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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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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 ≥25 and <30 (kg/m²). 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 0.57 to 1.59) 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.

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/m²) 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.\(^8\) \(\text{CO is the best predictor of metabolic syndrome, cardiovascular disease and mortality.}\(^9\)\text{–}^{11}\

The epidemiology of \(\text{Ob is well known.}\) \(\text{Ob occurs regardless of ethnicity, geographic location and socioeconomic status and has increased in people of all ages.}\) 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.\(^6\)\text{ 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 \(\text{Ow, Ob and CO.}\)\text{\textsuperscript{5,7}}\)

Colombia is a developing country located in the northwestern corner of South America, where two transitions are taking place simultaneously: a nutritional transition, where \(\text{Ow is now predominant instead of malnutrition, and an alimentary transition, where the traditional diet is beginning to be abandoned and a more Western-type diet is being incorporated.}\)\text{\textsuperscript{12,13}} In Colombia, the rate of excess weight (\(\text{Ow+Ob}\)) 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 17.0% in 2015; and in adults (18–64 years), it was 45.9% in 2005, 51.2% in 2010 and 56.5% in 2015.\text{\textsuperscript{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.\text{\textsuperscript{12}} The prevalence of \(\text{Ob in adults (BMI ≥30 kg/m}^2\) was 13.9% in 2005, 16.4% in 2010 and 18.7% in 2015.\text{\textsuperscript{14}} The nutritional transition is occurring more rapidly in the poorest individuals and those living in urban areas. Moreover, women are at a disadvantage.\text{\textsuperscript{12}}

The \(\text{Ob epidemic developed under a dietary pattern of three dense and two intermediate meals per day (meals/day).\text{\textsuperscript{15,16}}}}\text{ Regardless of the total energy intake and the possible confounding factors mentioned above, the number of meals/day has been inversely associated with \(\text{Ob in children and directly associated with \(\text{Ob and CO in adults.}\)\text{\textsuperscript{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.\text{\textsuperscript{3,19–21}} The number of meals/day affects metabolism and the mechanisms involved in visceral and body fat deposition.\text{\textsuperscript{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.\text{\textsuperscript{24}}}}\text{ 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.\text{\textsuperscript{25}}\text{ The number of meals/day is associated with \(\text{BMI, body composition, health markers such as lipid profiles, postprandial insulin, lipid and glucose concentrations and the sensation of hunger and satiety.}\text{\textsuperscript{23}}}}\text{ In Colombia, there is a growing interest in controlling \(\text{Ow, Ob and metabolic markers through the number of meals due to the increase in chronic diseases associated with \(\text{Ob.}\)\text{\textsuperscript{23}} However, given that evidence on the relationship between the number of meals/day and \(\text{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 \(\text{Ow, Ob and CO in apparently healthy Colombian children and adults.}}\)}\)

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).\text{\textsuperscript{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’.\text{\textsuperscript{14}} ENSIN was carried out in Colombia in 2005, 2010 and 2015.\text{\textsuperscript{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.\text{\textsuperscript{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 15,043 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 (ShortBoard) 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. 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. In adults, BMI was established as kg/m². 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.

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.

**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. 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. 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.

The 24HR applied in the ENSIN-2015 used standardised geometric figures representing foods to estimate portion sizes. 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. 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-Describe software V.1.0.

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. 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. 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 100 000 and 1 million inhabitants; and dispersed populations; less than 100 000 inhabitants. The food security status of the household was established through the Latin American and Caribbean Food Security Scale. 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. 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, 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.
| 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)            | 5.2 (3.3 to 8.1)                | 3.7 (2.5 to 5.4)                      | 37.8 (33.2 to 42.6)             | 18.3 (14.9 to 22.2)             | 48.9 (44.3 to 53.5)                |
| Four                          |                                 |                                |                                     |                                |                                |                                  |
| (1440: 1533: 1862: 2069: 1941: 1599) | 20.8 (16.0 to 26.7)           | 7.3 (4.9 to 10.8)               | 4.0 (2.8 to 5.8)                      | 36.8 (32.1 to 41.8)             | 12.3 (9.5 to 15.6)             | 49.1 (44.3 to 53.9)                |
| Five or more                  |                                 |                                |                                     |                                |                                |                                  |
| (4091: 4335: 3732: 3939: 3009: 2267) | 18.5 (16.1 to 21.2)          | 6.8 (5.1 to 9.0)                | 4.2 (2.7 to 6.4)                      | 26.7 (23.8 to 29.8)             | 10.6 (8.3 to 13.4)             | 38.6 (34.6 to 42.7)                |
| 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: n; for children 5–17 years old for overweight and obesity, respectively, n: n: for adults 18–64 years old for overweight and obesity, respectively, n: n: 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/m²), 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/m²), BMI≥30.

§Based on International Diabetes Federation.28

BMI, body mass index; ENSIN, Encuesta Nacional de la Situación Nutricional; FFQ, Food Frequency Questionnaire.
| Variable                                    | n   | Overweight* (95% CI) | P value‡ | Obesity* (95% CI) | P value‡ |
|----------------------------------------------|-----|----------------------|----------|-------------------|----------|
| Usual intake (kcal/day)†: mean±SD           |     | 2104±76              | 0.983    | 2015±106          | 0.258    |
| Number of meals/day                          | 0.372 |                      | 0.459    |                   |          |
| 3 or fewer                                   | 1054 | 15.0 (11.7 to 19.0)  |          |                   |          |
| 4                                             | 1440 | 20.8 (16.0 to 26.7)  |          |                   |          |
| 5 or more                                     | 4091 | 18.5 (16.1 to 21.2)  |          |                   |          |
| Sex                                           | 0.039 |                      | 0.776    |                   |          |
| Males                                         | 3557 | 6.9 (5.0 to 9.5)     |          |                   |          |
| Females                                       | 3428 | 6.5 (4.6 to 9.1)     |          |                   |          |
| Age group (years)                             | 0.434 |                      | 0.062    |                   |          |
| Schoolchildren (5 to <13)                    | 3395 | 8.1 (5.6 to 11.5)    |          |                   |          |
| Adolescents (13 to <18)                      | 3590 | 5.5 (4.4 to 6.7)     |          |                   |          |
| Physical activity compliance                 | 0.656 |                      | 0.157    |                   |          |
| Yes                                           | 4991 | 7.2 (5.5 to 9.5)     |          |                   |          |
| No                                            | 1484 | 5.4 (3.6 to 7.9)     |          |                   |          |
| Household members                             | 0.021 |                      | 0.001    |                   |          |
| 4 or fewer                                    | 3433 | 9.5 (7.1 to 12.6)    |          |                   |          |
| 5–6                                           | 2372 | 3.0 (2.1 to 4.4)     |          |                   |          |
| 7 or more                                     | 1180 | 5.5 (3.7 to 8.2)     |          |                   |          |
| Education of head                             | 0.296 |                      | 0.014    |                   |          |
| <5 (primary or less)                          | 2018 | 4.1 (3.0 to 5.6)     |          |                   |          |
| 5 to <11                                      | 2371 | 6.6 (4.1 to 10.3)    |          |                   |          |
| 11 to <16                                     | 2188 | 7.9 (5.3 to 11.6)    |          |                   |          |
| ≥16 (university)                              | 361  | 10.1 (4.4 to 21.3)   |          |                   |          |
| Wealth index, quintiles§                     | 0.265 |                      | 0.833    |                   |          |
| Q1                                            | 3627 | 6.7 (4.4 to 10.2)    |          |                   |          |
| Q2                                            | 1702 | 6.4 (4.6 to 8.9)     |          |                   |          |
| Q3                                            | 1110 | 6.4 (3.2 to 12.2)    |          |                   |          |
| Q4                                            | 546  | 8.0 (5.5 to 11.4)    |          |                   |          |
| Food insecurity in the home¶                 | 0.024 |                      | 0.006    |                   |          |
| No                                            | 2221 | 8.8 (6.5 to 12.0)    |          |                   |          |
| Mild                                          | 2463 | 6.7 (4.3 to 10.4)    |          |                   |          |
| Moderate                                      | 1319 | 3.6 (2.5 to 5.2)     |          |                   |          |
| Severe                                        | 980  | 4.7 (2.8 to 8.0)     |          |                   |          |
| Urbanicity                                    | 0.116 |                      | 0.104    |                   |          |
| Big cities**                                  | 1093 | 8.5 (5.6 to 12.9)    |          |                   |          |
| 100 001–1 000 000 population                  | 1503 | 6.5 (4.7 to 8.9)     |          |                   |          |
| 0–100 000 population                          | 2749 | 5.1 (3.8 to 6.7)     |          |                   |          |
| Disperse population                           | 1640 | 5.3 (3.2 to 8.7)     |          |                   |          |
| Country region                                | 0.122 |                      | 0.835    |                   |          |
| Central                                       | 1764 | 8.1 (5.3 to 12.0)    |          |                   |          |
| Atlantic (North)                              | 999  | 4.6 (3.1 to 6.8)     |          |                   |          |
| Oriental                                      | 1121 | 4.8 (3.0 to 7.7)     |          |                   |          |
| Pacific (West)                                | 980  | 6.5 (4.3 to 9.8)     |          |                   |          |
| Bogotá                                        | 523  | 9.2 (4.4 to 18.0)    |          |                   |          |
| Amazonia-Orinoquia                            | 1598 | 6.4 (4.4 to 9.3)     |          |                   |          |

Continued
| Variable                  | n   | Overweight* | P value‡ | n   | Obesity* | P value‡ |
|---------------------------|-----|-------------|----------|-----|----------|----------|
|                           |     | % (95% CI) |          |     | % (95% CI) |          |
|                           |     |            |          |     |           |          |
| n=the analysed sample may be less than 6585 or 6985 due to missing values. |
| *Based on Z-score for BMI (WHO), 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. |
| ‡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). |
| **Bogotá, Barranquilla, Medellin, Cali. |

BMI, body mass index; ELCSA, Latin American and Caribbean Food Security Scale; ENSIN, Encuesta Nacional de la Situación Nutricional.

**Table 2** Continued

**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

| Explanatory variable | PR for meal frequency (95% CI) | Overweight* | Obesity* |
|----------------------|--------------------------------|-------------|----------|
|                      | 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), 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). |
§Bogotá, Barranquilla, Medellin, Cali. |
BMI, body mass index; ELCSA, Encuesta Nacional de la Situación Nutricional; ENSIN, Encuesta Nacional de la Situación Nutricional.

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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

| Variable                                      | n   | Overweight* (1497) % (95% CI) | P value‡ | n   | Obesity* (693) % (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 29.9)            |          | 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                  | Overweight* (1497) | P value† | Obesity* (693) | P value† |
|---------------------------|--------------------|----------|----------------|----------|
|                           | n                  | % (95% CI)|                | n        | % (95% CI)|                |
| Country region            |                    |          |                |          |
| Central                   | 1675               | 29.9 (26.5 to 33.6) | 0.008         | 1856     | 13.8 (10.9 to 17.3) | 0.121 |
| 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/m²), 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.
**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 kilocaloric intake (continuous), age (continuous), sex, whether physical activity goals were met (binary), 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.14.1.31

**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 (Q1), and 13.1% was in the highest quartile (Q4). 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...
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 0.70 (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

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**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

| Explanatory variable | PR for meal frequency (95% CI) |  |  |  |  |
|----------------------|-------------------------------|---|---|---|---|
|                       | Children 5–17 years           |   |   |   |   |
|                       | Crude                        | Adjusted† | Crude | Adjusted† | Crude | Adjusted† |
| Number of meals/day   |                               |         |     |     |     |     |
| 3 or fewer           | 1                             | 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   | 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   | 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   | 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.
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, $\beta=0.39$; 95% CI 0.17 to 0.62). 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. 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 <3 meals/day. 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.

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 1.29 to 1.89) 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. 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). In British adults aged 19–64 years, a direct association was found among the number of meals/day, BMI-based Ob and CO. 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.

In adults, as in children, the relationship 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 physical activity goals. These variables were not simultaneously available in many of the studies cited.

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. Increasing the number of meals/day is a potential strategy for the control of Ow, Ob and CO.

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