonymised secondary information (public anonymous databases), the health research ethics committee of the Universidad Industrial de Santander did not have to issue approval for the study. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request.

ORCID iDs
Oscar Fernando Herrán http://orcid.org/0000-0002-2509-8636
Catalina Herrán-Fonseca http://orcid.org/0000-0002-5422-8751

REFERENCES

1 Eknoyan G. A history of obesity, or how what was good became ugly and then bad. *Adv Chronic Kidney Dis* 2006;13:421–7.
2 Beller AS. *Fat and thin: a natural history of obesity. Farrar, Strauss*. New York, NY: Giroux, 1977.
3 James WPT. WHO recognition of the global obesity epidemic. *Int J Obes* 2008;32:S120–6.
4 Myung J, Jung KY, Kim TH, *et al*. Assessment of the validity of multiple obesity indices compared with obesity-related co-morbidities. *Public Health Nutr* 2019;22:1–9.
5 Toschke AM, Küchenhoff H, Koletzko B, *et al*. Meal frequency and childhood obesity. *Obes Res* 2005;13:1932–8.
6 Chooi YC, Ding C, Magkos F. The epidemiology of obesity. *Metabolism* 2019;92:6–10.
7 Janakiraman B, Abebe SM, Chala MB, *et al*. Epidemiology of general, central obesity and associated Cardio-Metabolic risks among university employees, Ethiopia: a cross-sectional study. *Diabetes Metab Syndr Obes* 2020;13:345–53.
8 Flegal KM, Kit BK, Orpana H, *et al*. Association of all-cause mortality with overweight and obesity using standard body mass index categories: a systematic review and meta-analysis. *JAMA* 2013;309:71–82.
9 Czernichow S, Kengne A-P, Stamatakis E, *et al*. Body mass index, waist circumference and waist-hip ratio: which is the better discriminator of cardiovascular disease mortality risk?: evidence from an individual-participant meta-analysis of 82 864 participants from nine cohort studies. *Obes Rev* 2011;12:680–7.
10 Carlsson AC, Riserus U, Ärnlöv J, *et al*. Prediction of cardiovascular disease by abdominal obesity measures is dependent on body weight and sex – results from two community based cohort studies. *Nutr Metab Cardiovasc Dis* 2014;24:891–9.
11 de Koning L, Merchant AT, Pogue J, *et al*. Waist circumference and waist-to-hip ratio as predictors of cardiovascular events: meta-regression analysis of prospective studies. *Eur Heart J* 2007;28:850–6.
12 Kasper NM, Herrán OF, Villamor E. Obesity prevalence in Colombian adults is increasing fastest in lower socio-economic status groups and urban residents: results from two nationally representative surveys. *Public Health Nutr* 2014;17:2398–406.
13 Herrán OF, Patiño GA, Del Castillo S. "Transición alimentaria y exceso de peso en adultos. Encuesta de la Situación Nutricional en Colombia, 2010". *Biomédica* 2016;36:109–20.
14 "ICBF, Minsalud (Colombia). Metodología ENSIN-2015". ICBF,, 2021. Available: www.minsalud.gov.co/sites/rid/Lists/BibliotecaDigital/RIDE/VS/ED/GCFI/documento-metodologico-ensin-2015.pdf
15 Mattson MP, Allison DB, Fontana L, *et al*. Meal frequency and timing in health and disease. *Proc Natl Acad Sci U S A* 2014;111:16647–53.
16 Zea MDP, Herrán OF. Meal pattern in the Colombian population: results of the National nutrition survey. ENSIN, 2015. *J Nutr Metab* 2022;2022:1047524.
17 Jon Schoenfeld B, Albert Aragon A, Krieger JW. Effects of meal frequency on weight loss and body composition: a meta-analysis. *Nutr Rev* 2015;73:69–82.
18 Dallacker M, Hertwig R, Mata J. The frequency of family meals and nutritional health in children: a meta-analysis. *Obesity Reviews* 2018;19:638–53.
19 Murakami K, Livingstone MBE. Eating frequency is positively associated with overweight and central obesity in US adults. *J Nutr* 2015;145:2715–24.
20 Murakami K, Livingstone MBE. Eating frequency in relation to body mass index and waist circumference in British adults. *Int J Obes* 2014;38:1200–6.
21 Leech RM, Worsley A, Timperio A, *et al*. Understanding meal patterns: definitions, methodology and impact on nutrient intake and diet quality. *Nutr Res Rev* 2015;28:1–21.
22 Alencar MK, Beam JR, McCormick JJ, *et al*. Increased meal frequency attenuates fat-free mass losses and some markers of health status with a portion-controlled weight loss diet. *Nutr Res* 2015;35:375–83.
23 Kulovitz MG, Kravitz LR, Mermier C, *et al*. Potential role of meal frequency as a strategy for weight loss and health in overweight or obese adults. *Nutrition* 2014;30:386–92.
24 Azizi N, Shab-Bidar S, Bazshahi E, *et al*. Joint association of meal frequency and diet quality with metabolic syndrome in Iranian adults. *BMC Nutr* 2022;8:12.
25 Jenkins DJA, Wolever TMS, Vuksan V, *et al*. Nibbling versus gorging: metabolic advantages of increased meal frequency. *N Engl J Med Overseas Ed* 1989;321:929–34.
26 de Onis M. Development of a WHO growth reference for school-aged children and adolescents. *Bull World Health Organ* 2007;85:660–7.
27 WHO-World Health Organization. *"Patrones de Crecimiento Infantil de la OMS". World Health Organization*. Geneva, Switzerland, 2011.
28 Xi B, Zong Xin'nan, Kelishadi R, *et al*. International waist circumference percentile cutoffs for central obesity in children and adolescents aged 6 to 18 years. *J Clin Endocrinol Metab* 2020;105:e1569–83.
29 Willet WC. *Nutritional epidemiology*. Third ed. New York, NY: Oxford University Press, 2013.
30 Blanton CA, Moshfegh AJ, Baer DJ, *et al*. The USDA automated Multiple-Pass method accurately estimates group total energy and nutrient intake. *J Nutr* 2006;136:2594–9.
31 AMPM—USDA automated multiple-pass method: USDA ARS, 2020. Available: www.ars.usda.gov/northeast-area/beltsville-md-bhnrc/beltsville-human-nutrition-researchcenter/ food-surveys-research-group/docs/ampm-usdaautomated-multiple-pass-method/
32 NIH. National cancer Institute: dietary assessment primer, 2022. Available: https://dietassessmentprimer.cancer.gov/profiles/recall/
33 Guenther PM, Kott PS, Carriquiry AL. Development of an approach for estimating usual nutrient intake distributions at the population level. *J Nutr* 1997;127:1106–12.
34 MMWR-CDC. Methodology of the youth risk behavior surveillance system, 2013 recommendations and reports / Vol. 62 / No. 1. Available: www.cdc.gov/mmwr/pdf/rr/rr6201.pdf
35 Craig CL, Marshall AL, Sjöström M, *et al*. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc* 2003;35:1381–95.
36 FAO. Escala Latinoamericana y Caribeña de Seguridad Alimentaria (ELCSA) - Manual de uso y aplicación, 2012. Available: www.rlc.fao.org

37 Rutstein SO. The DHS wealth index: approaches for rural and urban areas, 2008. Available: www.academia.edu/63270387/The_DHS_Wealth_Index_Approaches_for_Rural_and_Urban_Areas
38 PNUD. Informe sobre desarrollo humano. Colombia, 2019. Available: www.co.undp.org/content/colombia/es/home/library/human_development/informe-sobre-desarrollo-humano-2019.html
39 Cuzick J. A wilcoxon-type test for trend. *Stat Med* 1985;4:543–7.
40 Buonaccorsi JP, Laake P, Veierød MB. On the power of the Cochran-Armitage test for trend in the presence of misclassification. *Stat Methods Med Res* 2014;23:218–43.
41 StatCorp. *Stata statistical software: release 10*. College Station, TX: StataCorp, 2007.
42 World Medical Association. Declaración de Helsinki de la AMM—ethical principles for human medical research, 2015. Available: www.wma.net/es/policies-post/declaracion-de-helsinki-dela-amm-principios-eticos-para-las-investigaciones-medicas-en-seres-humanos/
43 Ministerio de Salud (Colombia). *Resolución Numero 8430 de 1993. República de Colombia*. Ministerio de Salud, 1993.
44 Taylor RW, Iosua E, Heath A-LM, *et al*. Eating frequency in relation to BMI in very young children: a longitudinal analysis. *Public Health Nutr* 2017;20:1372–9.
45 Fábry P, Hejda S, Cerný K, *et al*. Effect of meal frequency in schoolchildren. changes in weight-height proportion and skinfold thickness. *Am J Clin Nutr* 1966;18:358–61.
46 Nicklas TA, Yang S-J, Baranowski T, *et al*. Eating patterns and obesity in children. The Bogalusa heart study. *Am J Prev Med* 2003;25:9–16.
47 Nicklas TA, Morales M, Linares A, *et al*. Children's meal patterns have changed over a 21-year period: the Bogalusa heart study. *J Am Diet Assoc* 2004;104:753–61.
48 Bernabe-Ortiz A, Carrillo-Larco RM. Longitudinal association between food frequency and changes in body mass index: a prospective cohort study. *BMJ Open* 2020;10:e037057.
49 Serrano M, Torres R, Pérez CM, *et al*. Social environment factors, diet quality, and body weight in 12-year-old children from four public schools in Puerto Rico. *P R Health Sci J* 2014;33:80–7.
50 Franko DL, Striegel-Moore RH, Thompson D, *et al*. The relationship between meal frequency and body mass index in black and white adolescent girls: more is less. *Int J Obes* 2008;32:23–9.
51 Munyogwa MJ, Ntalima KS, Kapalata SN. Setting – based prevalence and correlates of central obesity: findings from a cross-sectional study among formal sector employees in Dodoma City, central Tanzania. *BMC Public Health* 2021;21:97.
52 Tamez M, Rodriguez-Orengo JF, Mattei J. Higher eating frequency, but not skipping breakfast, is associated with higher odds of abdominal obesity in adults living in Puerto Rico. *Nutr Res* 2020;73:75–82.
53 Leech RM, Spence AC, Lacy KE, *et al*. Characterizing children's eating patterns: does the choice of eating occasion definition matter? *Int J Behav Nutr Phys Act* 2021;18:165.
54 Kaaks R, Plummer M, Riboli E, *et al*. Adjustment for bias due to errors in exposure assessments in multicenter cohort studies on diet and cancer: a calibration approach. *Am J Clin Nutr* 1994;59:245S–50.
55 Tylavsky FA, Sharp GB. Misclassification of nutrient and energy intake from use of closed-ended questions in epidemiologic research. *Am J Epidemiol* 1995;142:342–52.
56 Beaton GH, Milner J, Corey P, *et al*. Sources of variance in 24-hour dietary recall data: implications for nutrition study design and interpretation. *Am J Clin Nutr* 1979;32:2546–59.